Technical Report M31

SEDIMENTATION AND NAVIGATION STUDY OF THE MIDDLE MISSISSIPPI RIVER IN THE ST. LOUIS HARBOR RIVER MILES 192.0 TO 172.0

HYDRAULIC MICRO MODEL INVESTIGATION

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INTRODUCTION

The U.S. Army Corps of Engineers, St. Louis District initiated a sedimentation and navigation study of the Middle Mississippi River between Miles 192.0 and 172.0. The purpose of the study was to evaluate and propose design modifications to existing stone dike and/or weir structures and the possible introduction of new structures for the purpose of improving navigation conditions and reducing dredging in the St. Louis Harbor.

The study was conducted between January 2003 and December 2003 by Mrs. Dawn Lamm, Hydraulic Engineer, and Mr. Edward Riiff, Engineering Technician, with assistance provided by Mr. Edward Brauer and Mr. Jasen Brown, Engineering Interns, under direct supervision of Mr. Robert Davinroy, District Potamologist. Other personnel also involved with the study included: Mr. Claude Strauser, Chief of the Hydrologic and Hydraulics Branch, Mr. Stephen Redington and Mr. Leonard Hopkins, Project Managers from the River Engineering Unit of the Hydrologic and Hydraulics Branch, Mr. David Busse, Potamology Section Chief of the Hydrologic and Hydraulics Branch; Mr. Mark Alvey and Ms. Marilyn Kwentus from the Geotechnical Branch; Mr. Lance Engle, District Dredging Project Manager from the Construction Operations Readiness Division.

Personnel from other agencies involved in the study included: Mr. Scott Stuewe and Mr. Butch Atwood from the Illinois Department of Natural Resources; Ms. Joyce Collins, Mr. Mike Thomas, Ms. Karen Westphal and Mr. John Magera from the U.S. Fish and Wildlife Service; and Ms. Valeria Barko from the Missouri Department of Conservation.

Personnel representing the river industry included: Mr. Tommy Seals, private consultant; Mr. Raymond Hopkins, Chairman of the River Industry Action Committee and from the American River Transportation Company, Mr. Sammy Dickey and

Capt. Ed Henleben of the River Industry Action Committee, Mr. Tim Robinson and Mr. Al Weaver of American Commercial Barge Line; Mr. Bruce Hancock and Mr. Larry King of Riverway; Mr. George Foster and Mr. Danny Parrent of J.B. Marine; Mr. Jim Patterson of the St. Louis Harbor Association and Osage Marine; Mr. Ritch Keller of Osage Marine; Mr. Richard W. Stegmann, Mr. Michael D. Stegmann, and Mr. Rich Coffman of Lange-Stegmann; Mr. Ed Fowler of Beelman River Terminals, Inc. and Mr. Matt French, Mr. Randy Johnson and Mr. David Cook of ARTCO; Mr. Nick Nichols of the City of St. Louis Port Authority; Mr. Tim Thomas and Mr. Dick Burke of Eagle Marine and Mr. Jim Labit of the Tri-City Regional Port District.

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BACKGROUND

Micro modeling methodology was used to evaluate the existing sediment transport conditions and the impact of various structural design measures in an effort to improve navigation conditions in the St. Louis Harbor of the Middle Mississippi River. The study was funded by the Regulating Works Project in the Hydrologic and Hydraulics Branch, of the St. Louis District.

The goal of this study was to reduce dredging and improve navigation conditions through the St. Louis Harbor without detrimentally effecting the various fleeting and loading/unloading operations located along both banks of the Mississippi River.

1. Study Reach

Plate 1 is a location and vicinity map of the study reach. The study area is located in St. Louis City and St. Louis County, Missouri and Madison, St. Clair and Monroe Counties, Illinois. The study reach comprised a 20-mile stretch of the Middle Mississippi River, between Miles 192.0 and 172.0. Downtown St. Louis, Missouri and the Gateway Arch are located near River Mile 179.5.

Plate 2 is a 1998 aerial photograph illustrating the characteristics, configuration, and nomenclature of the Mississippi River between Miles 192.0 and 172.0. The reach includes 6 bridge spans, Low Water Dam No. 27, the outlet of the Chain of Rocks Canal, and approximately 58 separate fleeting operations. The majority of the right descending bank (RDB) downstream of Mile 184.0 is steeply sloped and reveted with stone but also included some vegetated growth. Upstream of Mile 184.0, the RDB has a gentler slope and significantly more vegetation. Along the St. Louis Downtown Riverfront, the bankline has minimal slope and is lined with hand-placed cobblestone. From approximately Mile 183 to Mile 177, the left descending bank (LDB) is steeply sloped and heavily reveted with only occasional vegetation present. The LDB upstream of Mile 183.0 and downstream of Mile 177.0 has significantly

more vegetation and a minimal slope. Both the LDB and the RDB are flanked by levees or floodwalls throughout a majority of the project area.

This middle of the study reach, from Mile 185.0 to 175.0, is actually a long narrow bend of the Mississippi River. Because of this, the channel thalweg meanders back and forth from the Missouri and Illinois banks creating many crossing and shoaling problems.

Fleeting operations are present throughout much of the study area. Along the RDB, fleeting operations are present continuously from Mile 184.0 to Mile 172.0. Along the LDB, fleeting operations are present but were more sporadic from Mile 183.5 to Mile 172.5.

The main channel in the St. Louis Harbor is comprised of two dike fields and three individual dikes, containing a total of 17 structures, and two weir fields, containing a total of nine structures. A side channel, Mosenthien Chute, includes one dike field and contained four structures.

The Chain of Rocks Canal was completed in May 1953. This canal bypasses the Chain of Rocks. The Chain of Rocks reach was difficult to navigate in low water due to exposed bedrock. The canal entrance is located along the LDB just downstream of the confluence with the Missouri River and is 8.4 miles long. It contains a 1200-foot main lock chamber with a 600-foot auxiliary lock chamber. The levees that flank the 300-foot wide canal are a distance of 550-feet apart.

Construction of the Chain of Rocks Low Water Dam #27 began in 1959 and was completed in 1964. The average height of the dam was +8 feet LWRP and the length was 3,240 feet. (Note: All bed elevations described in this report are referenced to the Low Water Reference Plane (LWRP). The LWRP represents a theoretical water surface elevation profile based upon a low flow of 54,000 cfs. The reference elevation of 0 feet LWRP is based upon the probability that this stage and flow will be exceeded 97% of the time annually.) A 680-foot wide spillway was

constructed with a notch invert elevation of +3 feet LWRP. The crown has a width of 30 feet. The construction of the Low Water Dam rendered the area impassable regardless of the gage reading. The section of the Mississippi River between the entrance/exit of the Chain of Rocks Canal is now commonly called the old river channel.

The following tables detail the specific dimensions and characteristics of the dikes and weirs within the study reach.

Dike/Mile	Elevation (feet LWRP)	Dike Length	Trail Length	Double Dikes	Last Known Modification
189.6 L	+ 13	1600 ft	700 ft	N/A	
189.3 L	+ 11	2900 ft	2800 ft	N/A	
188.6 L	+ 11	1450 ft	N/A	N/A	1976
188.6 L Chute	+ 11	600 ft	N/A	N/A	1987
188.5 L	+ 12	1440 ft	650 ft	N/A	1881
188.4 L Chute	+ 13	820 ft	N/A	N/A	1987
188.2 L Chute	+ 11	775 ft	N/A	N/A	1987
187.8 L Chute	+ 11	550 ft	500 ft	N/A	1987
187.6 L	+ 10	1300 ft	N/A	N/A	1981
187.0 L	+ 9	550 ft	N/A	N/A	1981
186.3 L	+ 9	750 ft	N/A	N/A	1981
185.8 L	+ 8	700 ft	N/A	N/A	
185.3 L	+ 7	800 ft	N/A	N/A	1981
184.4 L	+ 15	450 ft	N/A	N/A	1981
184.2 L	+ 15	400 ft	2400 ft	N/A	
182.9 L	+ 13	300 ft	N/A	N/A	1972
181.7 L	+ 15	350 ft	N/A	N/A	
177.8 L	+ 13	350 ft	N/A	N/A	
175.9 L	+ 13	300 ft	N/A	N/A	
175.3 L	+ 20	850 ft	1450 ft	2 @ 300 ft	2001/2002
174.5 L	+ 18	900 ft	N/A	N/A	2002

Weir / Mile	Approximate Elevation (Feet LWRP)	Approximate Weir Length (feet)	Year Of Last Known Modification
174.65 R	-15	510	1996
174.5 R	-15	640	1996
174.35 R	-15	670	1996
174.2 R	-15	800	1996
174.0 R	-15	720	1996
172.75 R	-15	510	2002
172.60 R	-15	750	2002
172.45 R	-15	650	2002
172.3 R	-15	750	2002

2. Problem Description

The St. Louis Harbor, from Mile 192.0 to 172.0, is an important harbor on the Inland Waterway System for the navigation industry. This reach of the Middle Mississippi River had been plagued with repetitive dredging and shoaling problems as well as difficult channel alignment through numerous bridges. Many accidents have resulted along this difficult reach of the Mississippi River.

Dredging

Within the St. Louis Harbor, there have been three repetitive dredging locations. Dredging areas in the St. Louis Harbor for the last 13 years, from 1990 to 2003 are shown on Plate 3. The total cost of dredging these locations since 1990 has been almost $14.9 million. These areas must be dredged annually to maintain thalweg depth as well as channel alignment through the many bridges.

The first repetitive dredging site has been located along the LDB, between the Chain of Rocks Canal and the Merchants and McKinley Bridges at Mile 183.0. This dredge location had averaged approximately 387,000 cubic yards of dredged material a year at an average cost of over $451,000 per year. Disposal from this dredging location had been typically side-cast onto a sandbar along the RDB. However, shallow depths through this disposal area have been a problem during low water for fleeting and loading operations along the RDB.

The second repetitive dredging site was located at the crossing between Miles 182.0 to Mile 181.0. This crossing was artificially maintained to assist the navigation industry in approaching and traversing through the four bridges located in the downtown St. Louis area. This dredge location averaged almost 280,000 cubic yards of dredged material a year at an average cost of over $326,000 per year. Disposal from this dredging location was typically side-cast along the LDB.

The third repetitive dredging site had been located between Miles 175.5 and 174.5. At this location, the thalweg crosses from the RDB at Mile 177.2 to the LDB at Mile 176.9 and then back towards the RDB at Mile 176.0. These changes in channel

position have created shoaling problems along both banklines. The U.S. Army Corps of Engineers Fleet is located along the RDB at Mile 176.6 and had experienced shoaling. The channel also begins to widen considerably at Mile 175.5. A large sandbar referred to as Arsenal Island is located here. This sandbar encroaches upon the navigation channel and constricts the thalweg. This location has averaged almost 212,000 cubic yards of dredged material a year at an average cost of over $247,000 per year. Disposal of dredged material from the shoaling along the RDB had been deposited towards the LDB in the channel thalweg. Disposal of material dredged adjacent to Arsenal Island had been disposed on top of the Arsenal Island sandbar.

There have been additional areas in the harbor that have also required repeated dredging. These shoaling areas have not affected the navigation channel, but have impacted private businesses located along the bankline. Some of these shoaling areas have been so severe that businesses have temporarily closed during low water conditions. These areas were not a main concern of the study but were taken into account during design testing.

Channel Alignment

Navigation through the St. Louis Harbor has been described as one of the most treacherous on the entire Mississippi River. Six bridges cross the Mississippi River between Miles 183.2 and 179.0, with the navigation spans of nearly all of the bridges not matching the alignment of the channel thalweg. Furthermore, as up-bound traffic navigates through these bridge spans, they must maneuver into the Chain of Rocks Canal. Representatives from the navigation industry have stated that a more streamlined approach to and through these bridges and the Chain of Rocks Canal would be ideal.

Downstream of the Chain of Rocks Canal the thalweg favors the LDB through the Illinois spans of the Merchants Railroad and McKinley Highway and Railroad Bridges. Traffic navigating to or from the Old Mississippi River channel uses the center spans of these bridges. The channel thalweg has been located through the

Illinois spans on these bridges. The Missouri spans of these bridges have been impassable during water stages below + 8 feet LWRP.

The thalweg has then generally followed the LDB until Mile 182.0 where it crossed through a repetitive maintenance dredging area. This alignment allows downbound tows to line up with the center spans of the next 4 bridges, Martin L. King Memorial, Eads Highway and Railroad, Poplar Street, and Douglas MacArthur Railroad. The Illinois spans of these bridges have been used only if river stages are high enough for upbound tows to traverse under them. During low water, upbound tows must share the center spans with the downbound tows. Representatives from the navigation industry have expressed that a thalweg alignment where the current direction would coincide with the center spans of these bridges would be preferred.

Accident History

The St. Louis Harbor and the multiple bridges have been the site of numerous accidents. Many accidents have occurred due to the velocity direction and magnitude through the bridge spans, around the many fleeting and loading operations, and along the shoaling areas. From 1998 to mid 2003 alone there were 25 groundings, 13 collisions, and 3 allisions, which is an accident involving a vessel and a fixed object.

The most notable collision in recent history was an accident involving the President Casino on the Admiral and an American Boat Company tow in April 1998. The upbound tow struck a pier of the Eads Bridge upstream of the casino and broke apart, sending 14 runaway barges toward the permanently moored casino. Upon impact, the casino broke away from all but one of its moorings and drifted 500 feet downstream before a towboat was able to secure it. The casino had rotated 180 degrees with the entrance/exit pedestrian ramps facing the middle of the river. A nearby excursion boat assisted in getting the 2,500 casino passengers to shore safely. Approximately 31 passengers were injured in the accident, one critically. Other towboats in the area secured all but one of the runaway barges. One of the barges sank just downstream of the Douglas MacArthur Bridge.

3. Study Purpose and Goals

The purpose of the study was to evaluate and propose design modifications to existing stone dike and/or weir structures and the possible introduction of new structures. These structures were evaluated on their ability to improve navigation conditions by better aligning the channel thalweg through the center spans of the four downtown St. Louis bridges and their effects on reducing repetitive maintenance dredging areas. Navigation throughout the St. Louis Harbor will improve and become safer if these problems can be reduced and the federal government along with private industry may save millions of dollars in dredging costs.

4. History

Historical surveys and photographs were researched to better understand the changes that have occurred over time in the study reach. Each survey or photograph is described in detail in the next section.

1881

An 1881 topographic and hydrographic survey of the St. Louis Harbor on the Middle Mississippi River is shown on Plates 4 and 5. According to this survey, the upper portion of the study area contained a different river channel location as compared to the present day channel location. However, the lower portion of the study area appeared to be relatively unchanged in the last 100 years.

The upper portion of the study area appeared to contain a split channel, with the deeper main channel, located along the RDB at Sawyers Bend, and the second shallower channel located in the same general area as Mosenthien Chute. Many additional small islands also existed throughout this reach. A continuous side channel also appeared to separate Cabaret Island from the Illinois bankline. The Eads Bridge was the only bridge over the river in the St. Louis area. The lower portion of the study area appeared to be in a similar location as the present day Mississippi River channel. The River Des Peres and Cahokia Creek both demonstrated meandering characteristics that were different from the present day

tributaries, which have been channelized. At Arsenal Island the channel was wider upstream and narrower downstream of the island than present day conditions.

1908

The 1908 historical topographic and hydrographic survey, shown on Plates 6 and 7, indicated a channel location very similar to present day conditions. This included the establishment of the channel thalweg to the west of Mosenthien Island. Mosenthein Chute experienced significant deposition and developed into a single narrow channel. Cabaret Chute lost its upstream connection to the river and relied on upland runoff for flow.

Additional observations of the lower study area included Cahokia Creek and the River Des Peres, which still exhibited meandering characteristics. As compared to the 1881 Survey, the channel upstream of Arsenal Island became narrower but widened downstream, at the exit of Cahokia Chute.

The Merchants and St. Louis Electric Bridges (to be renamed McKinley) had been constructed across the Mississippi River at Miles 183.3 and 182.5.

1928

Plates 8-10 are 1928 aerial photographs of the reach. The main channel was more defined at Sawyer Bend. A large side channel existed between Mosenthien Island and Cabaret Island, but was narrower than in the previous survey. Cabaret Island still contained a narrow but continuous side channel. Channel width was fairly consistent from the downstream end of Mosenthien Island to Arsenal Island. The Chain of Rocks Bridge was under construction in the photograph and the Merchants, McKinley, and Municipal (to be renamed Douglas MacArthur R.R. Bridge) Bridges were already constructed. Cahokia Chute at Arsenal Island appeared to be continuous. The navigation channel downstream of Arsenal Island widened for about a mile.

1959

The 1959 Hydrographic Survey is shown on Plates 11-14. This was the first comprehensive hydrographic survey available. The Chain of Rocks Canal was completed and construction had begun on the Low Water Dam. The channel downstream of the Low Water Dam was shallow. Sufficient navigable depths were not reached until near the exit of the Chain of Rocks Canal at Mile 184.0. In addition, the exit of the canal appeared to have shallow depths of –10 feet LWRP or less. Shoaling was apparent in the crossing between Mile 182.5 and 181.8. A 2-mile long sandbar was located along the LDB at Mile 176.2. The channel thalweg along the RDB and adjacent to this sandbar was narrower and deeper. A slight shoaling area existed along the RDB between Miles 172.0 and 171.0.

Individual structures existing at the time of this survey were Dikes 184.2 L, 177.2 L, 176.7 L, 176.2 L, and 175.9 L. Two dike fields that contained short dikes also existed. The first dike field contained eight dikes between Miles 183.0 L and 182.0 L, the second dike field contained six dikes between Miles 178.8 L and 178.4 L. Also present were the Chain of Rocks, Merchants Railroad, McKinley Highway, Martin Luther King, Eads, and MacArthur Railroad Bridges, all with piers in the navigation channel.

1969/1971

The 1969/1971 Hydrographic Survey is shown on Plates 15-18. In this survey, the channel downstream of the Chain of Rocks Low Water Dam had changed slightly. A defined channel has begun to form downstream of the notch in the low water dam but remains shallow and narrow until Mile 184.5. The lower end of the Chain of Rocks Canal also appears to be shallow. A sandbar is located along the RDB between Miles 183.0 and 181.7. Downstream of Mile 181.7 and to Mile 178.8, the channel contained navigable depths bank to bank. Downstream of the Douglas MacArthur Rail Road Bridge, the thalweg meandered at one-mile increments. The channel then remained along the RDB from Mile 175.0 until the end of the study reach. A high sandbar was located along the LDB from Mile 175.4 to 172.7. River

training structures present in the study area included Dikes 189.6 L, 189.3 L, 184.4 L, 184.2 L, 177.8L, and 177.2 L. New bridge structures included the Interstate 270 Bridge in the old river channel and the Poplar Street Bridge located near downtown St. Louis, whose piers were located in the navigation channel.

1974

Plates 19-23 are 1974 Aerial Photographs of the study reach. The water elevation at the time of this survey was –0.5 feet LWRP according to the St. Louis, Missouri gage. These low water photographs show areas of shallow depth by the presence of sandbars in the channel. At Mile 188.0, a large middle bar is evident. A smaller sandbar is present near the RDB at Mile 187.2. However, Mosenthien Chute appeared deeper then present day conditions. There also appeared to be less fleeting operations upstream of the Martin Luther King Bridge then in the present day. An additional depositional area was present along the LDB at Mile 174.0.

1977

The 1977 Hydrographic Survey is shown on Plates 24-28. The bathymetry directly downstream of the Chain of Rocks Dam appeared to be shallower and exhibited increased shoaling when compared to previous surveys. The channel, which was located along the LDB at Mile 183.0 remained narrow and shallow until it widened with some middle bar shoaling downstream of Mile 181.0. The channel remained narrow and shallow until Mile 176.7 where it became slightly deeper. At Mile 176.0 the channel was very narrow and deep with a large sandbar along the LDB at Arsenal Island. River training structures indicated on this hydrographic survey included a dike field downstream of the Chain of Rocks Low Water Dam around Mosenthien Island containing Dikes 198.6 L, 189.3 L, 188.6 L, 188.5 L, 186.3 L, and 185.8 L. Three additional dikes were present upstream of the Chain of Rocks Canal, Dikes 184.7 L, 184.4 L, and 184.2 L. Additional single dikes were located at Miles 182.95 L, 177.8 L, 177.2 L and, 175.9 L.

1986/1987

The 1989 Hydrographic Survey is shown on Plates 27-30. In this survey the area downstream of the Chain of Rocks Low Water Dam to the lower end of the Chain of Rocks Canal was fairly shallow with very little depth below –10 feet LWRP. A sandbar was present along the RDB between Miles 183.2 and 181.2, with an additional depositional area developing across the channel thalweg and along the LDB between Miles 182.1 and 180.3. The channel became narrow and shallow at the crossing at Mile 177.5. From Mile 175.5 and through the remainder of the study reach, the channel was narrower and deeper.

1988

1988 Aerial Photographs depict the study area on Plates 31-34. These photographs were taken at +3.6 Feet LWRP according to the St. Louis, Missouri gage. These black and white photographs are unique in that they have the existing utility crossings and some fleeting facilities delineated. Some of these crossing are still in use today, while others have been abandoned. A few additional fleeting operations had been established upstream of the Martin Luther King. A depositional area was present near Arsenal Island along the LDB from Mile 174.7 to 173.3. No additional depositional areas are apparent in the photograph.

1993

The 1993 Hydrographic Survey is shown on Plate 35. The 1993 Hydrographic Survey indicated a channel that was significantly deeper then previous surveys. The depositional area along the RDB at Mile 183.2 to Mile 181.8 was present and the adjacent channel was slightly deeper. The channel thalweg had moved to the LDB from Mile 181.9 and through the downtown bridges. Unfortunately a large section of this survey from Mile 179.1 to 177.9 was missing. Below the missing section of the survey a depositional area was present from Mile 177.6 to Mile 176.0. At Mile 175.0, Arsenal Island encroached into the channel thalweg, greatly restricting the channel width.

1996

The 1996 Hydrographic Survey is shown on Plate 36. The 1996 Hydrographic Survey indicated a channel that was slightly shallower then the 1993 survey but deeper than surveys taken before 1993. The depositional area along the RDB from Mile 183.1 to Mile 182.0 was present with deeper scour holes located in the channel thalweg adjacent to the depositional area. A split channel was present with a middle bar located at Mile 181.6. The channel abruptly crossed to the RDB downstream of the MacArthur Bridge. The depositional areas along the LDB from Miles 178.5 to 177.8 and along the RDB from Miles 177.6 to 175.0 had diminished in size from previous years. The Harbor Weirs had been constructed across from Arsenal Island, reducing its encroachment into the navigation channel.

2001

The 2001 Hydrographic Survey is shown on Plate 37. The channel displayed adequate depth throughout the St. Louis Harbor and not much depth variation from previous surveys. The depositional area along the RDB from Mile 183.2 to Mile 181.8 was still present. The channel abruptly crossed to the RDB downstream of the MacArthur Bridge. A depositional area existed along the LDB at Mile 178.7 and from Mile 178.1 to Mile 177.1. An additional depositional area existed along the RDB from Mile 177.0 to Mile 175.6.

2002

The 2002 Aerial Photographs are shown on Plates 38-41. In these photographs the river is at +4.4 feet LWRP according to the St. Louis, Missouri gage. At this river stage, flow at the entrance to Mosenthien Chute had been isolated through the notches in Dike 189.3 L. The majority of the Chute appeared to be dry. A slight depositional area was present in the center of the channel at Mile 183.0. Fleeting has also increased within the St. Louis Harbor. The five Harbor Weirs constructed across from Arsenal Island appeared to have reduced the deposition along the LDB. Additional structures that had been constructed were Dike 175.3 L and Dike 174.5 L, and four weirs upstream from the outlet of River Des Peres at Mile 172.0.

2003

2003 Acoustic Doppler Current Profile data is shown on Plates 42-43. These surveys were taken at low and midbank flows at gage readings of +2.81 and +16.27 feet LWRP respectively. The Plates depict the velocities in the upper five feet of the water column. Both surveys are similar in velocity direction but differ in magnitude. The same color scheme was utilized on both surveys to show velocity magnitude and arrows were used to designate velocity direction.

The low flow ADCP survey indicated that in general, flows were between 3 and 5 ft/s. Higher velocities, 5 to 7 ft/s, were located adjacent to the trail of Dike 184.2 L. These flows then move sharply towards the LDB and decrease. From this point to the end of the study reach, the flows are fairly uniform. Areas that have exhibited shoaling tendencies had slightly slower velocities and areas that in general were deeper, had slightly higher velocities. One area where the velocities did not match the depth to velocity trend was the area just downstream of the Douglas MacArthur Bridge. At this location the channel crossed abruptly from the LDB to the RDB. The velocities did not follow this pattern and were shown to be flowing in a manner perpendicular to the banklines, similar to the majority of the flows through lower St. Louis Harbor.

The midbank ADCP Survey indicated that in general, flows were between 5 and 7 ft/s. Once again higher velocities were exhibited adjacent to the trail of Dike 184.2 L, however, flow did not move as sharply towards the LDB as shown in the low water ADCP survey. The same general trend of slower velocities in areas that have exhibited shoaling tendencies and higher velocities in deeper areas was present on this survey. The area from Mile 181.7 to 181.0 exhibited higher velocities then expected. The velocities immediately downstream of the Douglas MacArthur Bridge were missing but those further downstream suggest that the same velocity direction as shown in the low water data was present during higher water stages.

5. Field Observations

Personnel from the Applied River Engineering Center inspected the study reach by shallow draft boat and helicopter. These reconnaissance missions allowed the site to be photographed and studied. The site visits are described below with the water surface elevation referenced to LWRP at the St. Louis, Missouri gage.

-0.1 feet LWRP (January 30, 2003)

The study reach was visited by helicopter on January 30, 2003, to record observations throughout the district during extreme low water conditions. From this perspective many things could be seen that would not have been obvious or visible from a boat.

The most noted observation, shown on Plate 44, was the presence of a sand bar upstream of the McKinley Bridge, almost in the middle of the navigation channel. This sandbar and the associated shallow depths surrounding the sandbar had rendered facilities along the RDB inoperable. The shallow depths had also made the navigation channel narrower throughout the St. Louis Harbor. The amount of fleeting in the St. Louis Harbor was much more obvious from the air, as shown on Plate 44.

+ 7.6 feet LWRP (April 5, 2003)

The study reach was visited by boat on April 4 2003, to record field observations and measurements during low water conditions. The data collected at the site included general observations about the channel and structures within it. The following is a description of the data collected:

It was observed that some structures within the St. Louis Harbor were old pile structures that either have been degraded or have been repaired with stone. Degraded pile structures were also visible along the Illinois bankline from Mile 182.5 to 181.0. Many loading facilities contained steel pile constructed cells or loading ramps that may affect flow through the harbor.

The many bridge piers through the St. Louis Harbor also affect flow. Most of the bridge piers at the bankline also included elevated stone revetment that acted as dikes in the river. Along the LDB just downstream of the McKinley Bridge at Mile 182.5, an abandoned water intake from a closed power plant included protective screening that was full of debris and extended into the channel and also influenced flow through the area.

At this water elevation, Mosenthien Chute was shallow. While navigating up the side channel, the shallow draft boat ran aground numerous times. At the upstream entrance of Mosenthien Chute, the only water flowing into the side channel was through the two notches in Dike 189.3L.

Other notable observations were of a rock outcropping along the LDB, downstream of the Douglas MacArthur Bridge, The rock outcropping, shown on Plate 45, appeared to be a mix of natural stone and deteriorating reinforced concrete. The banklines upstream and downstream of the outcropping contain additional naturally occurring rock. The rock outcropping origins were uncertain, but some research indicated that it was at one time used to load livestock onto barges.

It was also observed that both banklines, from the Arch to the end of the study reach, were occupied by fleeting operations.

+ 22.4 feet LWRP (May 27, 2003)

The St. Louis Harbor was flown by helicopter on May 27, 2003 to record observations. From this perspective many things could be seen that were not obvious or visible from a boat. Unfortunately, due to a higher water stage, there were many things that were underwater and not visible.

At this water stage, Mosenthien Chute was flowing at bankfull, as shown on Plate 46. All structures in the side channel were underwater. The outline of Dike 189.3 L was evident from the water breaking over the top of it.

Dike 184.2 L at the exit of the Chain of Rocks Canal was also underwater as well as the rest of the structures in the study area. At this river stage, depositional areas within the study area did not appear to be a problem for the fleeting and loading operations that usually had to contend with them.

MICRO MODEL DESCRIPTION

1. Scales and Bed Materials

In order to investigate the sediment transport issues and habitat development described previously, a physical hydraulic micro model was designed and constructed. Plate 47 is a photograph of the hydraulic micro model used in this study. The model employed a horizontal scale of 1 inch = 800 feet, or 1:9600, and a vertical scale of 1 inch = 40 feet, or 1:480, for a 20 to 1 distortion ratio of linear scales. This distortion supplied the necessary forces required for the simulation of sediment transport conditions similar to those of the prototype. The bed material was granular polyester urea, Type II, with a specific gravity of 1.47.

2. Appurtenances

The micro model insert was constructed according to the 1998 high-resolution aerial photography of the study reach shown on Plate 2. The insert was then mounted in a standard micro model hydraulic flume. The riverbanks of the model were constructed from dense polystyrene foam, and modified during calibration with oil-based clay. The slope of the model was negligible. River training structures in the model were made of galvanized steel mesh.

Flow into the model was regulated by customized computer hardware and software interfaced with an electronic control valve and submersible pump. This interface was used to automatically control the flow of water and sediment into the model. Discharge was monitored by a magnetic flow meter interfaced with the customized computer software. Water stages were manually checked with a mechanical three-dimensional point digitizer. Resultant bed configurations were measured and recorded with a three-dimensional laser digitizer.

MICRO MODEL TESTS

1. Model Calibration

The calibration of the micro model involved the adjustment of water discharge, sediment volume, model slope, and entrance conditions of the model. These parameters were refined until the measured bed response of the model was similar to that of the prototype.

A. Micro Model Operation

In all model tests, a steady state flow was simulated in the Middle Mississippi River channel. This served as the average design energy response of the river. Because of the constant variation experienced in the prototype, this steady state flow was used to theoretically analyze the ultimate expected sediment response. The flow was held steady at a constant flow rate of 2.9 GPM during model calibration and for all design alternative tests. The most important factor during the modeling process is the establishment of an equilibrium condition of sediment transport. The high steady flow in the model simulated an average energy condition representative of the river's channel forming flow and sediment transport potential at bankfull stage.

B. Prototype Data and Observations

To determine the general bathymetric characteristics and sediment response trends that existed in the prototype, several present and historic hydrographic surveys were examined. Plates 11-18, 23-30, and 35-37 are plan view hydrographic survey maps of the Mississippi River from 1959, 1969/1971, 1977, 1986/1987, 1993, 1996, and 2001 respectively. In the latest surveys, the thalweg of the main channel was located in the same general alignment with the exception of the channel alignment in the 1993 survey from Mile 181.7 to Mile 180.2 being located along the LDB. Record flooding in 1993 may have been a factor for this temporary change.

The bathymetry of the most recent prototype surveys (1996 and 2001) were very similar to each other and were used to calibrate the micro model.

2. Base Test

Model calibration was achieved once it was determined through qualitative comparisons that the prototype surveys were similar to several surveys of the model. The resultant bathymetry of this calibrated bed response served as the base test of the micro model (Plate 48). This base test survey served as the comparative bathymetry for all design alternative tests.

Results of the micro model base test bathymetry and a comparison to the 1996 and 2001 prototype surveys indicated the following trends:

- At Mile 184.0 the channel began to cross from the RDB to the LDB similarly to the prototype but was slightly shallower than the prototype.

- Along the LDB from Mile 183.5 to Mile 181.9, the channel reached depths below –20 feet LWRP and in some areas reached depths below –30 feet LWRP. This was similar to the prototype surveys.

- A depositional area formed along the RDB from Mile 183.1 to Mile 181.8. This area on the base test was slightly higher and narrower than demonstrated on the prototype surveys.

- The base test was shallower from Mile 182.0 to Mile 181.5 than the prototype surveys. This was do to the fact that this area had been continually dredged to create a channel that aligned with the spans of the bridges starting at Mile 180.2.

- A small depositional area was present on the base test along the RDB from Mile 180.8 to Mile 179.2. A much smaller depositional area was present on the prototype surveys. However, this area had been commercially dredged for sand and this may have accounted for some of the depth differences.

- The channel along the LDB between Miles 180.5 and Mile 179.0 had depths that reached below –20 feet LWRP and some areas that reached depths below –30 feet LWRP. This reach was similar to the prototype surveys with the exception that the scour area downstream of the Eads Bridge was slightly larger than on the prototype surveys.

- On both the base test and the prototype surveys, the channel abruptly crossed from the LDB to the RDB at Mile 179.0. A small scour area formed downstream of the Douglas MacArthur Bridge at a rock outcropping along the LDB.

- A depositional area was present in the base test from Mile 178.9 to Mile 177.2 along the LDB. This was very similar to the prototype surveys.

- The channel thalweg crossed between Miles 178.0 and 177.0 in the same location when compared to the prototype surveys.

- Another depositional area along the RDB from Mile 177.6 to Mile 175.9 was observed in the base test. This was similar in location to the prototype surveys but was slightly larger. This may be in part due to the fact that this was the location of the St. Louis U.S. Army Corps of Engineers Fleet and has been periodically dredged to maintain adequate depths at the dock.

- The base test channel along the LDB between Miles 177.1 and 176.2 reached depths below –20 feet LWRP similar to the prototype surveys.

- The depositional area along the LDB known as Arsenal Island began at Mile at Mile 176.2 on the base test. On the prototype surveys deposition started at Mile 176.0.

- The channel thalweg crossed between Miles 176.0 and 175.0 in the same location when compared to the prototype surveys.

- In both the prototype surveys and the base test, the channel thalweg from Mile 175.4 and through the Harbor Weirs was along the RDB, with depths near –20 feet LWRP. However, the base test contained a slightly wider channel through the weir field.

Overall, the trends of the model as observed in the base test were similar to those observed from the prototype surveys. Differences between the model and the prototype were accounted for during all alternative tests.

3. Design Alternative Tests

Seventeen design alternative plans were model tested to examine methods of modifying the sediment transport response trends that would reduce dredging, align velocities through bridge spans and decrease shoaling areas. Impacts or changes induced by each alternative were evaluated by observing the sediment response of the model. The effectiveness of each design was evaluated by comparing the resultant bed configuration to that of the base condition.

Alternative 1: *In an attempt to reduce the depositional area from Mile 183.2 to Mile 182.0 and to better align flows through the spans of the St. Louis Harbor Bridges, the trail on Dike 184.2 was extended to the 2nd Illinois pier of the Merchants Bridge.*

- *Longitudinal Dike 184.2 L: trail was extended to a total length of approximately 5000 feet at an elevation of +15 feet LWRP.*

Plate 49 is a plan view map of the resultant bed configuration of Alternative 1. The test results indicated that this design reduced the size of the depositional area along the RDB, but did not eliminate it. Extending the Longitudinal Dike 184.2 L increased depths in the exit of the Chain of Rocks Canal. This was due to a channel alignment that was parallel to the trail dike, which appeared to discourage the formation of material depositing eddies at the end of the dike.

<u>Alternative 2:</u> *In an attempt to reduce the depositional area from Mile 183.2 to Mile 182.0 and to better align flows through the spans of the St. Louis Harbor Bridges, the trail on Dike 184.2 was extended to the 2nd Illinois pier of the Merchants Bridge and Dike 181.7 L was extended further into the channel.*

- *Dike 184.2 L: trail was extended to a total length of approximately 5000 feet at an elevation of +15 feet LWRP.*
- *Dike 181.7 L: dike extended to a total length of 500 feet from the bankline at an elevation of +15 feet LWRP.*

Plate 50 is a plan view map of the resultant bed configuration of Alternative 2. The test results indicated that this design reduced the size of the depositional area along the RDB at Mile 183.0, but did not eliminate it. This alternative appeared to have increased deposition along the RDB from Mile 182.2 to Mile 180.2. Also, the channel thalweg at Mile 182.9 to Mile 181.7 was shallower, with depths only reaching –10 feet LWRP. Extending Longitudinal Dike 184.2 L increased depths in the exit of the Chain of Rocks Canal. This was due to the previously mentioned channel alignment along the trail dike.

<u>Alternative 3:</u> *In an attempt to reduce the depositional area from Mile 183.2 to Mile 182.0 and to better align flows through the spans of the St. Louis Harbor Bridges, the trail on Dike 184.2 was extended to the 2nd Illinois pier of the Merchants Bridge and Dike 181.7 L was extended.*

- *Dike 184.2 L: trail was extended to a total length of approximately 5000 feet at an elevation of +15 feet LWRP.*
- *Dike 181.7 L: dike extended to a total length of 600 feet from the bankline at an elevation of +15 feet LWRP.*

Plate 51 is a plan view map of the resultant bed configuration of Alternative 3. The test results indicated that this design reduced the size of the depositional area along

the RDB at Mile 183.0, but did not eliminate it. This alternative appeared to have increased deposition along the RDB from Mile 182.3 to Mile 181.8.

Alternative 4: *In an attempt to reduce the depositional area from Mile 183.2 to Mile 182.0 and to better align flows through the spans of the St. Louis Harbor Bridges, the trail on Dike 184.2 was extended to the 2nd Illinois pier of the Merchants Bridge, Dike 181.7 L was extended, and a new dike was added at Mile 182.1.*

- *Dike 184.2 L: trail was extended to a total length of approximately 5000 feet at an elevation of +15 feet LWRP.*
- *Added Dike 182.1: 500 feet long at +15 feet LWRP.*
- *Dike 181.7 L: dike extended to a total length of 600 feet from the bankline at an elevation of +15 feet LWRP.*

Plate 52 is a plan view map of the resultant bed configuration of Alternative 4. The test results indicated that this design reduced the size of the depositional area along the RDB at Mile 183.0. Some depositional areas still existed at Mile 182.8 and Mile 182.0 and new depositional areas developed along the RDB from Mile 181.1 to Mile 180.1. A depositional area also formed along the LDB in the vicinity of the tested dikes between Miles 182.2 and 181.2.

The “shallow” areas located along the LDB through the downtown bridges were “moorings” that the scanning equipment had difficulty differentiating from the bottom of the channel.

Alternative 5: *In an attempt to reduce the depositional area from Mile 183.2 to Mile 182.0 and to better align flows through the spans of the St. Louis Harbor Bridges, the trail on Dike 184.2 was extended to the 2nd Illinois pier of the Merchants Bridge, Dike 181.7 L was extended, and a new dike was added at approximately Mile 182.1.*

- *Dike 184.2 L: trail was extended to a total length of approximately 5000 feet at an elevation of +15 feet LWRP.*
- *Added Dike 182.1: 600 feet long at +15 feet LWRP.*

- *Dike 181.7 L: dike extended to a total length of 600 feet from the bankline at an elevation of +15 feet LWRP.*

Plate 53 is a plan view map of the resultant bed configuration of Alternative 5. The test results indicated that this design reduced the size of the depositional area along the RDB at Mile 183.0. Some depositional areas still existed at Mile 182.8 and Mile 182.1 and new depositional areas developed along the RDB from Mile 181.3 to Mile 180.1.

The "shallow" areas located along the LDB through the downtown bridges are "moorings" that the scanning equipment had difficulty differentiating from the bottom of the channel.

Alternative 6: *In an attempt to reduce the depositional area from Mile 183.2 to Mile 182.0 and to better align flows through the spans of the St. Louis Harbor Bridges, a chevron was added at Mile 182.9.*

- *Added a chevron at Mile 182.9, the Illinois leg of the chevron was 300 foot long and the Missouri leg was 600 foot long, placed at an elevation of +15 feet LWRP.*

Plate 54 is a plan view map of the resultant bed configuration of Alternative 6. The test results indicated that this design did not reduce the depositional area along the RDB at Mile 183.0. In fact, this alternative appeared to increase deposition along the RDB at Mile 181.7.

Alternative 7: *In an attempt to reduce the depositional area from Mile 183.2 to Mile 182.0 and to better align flows through the spans of the St. Louis Harbor Bridges, the trail on Dike 184.2 was extended to the 2nd Illinois pier of the Merchants Bridge and a chevron was added at Mile 182.9.*

- *Dike 184.2 L: trail was extended to a total length of approximately 5000 feet at an elevation of +15 feet LWRP.*

- *Added a chevron at Mile 182.9, the Illinois leg of the chevron was 300 foot long and the Missouri leg was 600 foot long, placed at an elevation of +15 feet LWRP.*

Plate 55 is a plan view map of the resultant bed configuration of Alternative 7. The test results indicated that this design reduced the size of the depositional area along the RDB at Mile 183.0. A depositional area developed along the RDB from Mile 180.8 to Mile 179.9

Alternative 8: *In an attempt to reduce the depositional area from Mile 183.2 to Mile 182.0 and to better align flows through the spans of the St. Louis Harbor Bridges, the trail on Dike 184.2 was extended to the 2nd Illinois pier of the Merchants Bridge and chevrons were added at Mile 182.9 and 182.75*

- *Dike 184.2 L: trail was extended to a total length of approximately 5000 feet at an elevation of +15 feet LWRP.*
- *Added a chevron at Mile 182.9, the Illinois leg of the chevron was 300 foot long and the Missouri leg was 600 foot long, placed at an elevation of +15 feet LWRP.*
- *Added a chevron at Mile 182.75, 300 foot long and 300 foot wide, placed at an elevation of +15 feet LWRP.*

Plate 56 is a plan view map of the resultant bed configuration of Alternative 8. The test results indicated that this design reduced the size of the depositional area along the RDB at Mile 183.0 but the depositional area from Mile 182.4 to Mile 181.4 widened. The channel from the end of the trail dike to Mile 182.0 maintained depths below –20 foot LWRP. An additional depositional area developed along the RDB from Mile 180.8 to Mile 180.0.

Alternative 9: *In an attempt to reduce the depositional area from Mile 183.2 to Mile 182.0 and to better align flows through the spans of the St. Louis Harbor Bridges,*

the trail on Dike 184.2 was extended to the 2nd Illinois pier of the Merchants Bridge and chevrons were added at Mile 182.9, 182.7 and 182.3.

- *Dike 184.2 L: trail was extended to a total length of approximately 5000 feet at an elevation of +15 feet LWRP.*
- *Added a chevron at Mile 182.9, the Illinois leg of the chevron was 300 foot long and the Missouri leg was 600 foot long, placed at an elevation of +15 feet LWRP.*
- *Added a chevron at Mile 182.75, 300 foot long and 300 foot wide, placed at an elevation of +15 feet LWRP.*
- *Added a chevron at Mile 182.3, 300 foot long and 300 foot wide, placed at an elevation of +15 feet LWRP.*

Plate 57 is a plan view map of the resultant bed configuration of Alternative 9. The test results indicated that this design reduced the size of the depositional area along the RDB at Mile 183.0. A minor depositional area still existed from Mile 182.0 to Mile 181.6. The channel from the end of the trail dike to Mile 181.8 maintained depths below –20 foot LWRP. Once again it appeared that extending the Longitudinal Dike 184.2 L increased depths in the exit of the Chain of Rocks Canal.

Alternative 10: *In an attempt to reduce the depositional area from Mile 183.2 to Mile 182.0 and to better align flows through the spans of the St. Louis Harbor Bridges, the trail on Dike 184.2 was extended to the 2nd Illinois pier of the Merchants Bridge and chevrons were added at Mile 182.9, 182.7 and 182.4.*

- *Dike 184.2 L: trail was extended to a total length of approximately 5000 feet at an elevation of +15 feet LWRP.*
- *Added a chevron at Mile 182.9, 300 foot wide, with one leg of the chevron 300 foot long and the RDB leg 600 foot long, placed at an elevation of +15 feet LWRP.*
- *Added a chevron at Mile 182.7, 300 foot long and 300 foot wide, placed at an elevation of +15 feet LWRP.*

- *Added a chevron at Mile 182.4, 300 foot long and 300 foot wide, placed at an elevation of +15 feet LWRP.*

Plate 58 is a plan view map of the resultant bed configuration of Alternative 10. The test results indicated that this design was more effective in reducing the depositional area along the RDB at Mile 183.0 then Alternative 9. A minor depositional area still existed from Mile 182.0 to Mile 181.4 and along the RDB from Mile 181.4 to Mile 181.1 and Mile 180.8 to Mile 180.3. The channel from the end of the trail dike to Mile 182.1 maintained depths below –20 foot LWRP.

The "shallow" areas located along the LDB through the downtown bridges are "moorings" that the scanning equipment had difficulty differentiating from the bottom of the channel.

Alternative 11: *In an attempt to reduce the depositional area from Mile 183.2 to Mile 182.0 and to better align flows through the spans of the St. Louis Harbor Bridges, the trail on Dike 184.2 was extended to the 2nd Illinois pier of the Merchants Bridge, chevrons were added at Mile 182.9, 182.7 and 182.4, and Dike 181.7 L was extended.*

- *Dike 184.2 L: trail was extended to a total length of approximately 5000 feet at an elevation of +15 feet LWRP.*
- *Added a chevron at Mile 182.9, 300 foot wide, with one leg of the chevron 300 foot long and the RDB leg 600 foot long, placed at an elevation of +15 feet LWRP.*
- *Added a chevron at Mile 182.7, 300 foot long and 300 foot wide, placed at an elevation of +15 feet LWRP.*
- *Added a chevron at Mile 182.4, 300 foot long and 300 foot wide, placed at an elevation of +15 feet LWRP.*
- *Dike 181.7 L: dike extended to a total length of 600 feet from the bankline.*

Plate 59 is a plan view map of the resultant bed configuration of Alternative 11. The test results indicated that this design was effective in reducing the depositional area along the RDB at Mile 183.0. The depositional area along the RDB from Mile 180.8 to Mile 180.3 increased in width. The channel from the end of the trail dike to Mile 182.1 maintained depths below –20 foot LWRP.

Alternative 12: *In an attempt to reduce the depositional area from Mile 183.2 to Mile 182.0 and to better align flows through the spans of the St. Louis Harbor Bridges, three chevrons were added at Mile 182.9, 182.7 and 182.4.*

- *Added a chevron at Mile 182.9, the Illinois leg of the chevron was 300 foot long and the Missouri leg was 600 foot long, placed at an elevation of +15 feet LWRP.*
- *Added a chevron at Mile 182.7, 300 foot long and 300 foot wide, placed at an elevation of +15 feet LWRP.*
- *Added a chevron at Mile 182.4, 300 foot long and 300 foot wide, placed at an elevation of +15 feet LWRP.*

Plate 60 is a plan view map of the resultant bed configuration of Alternative 12. The test results indicated that this design reduced the size of the depositional area along the RDB at Mile 183.0. This alternative was to test if the extension of the trail of Dike 184.2 L was needed to maintain the effectiveness of the chevrons. It appeared that the trail extension would be necessary. A depositional area still existed along the RDB from Mile 183.0 to Mile 182.5 and from 182.2 to Mile 181.8. The channel from the end of the trail dike to Mile 181.7 maintained depths below –20 foot.

Alternative 13: *In an attempt to reduce the depositional areas from Mile 183.2 to Mile 182.0, Mile 178.9 to Mile 177.5, and Mile 177.6 to Mile 176.2 and to better align flows through the spans of the St. Louis Harbor Bridges, the trail on Dike 184.2 was extended to the 2nd Illinois pier of the Merchants Bridge, chevrons were added at Mile 182.9, 182.7 and 182.4 and a Dike was added at Mile 179.0 R.*

- *Dike 184.2 L: trail was extended to a total length of approximately 5000 feet at an elevation of +15 feet LWRP.*
- *Added a chevron at Mile 182.9, the Illinois leg of the chevron was 300 foot long and the Missouri leg was 600 foot long, placed at an elevation of +15 feet LWRP.*
- *Added a chevron at Mile 182.7, 300 foot long and 300 foot wide, placed at an elevation of +15 feet LWRP.*
- *Added a chevron at Mile 182.4, 300 foot long and 300 foot wide, placed at an elevation of +15 feet LWRP.*
- *Added a dike at Mile 179.0, 400 foot long, placed at an elevation of +15 feet LWRP. This Dike is located underneath the Douglas MacArthur Bridge and spans to the first Missouri pier located in the river.*

Plate 61 is a plan view map of the resultant bed configuration of Alternative 13. The test results indicated that this design was effective in reducing the depositional area along the RDB at Mile 183.0. A depositional area still existed along the RDB from Mile 182.0 to Mile 181.4. The channel from the end of the trail dike to Mile 182.1 maintained depths below –20 foot LWRP. The depositional area along the LDB from Mile 178.9 to Mile 177.5 appeared to have diminished slightly.

Alternative 14: *In an attempt to reduce the depositional areas from Mile 183.2 to Mile 182.0, Mile 178.9 to Mile 177.5, and Mile 177.6 to Mile 176.2 and to better align flows through the spans of the St. Louis Harbor Bridges, the trail on Dike 184.2 was extended to the 2nd Illinois pier of the Merchants Bridge, chevrons were added at Mile 182.9, 182.7 and 182.4, Dike 181.7L was extended and 4 weirs were added between the Martin Luther King and Popular Street Bridges*

- *Dike 184.2 L: trail was extended to a total length of approximately 5000 feet at an elevation of +15 feet LWRP.*
- *Added a chevron at Mile 182.9, the Illinois leg of the chevron was 300 foot long and the Missouri leg was 600 foot long, placed at an elevation of +15 feet LWRP.*

- *Added a chevron at Mile 182.7, 300 foot long and 300 foot wide, placed at an elevation of +15 feet LWRP.*
- *Added a chevron at Mile 182.4, 300 foot long and 300 foot wide, placed at an elevation of +15 feet LWRP.*
- *Dike 181.7 L: dike extended to a total length of 600 feet from the bankline at an elevation of +15 feet LWRP.*
- *Added four 500 foot long Weirs along the LDB at Miles 179.4, 179.6, 179.8, and 179.9 at an elevation of –15 feet LWRP*

Plate 62 is a plan view map of the resultant bed configuration of Alternative 14. The test results indicated that this design was effective in reducing the depositional area along the RDB at Mile 183.0. A minor depositional area still existed in the center of the channel from Mile 182.0 to Mile 181.4. The channel from the end of the trail dike to Mile 178.5 maintained depths below –20 foot. The depositional area along the LDB from Mile 178.9 to Mile 177.5 appeared to have diminished with only a slight depositional area existing for a ¼ mile upstream and downstream of Dike 177.8 L. A depositional area existed along the RDB from Mile 178.4 to 178.0. The existing depositional area from Mile 177.8 to Mile 176.3 was not affected by these alternatives. Arsenal Island along the LDB at Mile 175.0 appeared to have slightly reduced in size.

Alternative 15: *In an attempt to reduce the depositional areas from Mile 183.2 to Mile 182.0, Mile 178.9 to Mile 177.5, and Mile 177.6 to Mile 176.2 and to better align flows through the spans of the St. Louis Harbor Bridges, the trail on Dike 184.2 was extended to the 2nd Illinois pier of the Merchants Bridge, chevrons were added at Mile 182.9, 182.7 and 182.4, Dike 181.7L was extended and as requested by the navigation industry a trail was added, and 3 weirs were added between the Martin Luther King and Popular Street Bridges*

- *Dike 184.2 L: trail was extended to a total length of approximately 5000 feet at an elevation of +15 feet LWRP.*

- *Added a chevron at Mile 182.9, the Illinois leg of the chevron was 300 foot long and the Missouri leg was 600 foot long, placed at an elevation of +15 feet LWRP.*
- *Added a chevron at Mile 182.7, 300 foot long and 300 foot wide, placed at an elevation of +15 feet LWRP.*
- *Added a chevron at Mile 182.4, 300 foot long and 300 foot wide, placed at an elevation of +15 feet LWRP.*
- *Dike 181.7 L: dike extended to a total length of 600 feet from the bankline and a trail added at a length of 900 feet, all at an elevation of +15 feet LWRP.*
- *Added 600 foot long Weirs along the LDB at Miles 179.9, 179.8, and 179.6 at an elevation of –15 feet LWRP*

Plate 63 is a plan view map of the resultant bed configuration of Alternative 15. The test results indicated that this design was effective in reducing the depositional area along the RDB at Mile 183.0. A depositional area still existed in the center of the channel from Mile 182.0 to Mile 181.7. The channel from the end of the trail on Dike 184.2 L to Mile 178.5 maintained depths below –20 foot. The depositional area along the LDB from Mile 178.9 to Mile 177.5 appeared to have diminished with only a slight depositional area existing near Dike 177.8 L. The depositional area along the RDB from Mile 177.6 to Mile 176.4 appeared to have slightly diminished in size. Arsenal Island along the LDB at Mile 175.0 appeared to have slightly reduced in size.

Alternative 16: *In an attempt to reduce the depositional areas from Mile 183.2 to Mile 182.0, Mile 178.9 to Mile 177.5, and Mile 177.6 to Mile 176.2 and to better align flows through the spans of the St. Louis Harbor Bridges, the trail on Dike 184.2 was extended to the 2nd Illinois pier of the Merchants Bridge, chevrons were added at Mile 182.9, 182.7 and 182.4, Dike 181.7L was extended and as requested by the navigation industry a trail was added, 3 weirs were added between the Martin Luther King and Popular Street Bridges and 3 weirs were added between Miles 176.7 and 176.5.*

- *Dike 184.2 L: trail was extended to a total length of approximately 5000 feet at an elevation of +15 feet LWRP.*
- *Added a chevron at Mile 182.9, the Illinois leg of the chevron was 300 foot long and the Missouri leg was 600 foot long, placed at an elevation of +15 feet LWRP.*
- *Added a chevron at Mile 182.7, 300 foot long and 300 foot wide, placed at an elevation of +15 feet LWRP.*
- *Added a chevron at Mile 182.4, 300 foot long and 300 foot wide, placed at an elevation of +15 feet LWRP.*
- *Dike 181.7 L: dike extended to a total length of 600 feet from the bankline and a trail added at a length of 900 feet, all at an elevation of +15 feet LWRP.*
- *Added 600 foot long Weirs along the LDB at Miles 179.9, 179.8, and 179.6 at an elevation of –15 feet LWRP.*
- *Added 500 foot long Weirs along the LDB at Miles 176.7, 176.6, and 176.5 at an elevation of –15 feet LWRP.*

Plate 64 is a plan view map of the resultant bed configuration of Alternative 16. The test results indicated that this design was effective in reducing the depositional area along the RDB at Mile 183.0. A minor depositional area still existed in the center of the channel from Mile 182.0 to Mile 181.7. The channel from the end of the trail dike to Mile 178.5 maintained depths below –20 foot LWRP. The depositional area along the LDB from Mile 178.9 to Mile 177.5 appeared to have diminished with only a minor depositional area existing for a ¼ mile upstream and downstream of Dike 177.8 L. The depositional area along the RDB from Mile 177.6 to Mile 176.4 appeared to have slightly diminished in size. The thalweg crossing between Miles 176.0 and 175.0 appeared to be deeper. Arsenal Island along the LDB at Mile 175.0 appeared to have slightly reduced in size.

Alternative 17: *In an attempt to study the effectiveness of a previously suggested design alternative, weirs were added and the trail dike was removed. Dike heights were unaltered*

- *Dike 184.2 L: trail was removed*
- *Weirs 183.9 L to 183.4: 5 structures, 700 feet in length, placed at –15 feet LWRP, spaced approximately 700 feet apart, and angled upstream.*

Plate 66 is a plan view map of the resultant bed configuration of Alternative 17. The test results indicated that this design was not effective in reducing depositional areas and actually indicated an increased dredging problem at the mouth of the Chain of Rocks Canal. This alternative did not reduce the depositional area along the RDB from Mile 183.2 to Mile 182.0. A new depositional area developed for approximately ¼ mile upstream and downstream of Dike 181.7 L.

CONCLUSIONS

1. Summary

Seventeen alternative design tests were conducted in this study. Each alternative was tested with the intention of reducing dredging and improving navigation conditions through the St. Louis Harbor.

All alternatives sought to improve the upper area of the study reach, specifically the dredging problems at the mouth of the Chain of Rocks Canal, the crossing between Miles 182.5 and 181.0, and the shoaling area along the RDB between Miles 183.2 and 181.7. Once a design with favorable results was determined for the upstream areas, the downstream reaches were studied. The selected design was studied in conjunction with additional measures for remedying the downstream problems to ensure that the cumulative effects of the entire design were taken into account.

Of Alternatives 1 through 12 and 17, Alternative 11 produced the most favorable results by eliminating most of the shoaling and dredging problems in the upper reaches of the study area. Therefore, this design was also used while testing downstream alternatives. This design consisted of extending the trail on Dike 184.2 to the 2nd Illinois pier of the Merchants Bridge, adding chevrons at Miles 182.9, 182.7 and 182.4, and Dike 181.7 L was extended. This alternative reduced the depositional area at the end of the canal and along the RDB at Mile 183.0. It also reduced the need for dredging at the crossing from Miles 182.0 to 181.0. The trail was added to Dike 181.7 L later in the study after the navigation industry requested it be tested as a location for tows to push up against while waiting to lock through the Chain of Rocks Canal. This addition did not appear to affect the navigation channel.

Alternatives 13 through 16 focused on alignment through the downtown bridge piers and on the downstream dredging problems. In specific, the request to have the channel thalweg aligned through the center piers of the bridges located from Mile

180.2 to 179.0, and the reduction of the shoaling areas along the LDB from Miles 178.6 to 177.0 and along the RDB from Miles 177.0 to 176.0. Alternative 13 was not effective in achieving the above-mentioned goals. Alternatives 14 and 15 were the most effective in altering the alignment through the bridge piers and reducing some of the shoaling. Alternative 16 was not effective in reducing the shoaling along the RDB between Miles 177.0 and 176.0.

Alternative 15 appeared to be the most effective in achieving the stated goals of improving navigation conditions and reducing dredging in the St. Louis Harbor on the Mississippi River. The design consisted of extending the trail on Dike 184.2 to the 2nd Illinois pier of the Merchants Bridge, adding chevrons at Miles 182.9, 182.7 and 182.4, extending and adding a trail to Dike 181.7 L, and adding three weirs at Miles 179.9, 179.8, and 179.6. This alternative reduced the depositional area at the end of the canal and along the RDB at Mile 183.0. It also reduced the need for dredging at the crossing from Miles 182.0 to 181.0. The thalweg through the bridge piers also appeared to have a better alignment. The dredging area was reduced in the fleeting facilities along the RDB and LDB between Miles 178.0 and 176.3.

2. Recommendations

The recommended design alternative consisted of extending the trail on Dike 184.2 to the 2nd Illinois pier of the Merchants Bridge, adding chevrons at Miles 182.9, 182.7 and 182.4, extending and adding a trail to Dike 181.7 L, and adding three weirs at Miles 179.9, 179.8, and 179.6.

- *Dike 184.2 L: trail was extended to a total length of approximately 5000 feet at an elevation of +15 feet LWRP.*
- *Added a chevron at Mile 182.9, the Illinois leg of the chevron was 300 foot long and the Missouri leg was 600 foot long, placed at an elevation of +15 feet LWRP.*
- *Added a chevron at Mile 182.7, 300 foot long and 300 foot wide, placed at an elevation of +15 feet LWRP.*

- *Added a chevron at Mile 182.4, 300 foot long and 300 foot wide, placed at an elevation of +15 feet LWRP.*
- *Dike 181.7 L: dike extended to a total length of 600 feet from the bankline and a trail added at a length of 900 feet, all at an elevation of +15 feet LWRP.*
- *Added 600 foot long Weirs along the LDB at Miles 179.9, 179.8, and 179.6 at an elevation of –15 feet LWRP*

If this design is constructed, it may be built in phases to assist with cost and to allow for gradual changes for tow pilots navigating this reach. The project should be constructed from upstream to downstream. The extension of Longitudinal Dike 184.2L and the 3 chevrons should be the first phase. The extension of Dike 181.7 L and the construction of the trail on Dike 181.7 L should be the second phase. The construction of the weirs should be the third phase.

3. Interpretation of Model Test Results

In the interpretation and evaluation of the results of the tests conducted, it should be remembered that the results of these model tests were qualitative in nature. Any hydraulic model, whether physical or numerical, is subject to biases introduced as a result of the inherent complexities that exist in the prototype. Anomalies in actual hydrographic events, such as prolonged periods of high or low flows are not reflected in these results, nor are complex physical phenomena, such as the existence of underlying rock formations or other non-erodible variables. Flood flows were not simulated in this study.

This model study was intended to serve as a tool for the river engineer to guide in assessing the general trends that could be expected to occur in the actual river from a variety of imposed design alternatives. Measures for the final design may be modified based upon engineering knowledge and experience, real estate and construction considerations, economic and environmental impacts, or any other special requirements.

FOR MORE INFORMATION

For more information about micro modeling or the Applied River Engineering Center, please contact Robert Davinroy, David Gordon or Dawn Lamm at:

Applied River Engineering Center
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Hydrologic and Hydraulics Branch
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St. Louis, Missouri 63118

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E-mail: Robert.D.Davinroy@mvs02.usace.army.mil
David.Gordon@mvs02.usace.army.mil
Dawn.Lamm@mvs02.usace.army.mil

Or you can visit us on the World Wide Web at:

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

APPENDIX OF PLATES

Plate #'s 1 through 66 follow:

1. Location and Vicinity Map of the Study Reach
2. Study Area Characteristics
3. Dredging History from 1990 to 2003
4. 1881 Hydrographic & Topographic Survey, Mississippi River Miles 193-183
5. 1881 Hydrographic & Topographic Survey, Mississippi River Miles 182-172
6. 1908 Hydrographic & Topographic Survey, Mississippi River Miles 191-184
7. 1908 Hydrographic & Topographic Survey, Mississippi River Miles 183-172
8. 1928 Aerial Photograph, Mississippi River Miles 190-184
9. 1928 Aerial Photograph, Mississippi River Miles 184-178
10. 1928 Aerial Photograph, Mississippi River Miles 177-172
11. 1959 Hydrographic Survey, Mississippi River Miles 192-187
12. 1959 Hydrographic Survey, Mississippi River Miles 186-181
13. 1959 Hydrographic Survey, Mississippi River Miles 181-176
14. 1959 Hydrographic Survey, Mississippi River Miles 175-171
15. 1969/1971 Hydrographic Survey, Mississippi River Miles 192-187
16. 1969/1971 Hydrographic Survey, Mississippi River Miles 186-182
17. 1969/1971 Hydrographic Survey, Mississippi River Miles 181-177
18. 1969/1971 Hydrographic Survey, Mississippi River Miles 176-172
19. 1974 Aerial Photograph, Mississippi River Miles 192-186
20. 1974 Aerial Photograph, Mississippi River Miles 186-181
21. 1974 Aerial Photograph, Mississippi River Miles 181-177
22. 1974 Aerial Photograph, Mississippi River Miles 176-172
23. 1977 Hydrographic Survey, Mississippi River Miles 192-187
24. 1977 Hydrographic Survey, Mississippi River Miles 187-182
25. 1977 Hydrographic Survey, Mississippi River Miles 181-176
26. 1977 Hydrographic Survey, Mississippi River Miles 176-172
27. 1986/1987 Hydrographic Survey, Mississippi River Miles 192-187
28. 1986/1987 Hydrographic Survey, Mississippi River Miles 187-182

29. 1986/1987 Hydrographic Survey, Mississippi River Miles 181-177
30. 1987 Hydrographic Survey, Mississippi River Miles 176-172
31. 1988 Aerial Photograph, Mississippi River Miles 192-186
32. 1988 Aerial Photograph, Mississippi River Miles 186-182
33. 1988 Aerial Photograph, Mississippi River Miles 181-177
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40. 2002 Aerial Photographs, Mississippi River Miles 181-177
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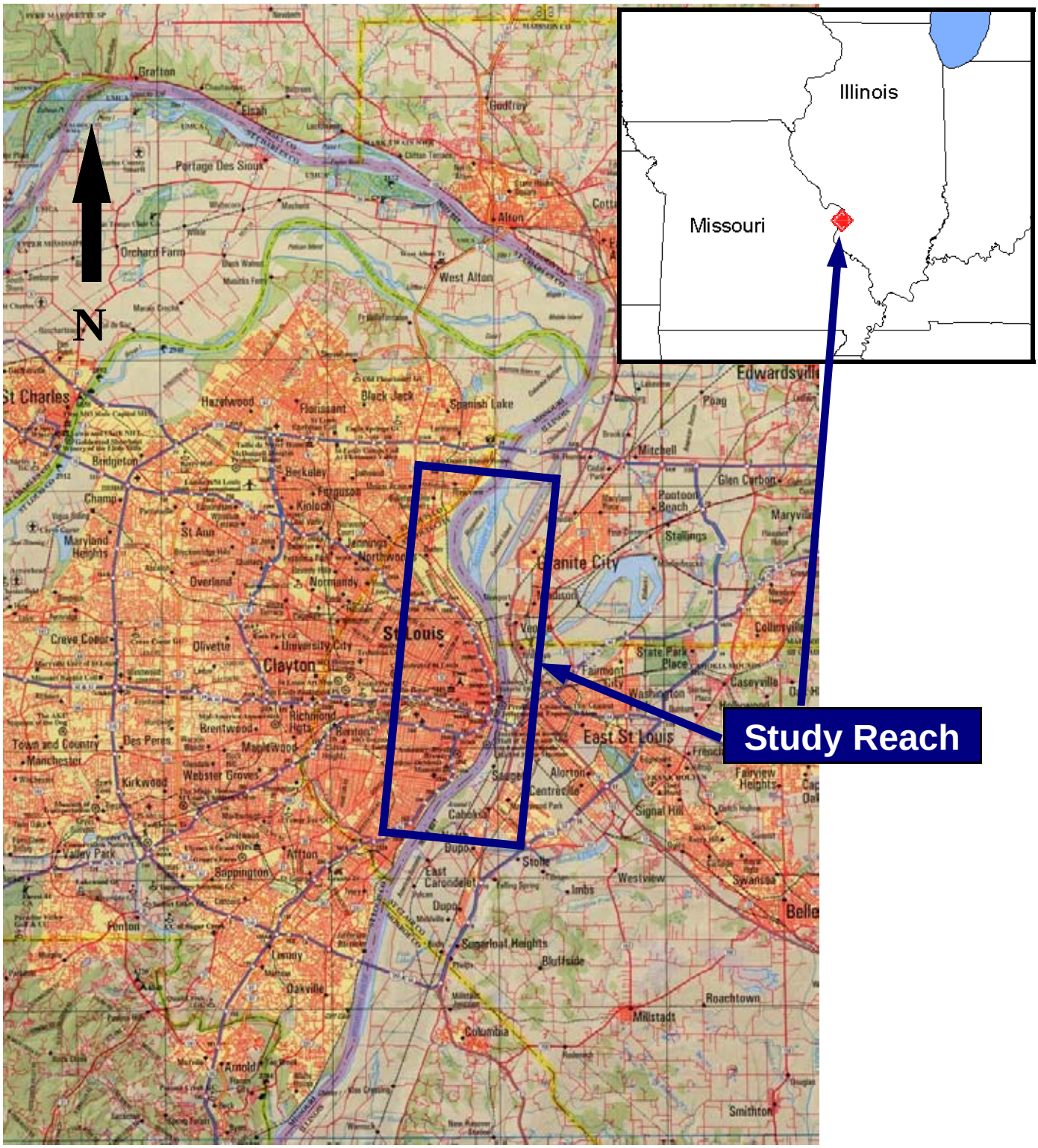
42. Low Water ADCP Data
43. Midbank ADCP Data
44. Downtown Helicopter Pictures
45. Rock Outcropping at Mile 178.9 L
46. Mosenthien Chute
47. St. Louis Harbor Flume
48. Base Test
49. Alternative 1
50. Alternative 2
51. Alternative 3
52. Alternative 4
53. Alternative 5
54. Alternative 6
55. Alternative 7
56. Alternative 8
57. Alternative 9
58. Alternative 10
59. Alternative 11

60. Alternative 12
61. Alternative 13
62. Alternative 14
63. Alternative 15
64. Alternative 16
65. Alternative 17



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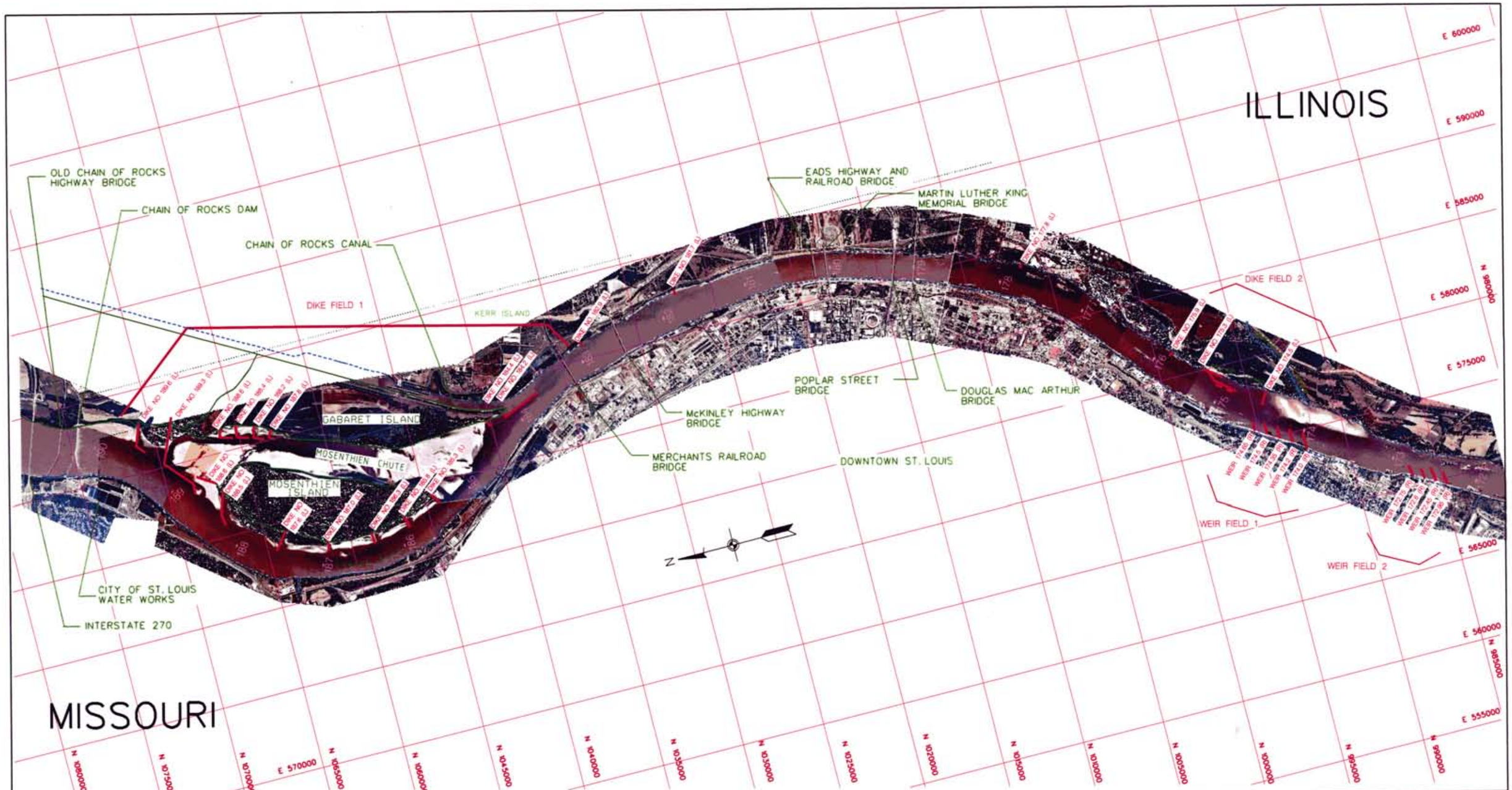
ST. LOUIS HARBOR MICRO MODEL STUDY
RIVER MILES 191.0 TO 172.0

LOCATION AND VICINITY MAP OF THE STUDY REACH

DESIGN FILE: STLVIC.PUB

PLATE NO.
1



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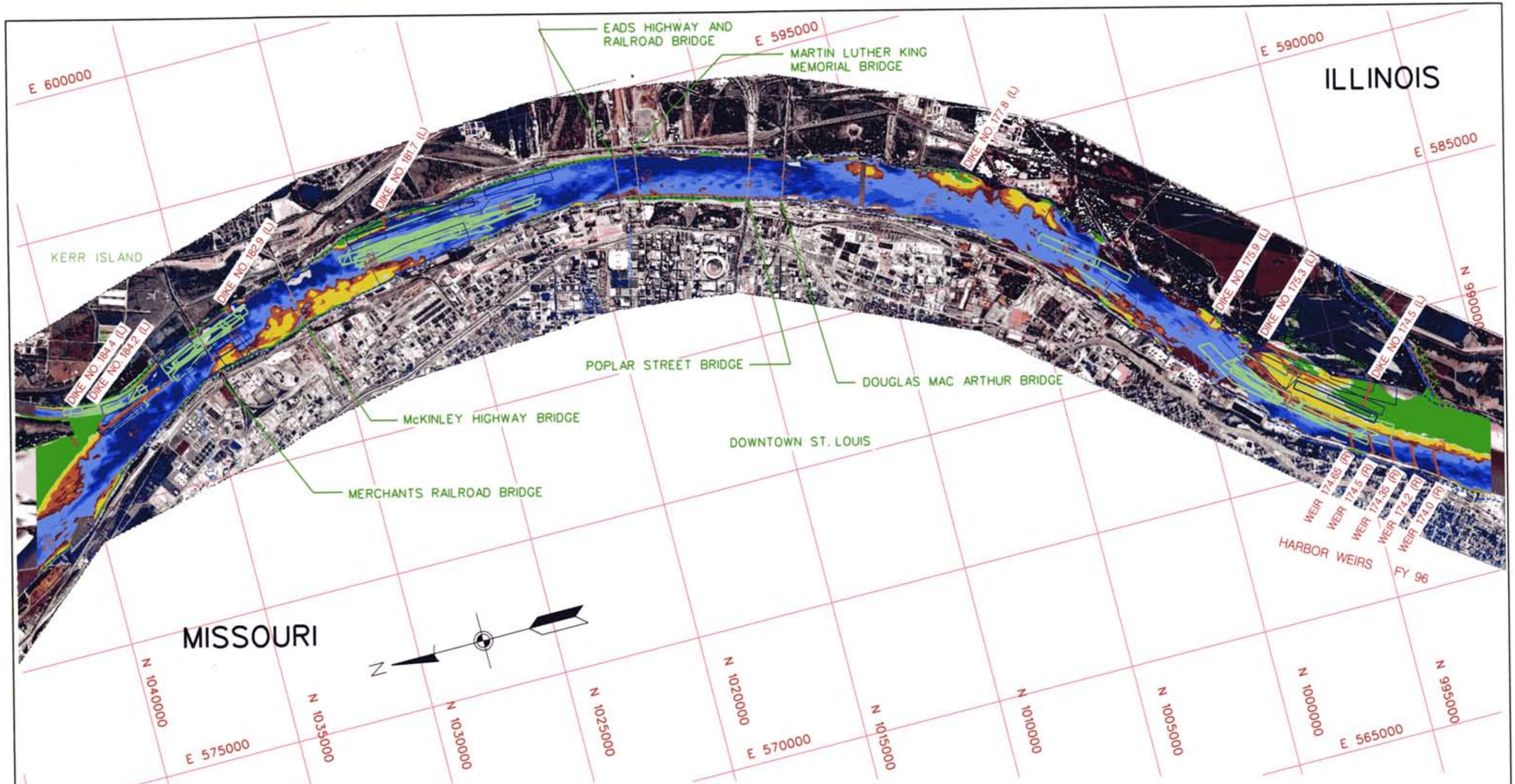
RIVER MILES 191.0 TO 172.0

STUDY AREA CHARACTERISTCS

5800' 3480' 2320' 1160' 0 2900' 5800'

DESIGN FILE: CHARACTER2
SCALE : 1" = 3600'
PLOT DATE: X
PLATE NO. 2



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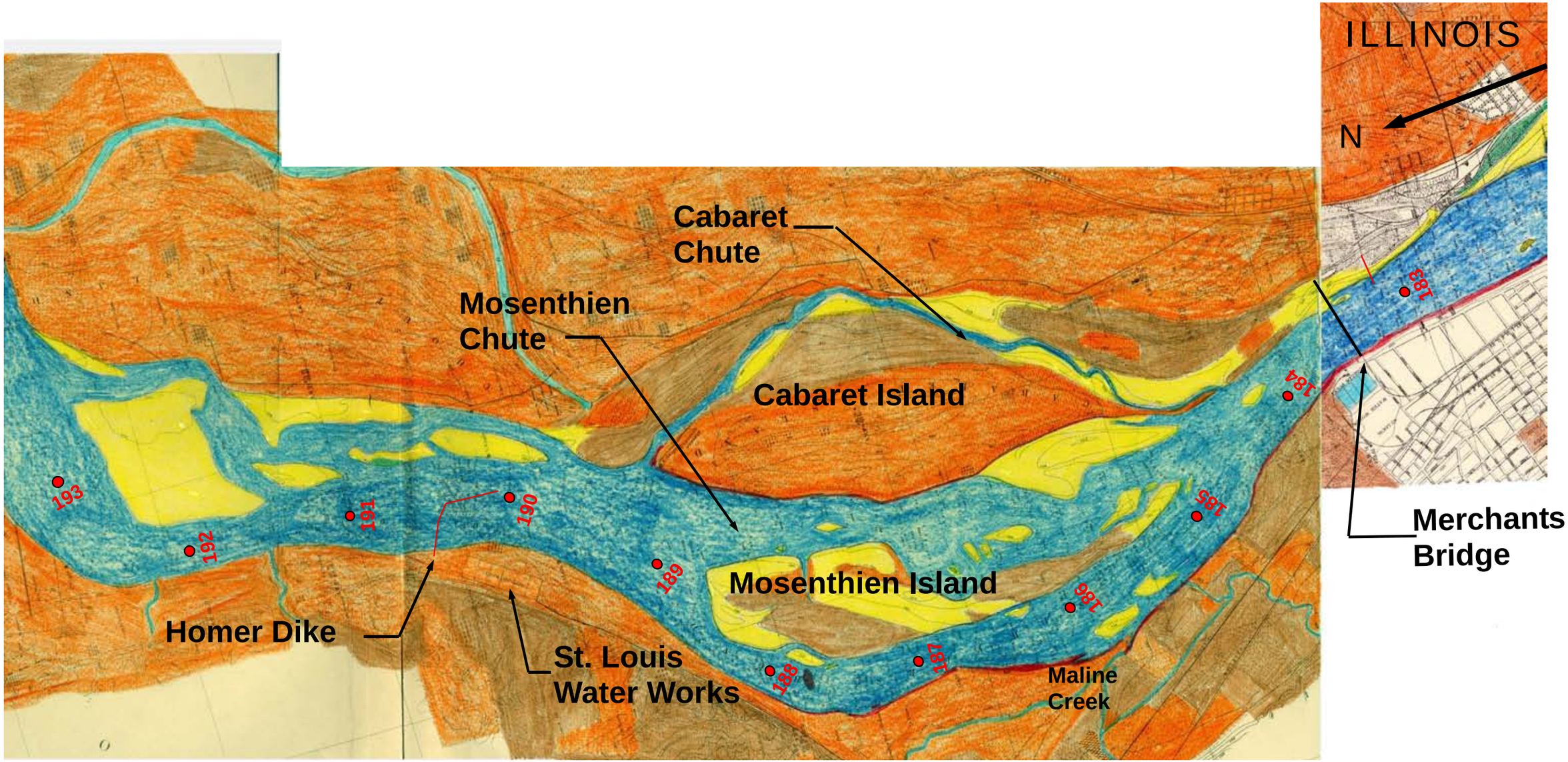
ST. LOUIS HARBOR MICRO MODEL STUDY
RIVER MILES 191.0 TO 172.0

DREDGING HISTORY FROM 1990 TO 2003

3600' 2700' 1800' 900' 0 1800' 3600'

DESIGN FILE: DREDGEA.DGN
SCALE: 1" = 3600'
PLATE NO.



MISSOURI

CITY OF ST. LOUIS

1881 TOPOGRAPHIC AND HYDROGRAPHIC SURVEY WITH COLOR-CODED LAND USAGE

- RIVER CHANNEL
- WATER POCKETS
- SAND
- MUD/GRAVEL
- WILLOWS
- TIMBER
- CULTIVATED

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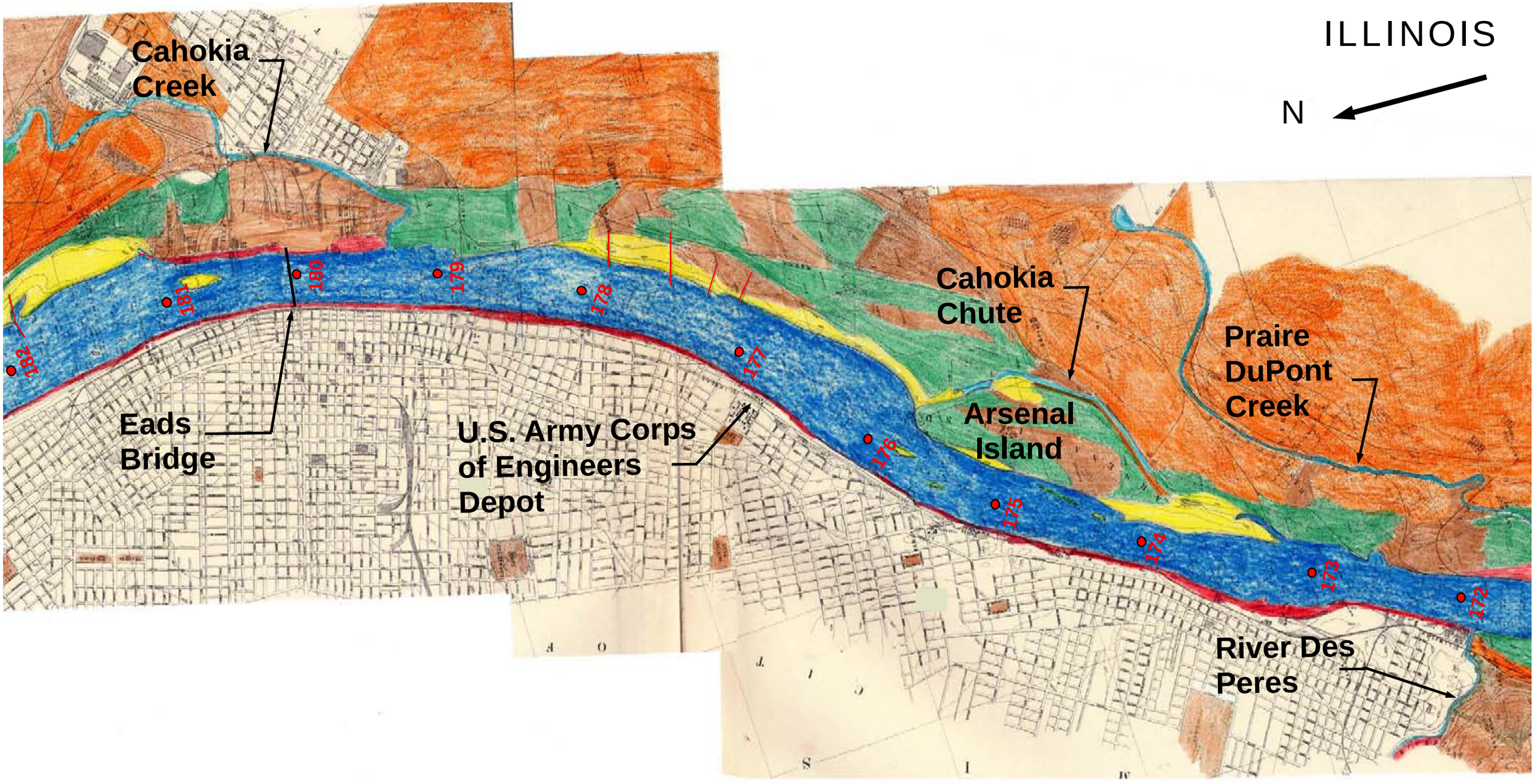
ST. LOUIS HARBOR MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 192-172
1881 TOPOGRAPHIC AND HYDROGRAPHIC SURVEY
MISSISSIPPI RIVER MILES 193-183

3300 2640 1980 1320 660 0 1650 3300

FILE NAME: 1881A.PUB
DATE PLOTTED:
PLATE NO. 4



MISSOURI

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1881 TOPOGRAPHIC AND HYDROGRAPHIC SURVEY WITH COLOR-CODED LAND USAGE

- RIVER CHANNEL
- WATER POCKETS
- SAND
- MUD/GRAVEL
- WILLOWS
- TIMBER
- CULTIVATED

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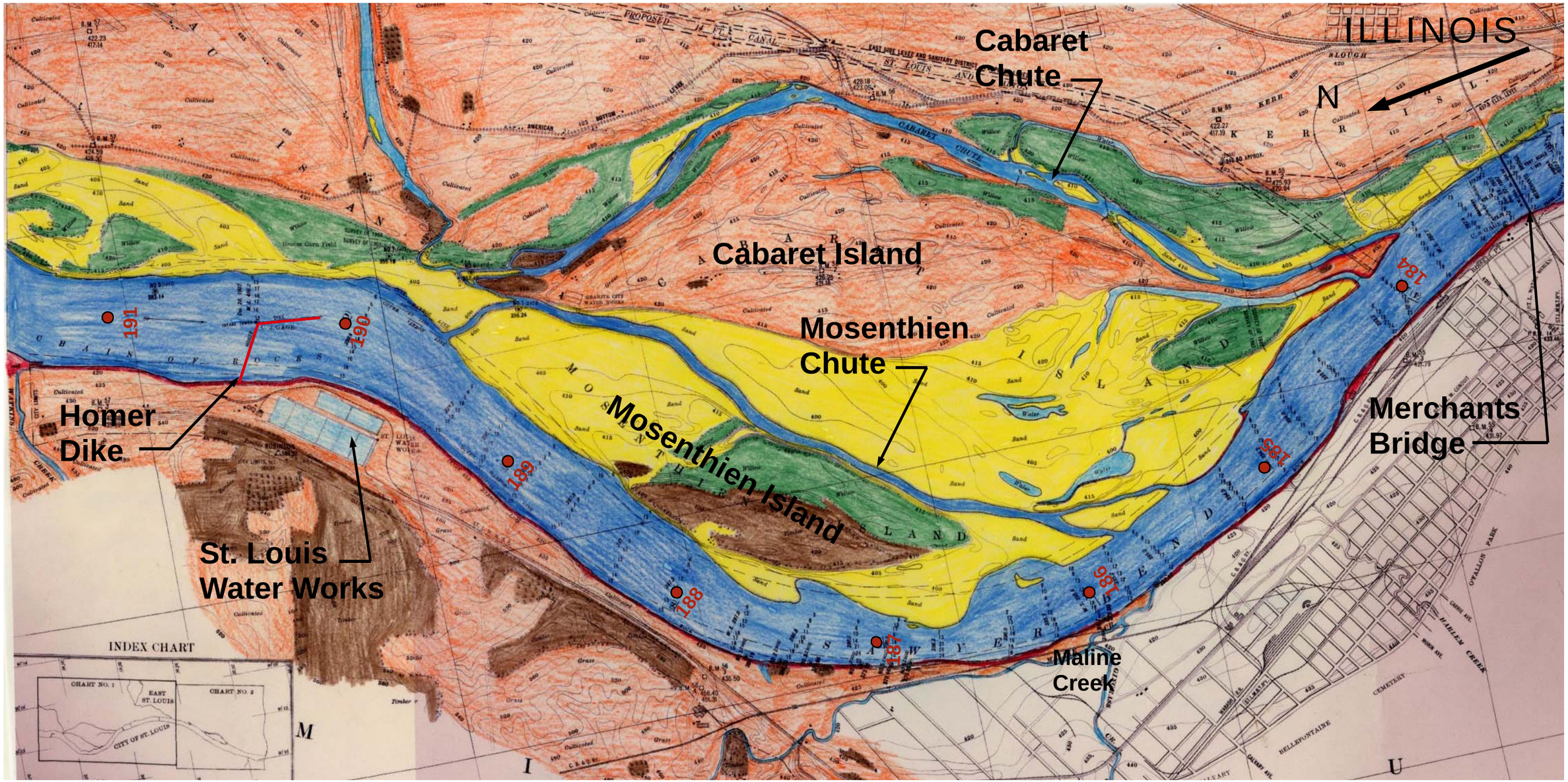
ST. LOUIS HARBOR MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 192-172
1881 TOPOGRAPHIC AND HYDROGRAPHIC SURVEY
MISSISSIPPI RIVER MILES 182-172

3100 2480 1860 1240 620 0 1550 3100

FILE NAME: 1881B.PUB
DATE PLOTTED: NOV 2003
PLATE NO. 5



MISSOURI

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1908 TOPOGRAPHIC AND HYDROGRAPHIC SURVEY WITH COLOR-CODED LAND USAGE

- RIVER CHANNEL
- WATER POCKETS
- SAND
- MUD/GRAVEL
- WILLOWS
- TIMBER
- CULTIVATED

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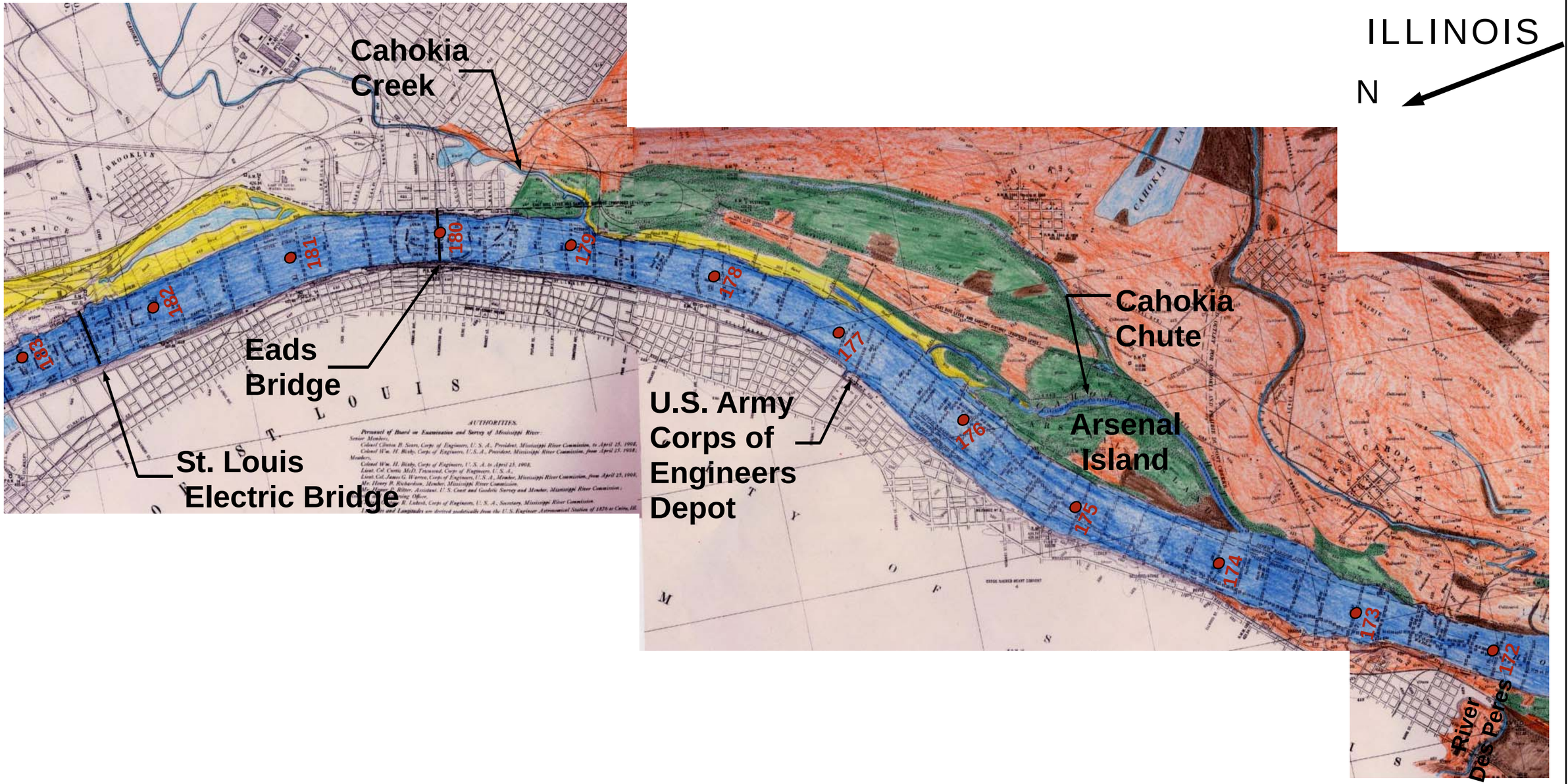
CHECKED BY: R. DAVINROY

ST. LOUIS HARBOR MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 192-172
1908 HYDROGRAPHIC & TOPOGRAPHIC SURVEY
MISSISSIPPI RIVER MILES 191-184

2450 1960 1470 980 490 0 1225 2450

FILE NAME: 1908a.PUB
DATE PLOTTED: 11/03

PLATE NO. 6



MISSOURI

CITY OF ST. LOUIS

1908 TOPOGRAPHIC AND HYDROGRAPHIC SURVEY WITH COLOR-CODED LAND USAGE

- RIVER CHANNEL
- WATER POCKETS
- SAND
- MUD/GRAVEL
- WILLOWS
- TIMBER
- CULTIVATED

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ST. LOUIS HARBOR MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 192-172

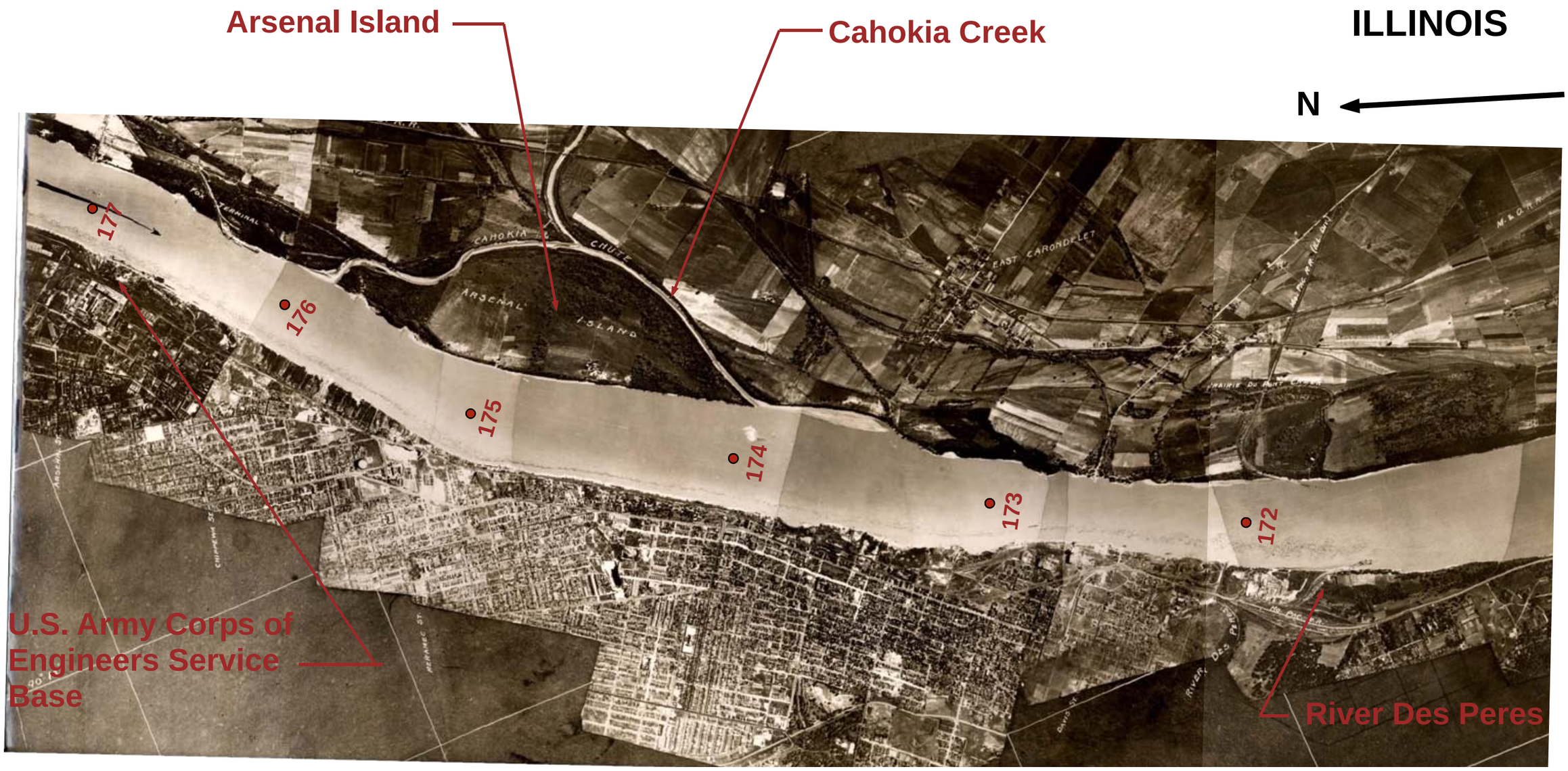
1908 HYDROGRAPHIC AND TOPOGRAPHIC SURVEY
MISSISSIPPI RIVER MILES 183-172

3640 2912 2184 1456 728 0 1820 3640

FILE NAME: 1908B.PUB

DATE PLOTTED: 11/03

PLATE NO. 7



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CHECKED BY: D. LAMM

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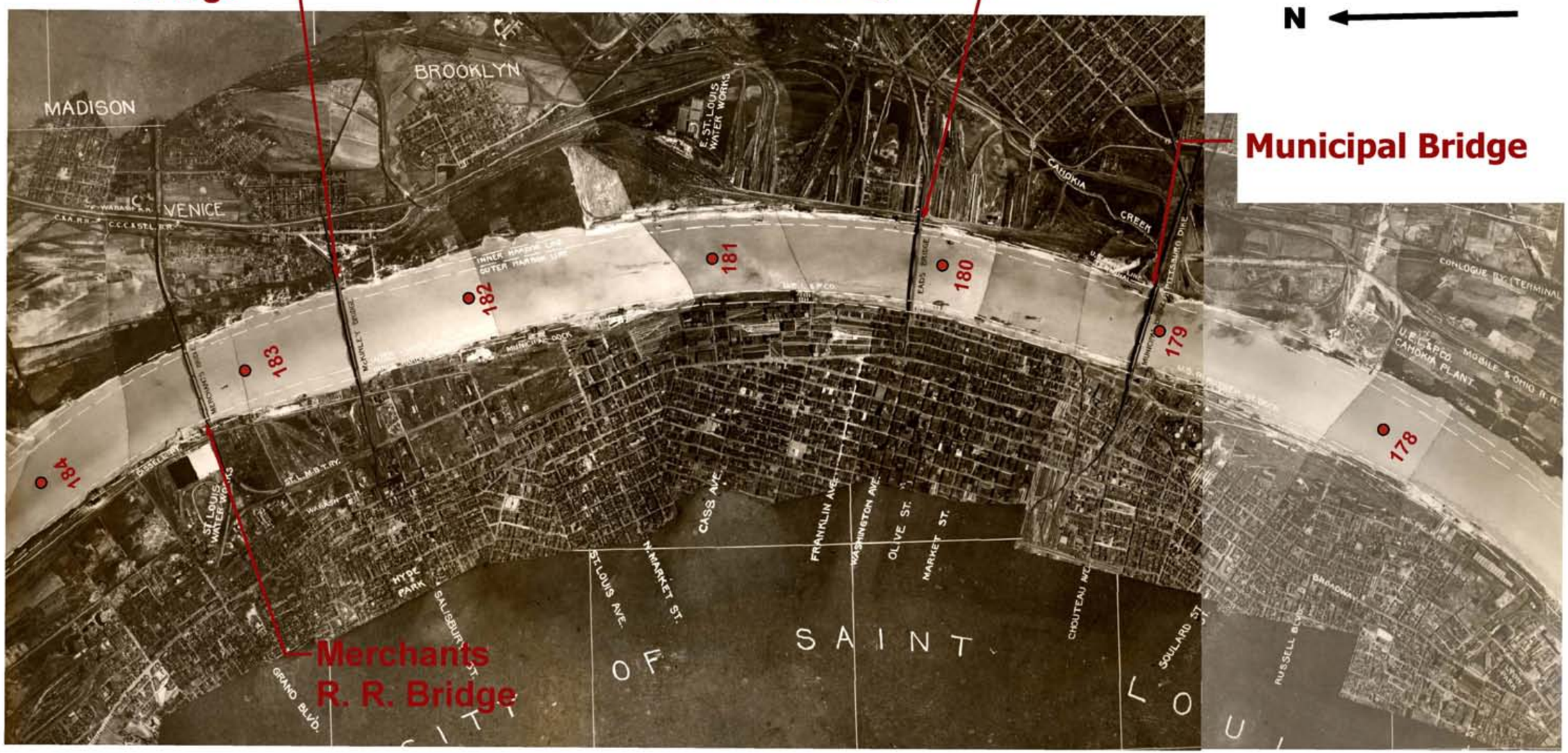
ST. LOUIS HARBOR MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 192-172
1928 HYDROGRAPHIC SURVEY
MISSISSIPPI RIVER MILES 177-172

1400 1120 840 560 280 0 700 1400

FILE NAME: 1928 177-172.PUB
DATE PLOTTED: 5/03

PLATE NO. 10



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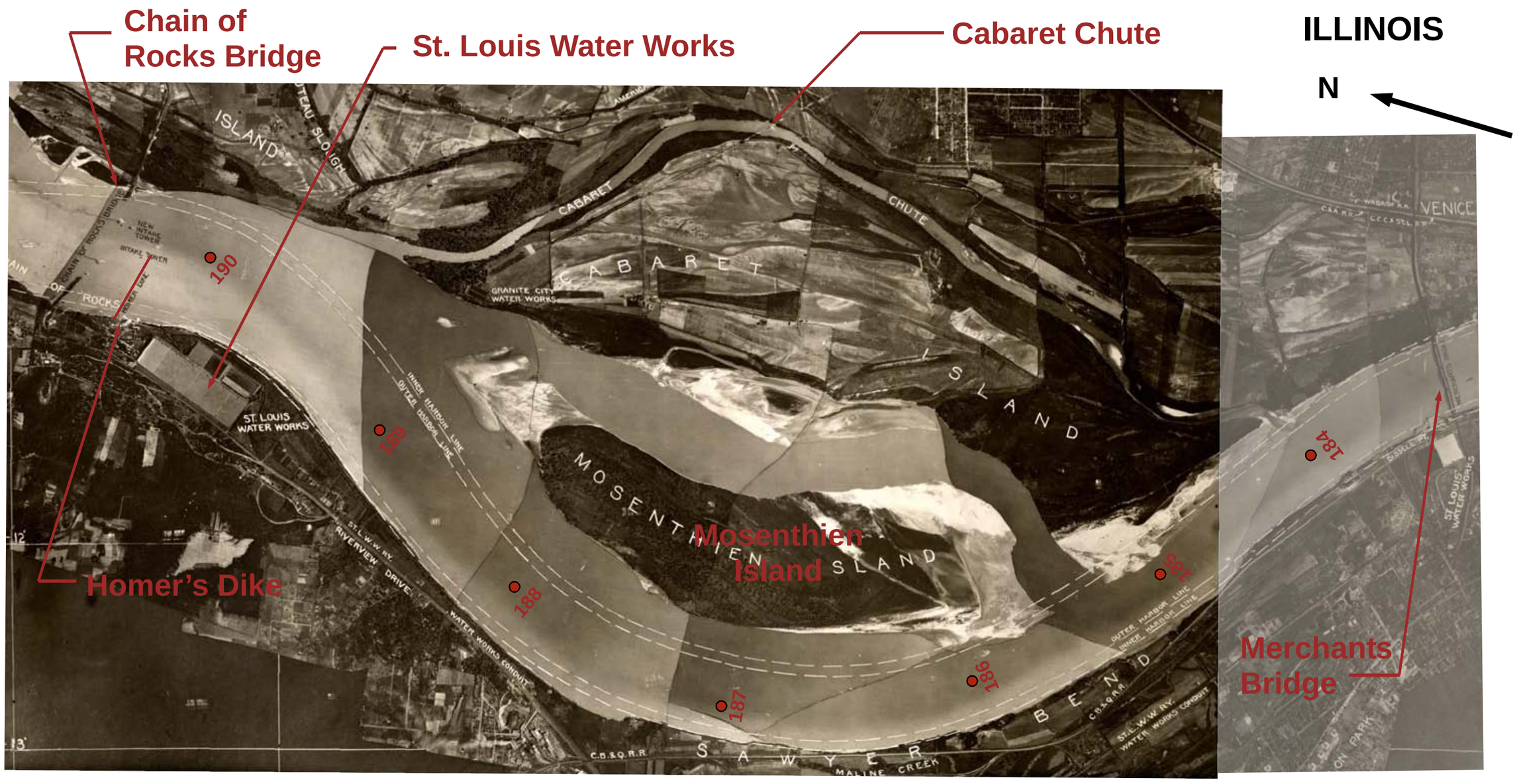
ST. LOUIS HARBOR MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 192-172
1928 AERIAL PHOTOGRAPH
MISSISSIPPI RIVER MILES 184-178

2300 1840 1380 920 460 0 1150 2300

FILE NAME: 1928 184-178.PUB
DATE PLOTTED: 5/03

PLATE NO. 9



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ST. LOUIS HARBOR MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 192-172

1928 AERIAL PHOTOGRAPH
MISSISSIPPI RIVER MILES 190-184

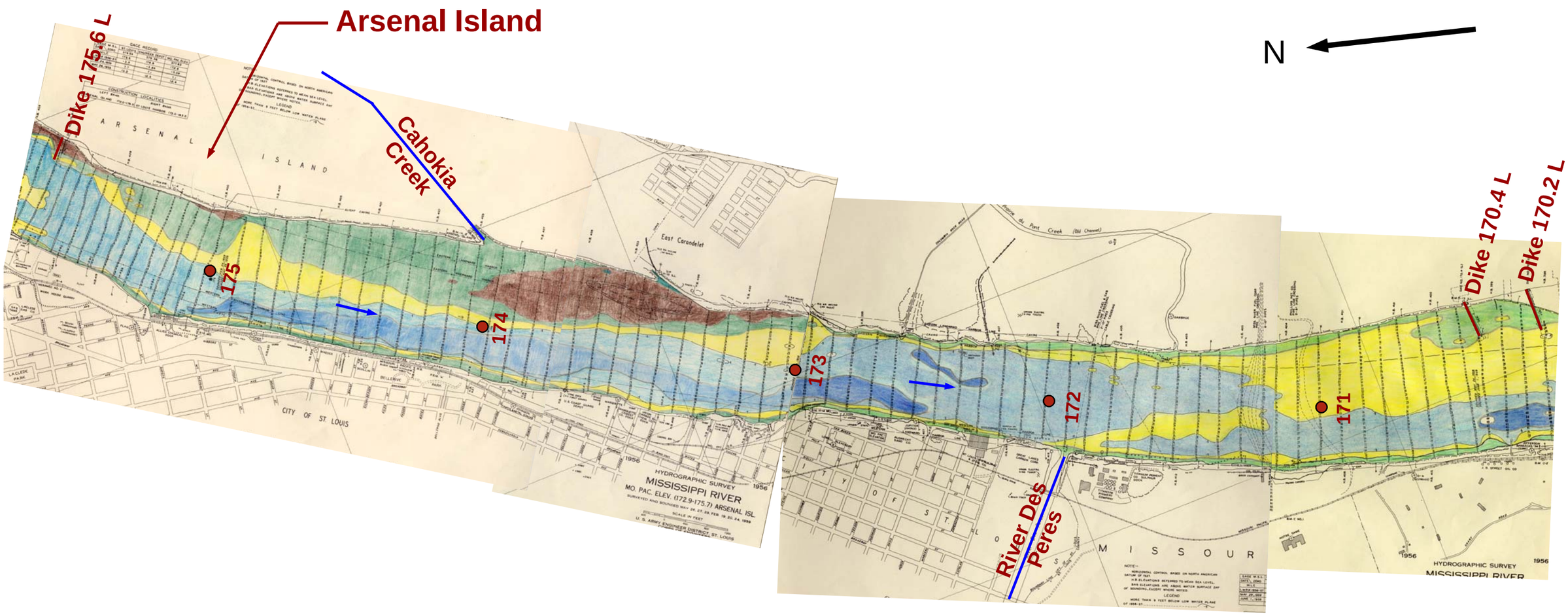
2100 1680 1260 840 420 0 1050 2100

FILE NAME: 1928 190-184.PUB
DATE PLOTTED: 5/03

PLATE NO. 8

ILLINOIS

N



MISSOURI

CITY OF ST. LOUIS

SURVEY TAKEN 02/24/1959 AND 05/29/1959.

U.S ARMY ENGINEER DISTRICT, ST. LOUIS
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ST. LOUIS, MISSOURI

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DRAWN BY: E. RIIFF
CHECKED BY: R. DAVINROY

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ST. LOUIS HARBOR MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 192-172

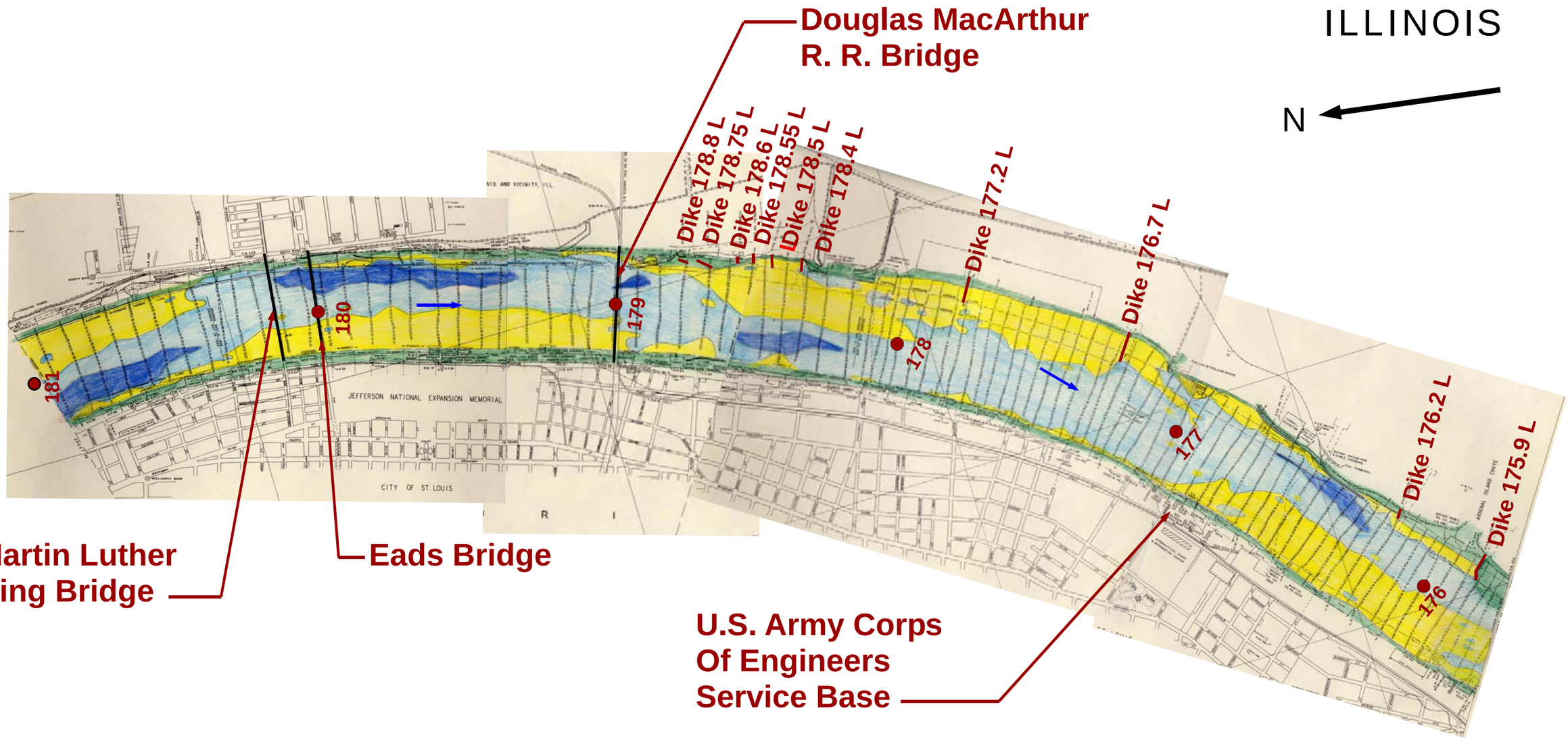
1959 HYDROGRAPHIC SURVEY
MISSISSIPPI RIVER MILES 175-171

1885 1508 1131 754 377 0 942.5 1885

FILE NAME: 1959 175-171.PUB

DATE PLOTTED: 12/03

PLATE NO. **14**



MISSOURI

CITY OF ST. LOUIS

SURVEY TAKEN 02/24/1959, 05/18/1959, AND 05/21/1959.

U.S ARMY ENGINEER DISTRICT, ST. LOUIS
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ST. LOUIS, MISSOURI

PREPARED BY: E. RIIFF
DRAWN BY: E. RIIFF
CHECKED BY: R. DAVINROY

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ST. LOUIS HARBOR MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 192-172

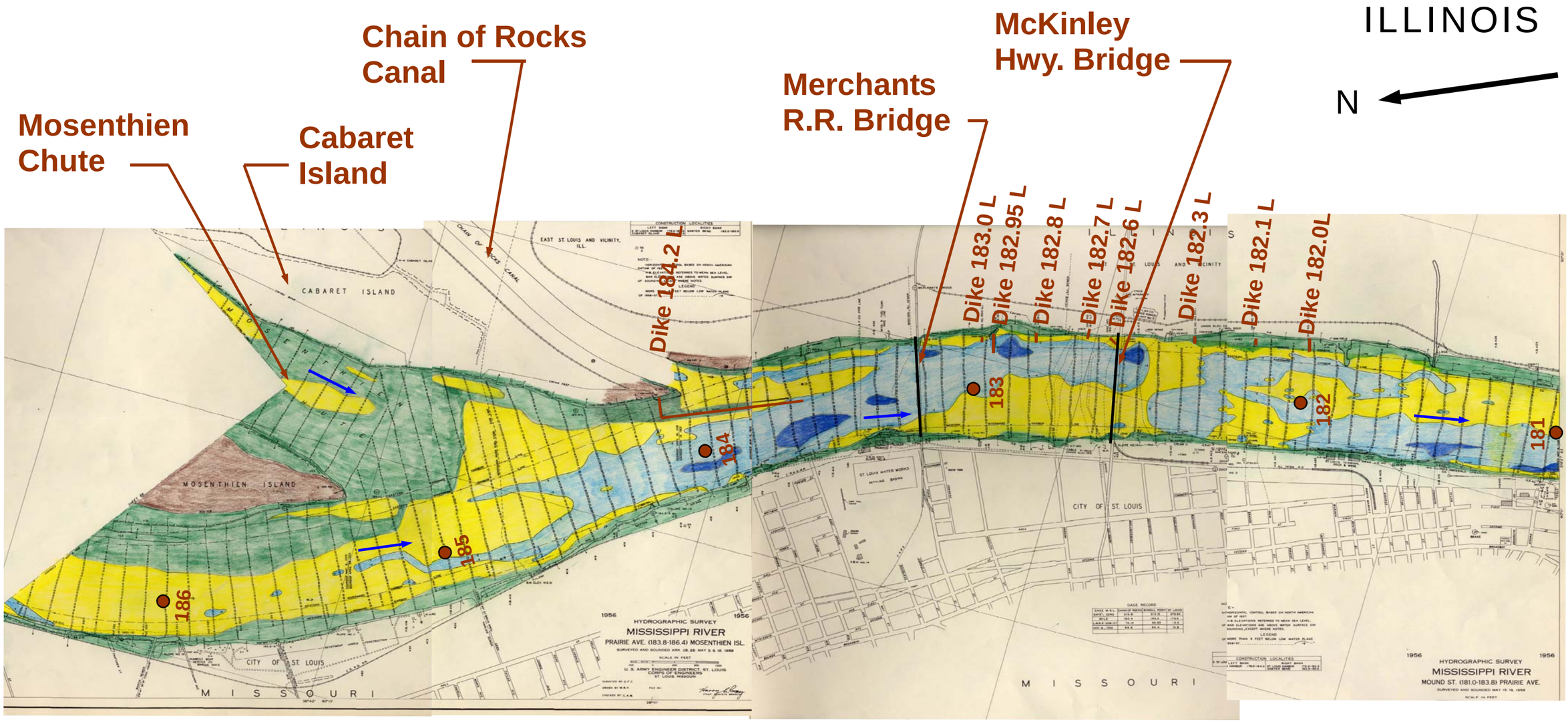
1959 HYDROGRAPHIC SURVEY
MISSISSIPPI RIVER MILES 181-176

1885 1508 1131 754 377 0 942.5 1885

FILE NAME: 1959 181-176.PUB

DATE PLOTTED: 12/03

PLATE NO.
13



MISSOURI

CITY OF ST. LOUIS

SURVEY TAKEN 04/29/1959, 05/6/1959, AND 05/18/1959.

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ST. LOUIS, MISSOURI

PREPARED BY: E. RIIFF
DRAWN BY: E. RIIFF
CHECKED BY: D. LAMM

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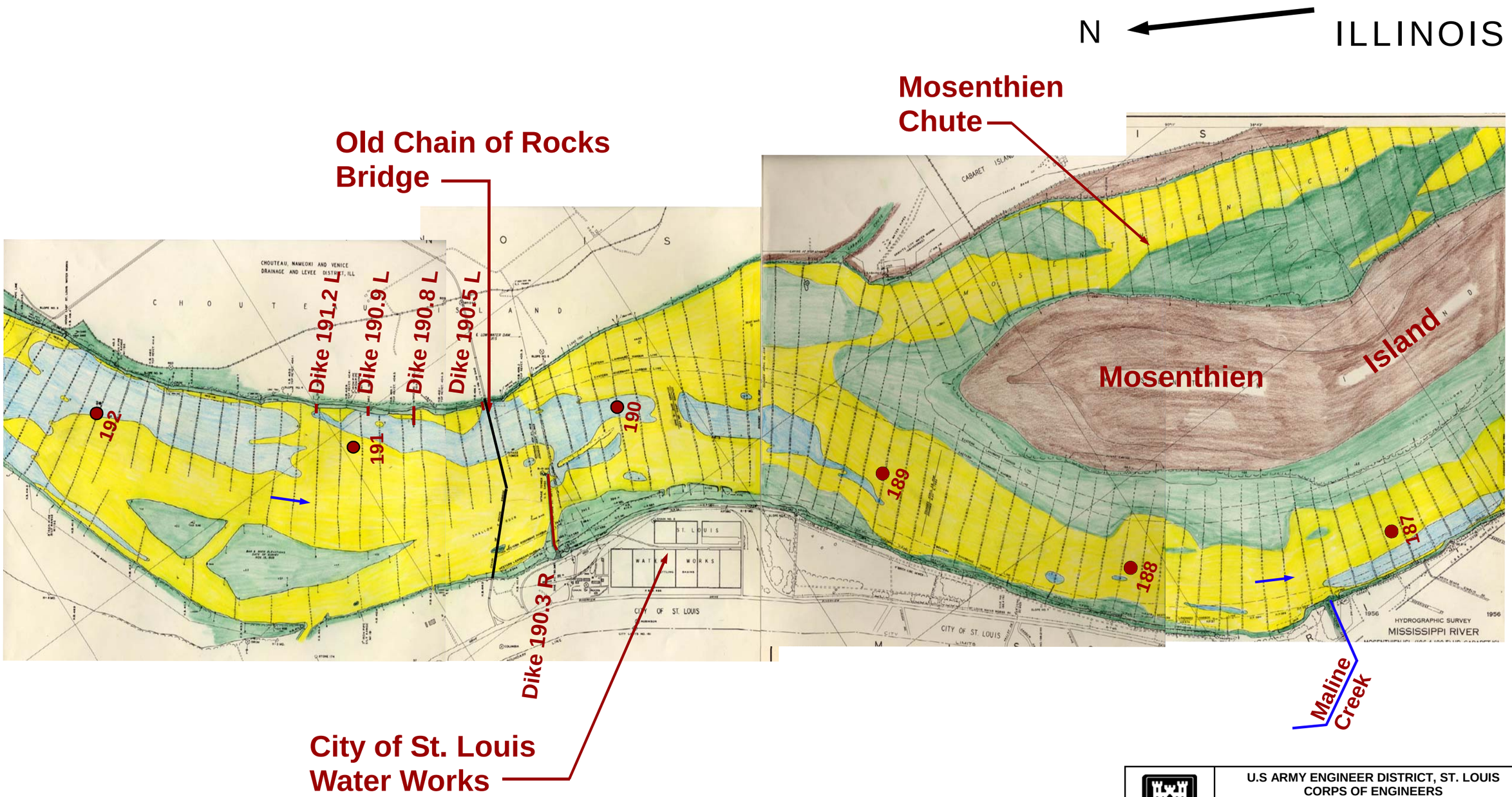
MISSISSIPPI RIVER MILES 192-172

1959 HYDROGRAPHIC SURVEY
MISSISSIPPI RIVER MILES 186-181

1885 1508 1131 754 377 0 942.5 1885

FILE NAME: 1959 186-181.PUB
DATE PLOTTED: 03/03

PLATE NO. 12



MISSOURI

CITY OF ST. LOUIS

SURVEY TAKEN 04/29/1959 AND 05/6/1959.

U.S ARMY ENGINEER DISTRICT, ST. LOUIS
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ST. LOUIS, MISSOURI

PREPARED BY: E. RIIFF
DRAWN BY: E. RIIFF
CHECKED BY: R. DAVINROY

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ST. LOUIS HARBOR MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 192-172

1959 HYDROGRAPHIC SURVEY
MISSISSIPPI RIVER MILES 192-187

2000 1600 1200 800 400 0 1000 2000

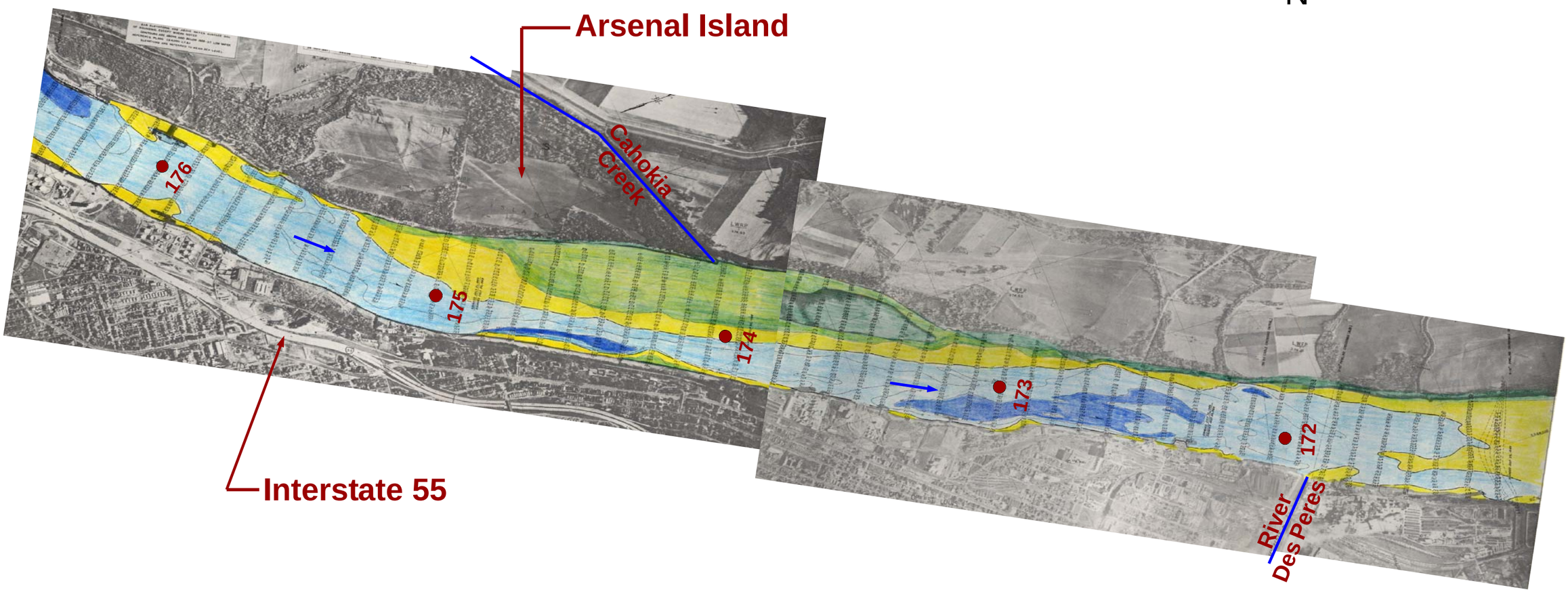
FILE NAME: 1959 192-187.PUB

DATE PLOTTED: 03/03

PLATE NO. 11

ILLINOIS

N



MISSOURI

CITY OF ST. LOUIS

PHOTO TAKEN 11/28/67 AT –4.9 FEET LWRP ACCORDING TO THE ST. LOUIS, MISSOURI GAGE. SURVEY TAKEN JULY 1969.

U.S ARMY ENGINEER DISTRICT, ST. LOUIS
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ST. LOUIS, MISSOURI

PREPARED BY: E. RIIFF
DRAWN BY: E. RIIFF
CHECKED BY: D. LAMM

APPLIED RIVER ENGINEERING CENTER

ST. LOUIS HARBOR MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 192-172

1969/1971 HYDROGRAPHIC SURVEY
MISSISSIPPI RIVER MILES 176-172

2000 1600 1200 800 400 0 1000 2000

FILE NAME: 1969 176-172.PUB

DATE PLOTTED:

PLATE NO. 18

ILLINOIS

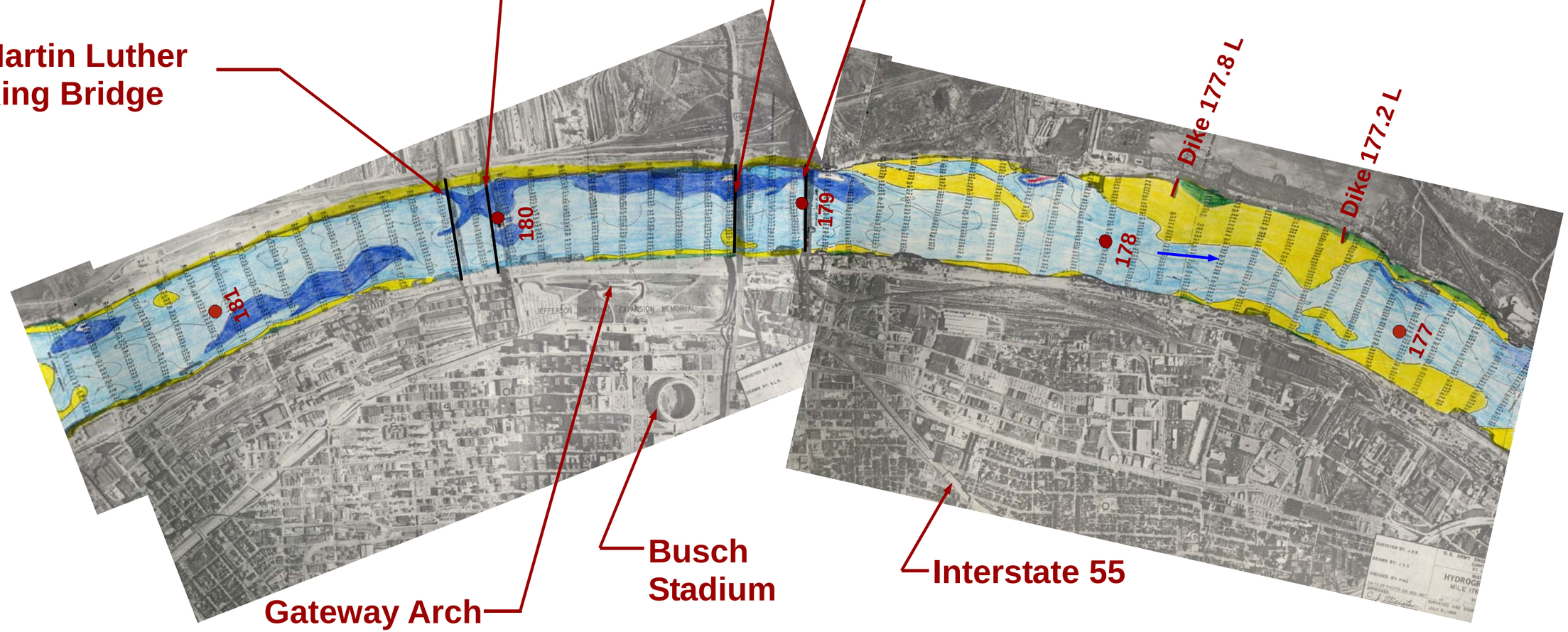
N

Poplar Street Bridge

Douglas MacArthur Bridge

Eads Bridge

Martin Luther King Bridge



Busch Stadium

Interstate 55

Gateway Arch

MISSOURI

CITY OF ST. LOUIS

PHOTO TAKEN IN 11/28/67 AT –4.9 FEET LWRP ACCORDING TO THE ST. LOUIS GAGE. SURVEY TAKEN JULY/AUGUST 1969.

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ST. LOUIS, MISSOURI

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DRAWN BY: E. RIIFF
CHECKED BY: D. LAMM

APPLIED RIVER ENGINEERING CENTER

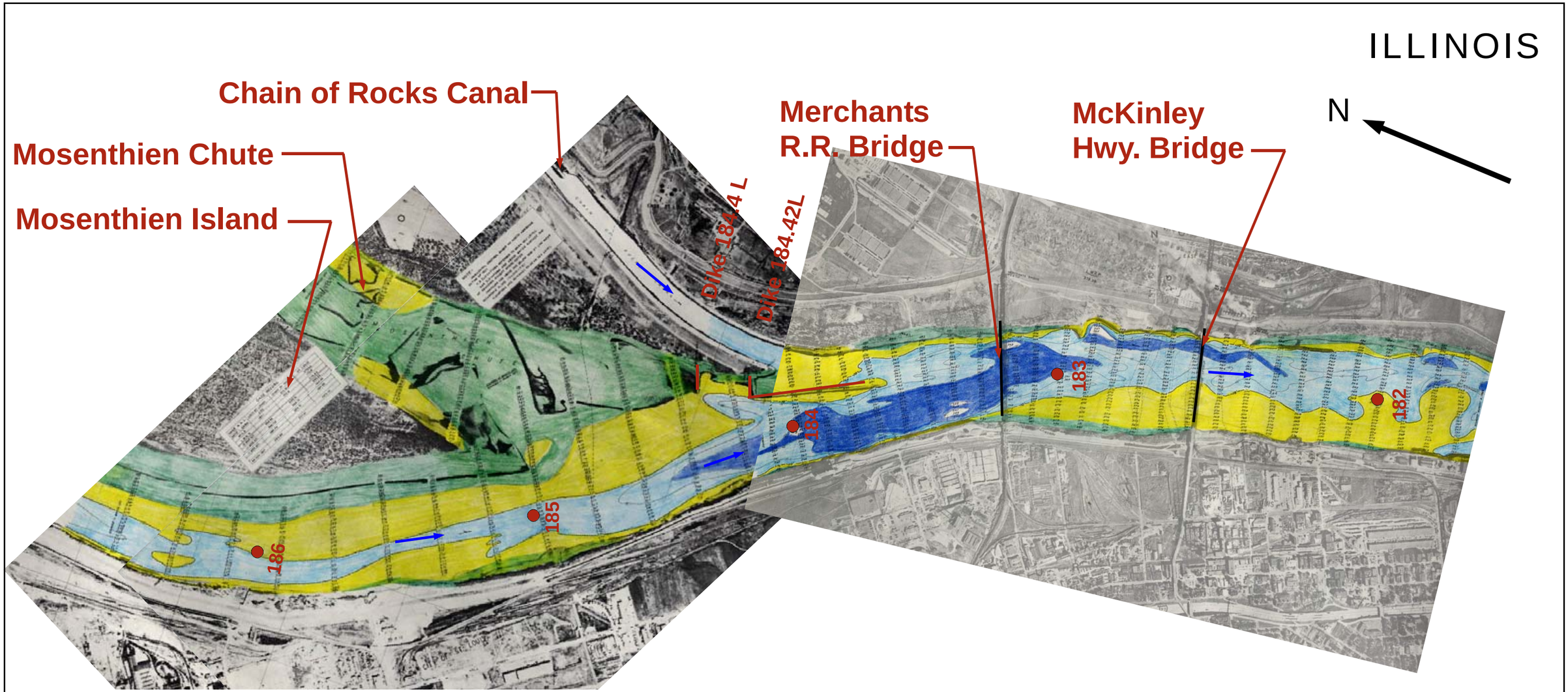
ST. LOUIS HARBOR MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 192-172
1969/1971 HYDROGRAPHIC SURVEY
MISSISSIPPI RIVER MILES 181-177

3000 2400 1800 1200 600 0 1500 3000

FILE NAME: 1969 181-177.PUB

DATE PLOTTED: 03/03

PLATE NO. 17



MISSOURI

CITY OF ST. LOUIS

PHOTO TAKEN 11/28/67 AT –4.9 FEET LWRP ACCORDING TO THE ST. LOUIS, MISSOURI GAGE. SURVEY TAKEN AUGUST 1969 / MARCH 1971.

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CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PREPARED BY: E. RIIFF
DRAWN BY: E. RIIFF
CHECKED BY: D. LAMM

APPLIED RIVER ENGINEERING CENTER

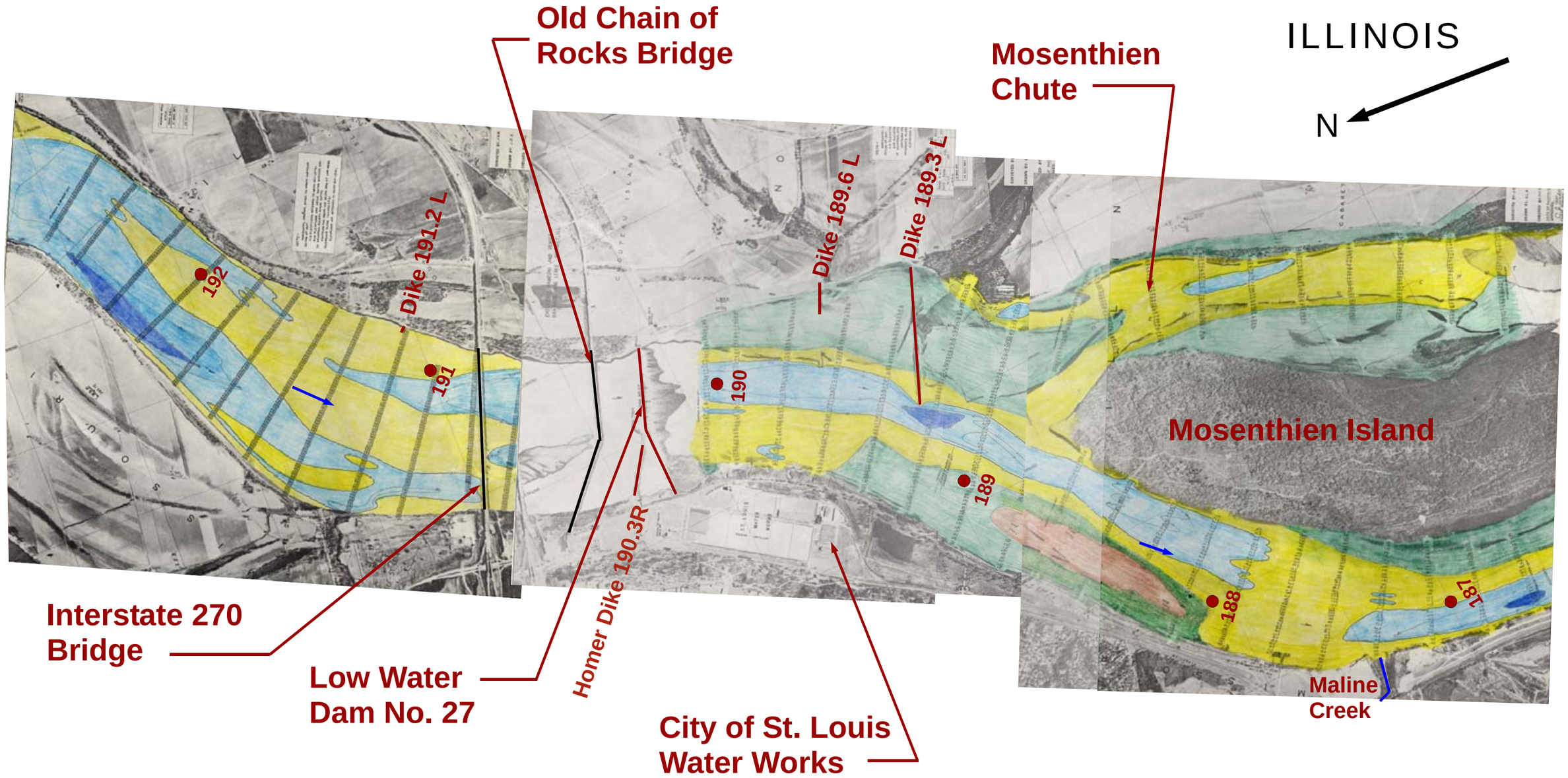
ST. LOUIS HARBOR MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 192-172

1969/1971 HYDROGRAPHIC SURVEY
MISSISSIPPI RIVER MILES 186-182

2000 1600 1200 800 400 0 1000 2000

FILE NAME: 1969 186-182.PUB
DATE PLOTTED: 03/03

PLATE NO. 16



MISSOURI

CITY OF ST. LOUIS

PHOTO TAKEN 11/28/67 AT –4.9 FEET LWRP ACCORDING TO THE ST. LOUIS, MISSOURI GAGE SURVEY TAKEN MARCH 1971

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

PREPARED BY: E. RIIFF
DRAWN BY: E. RIIFF
CHECKED BY: D. LAMM

APPLIED RIVER ENGINEERING CENTER

ST. LOUIS HARBOR MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 192-172

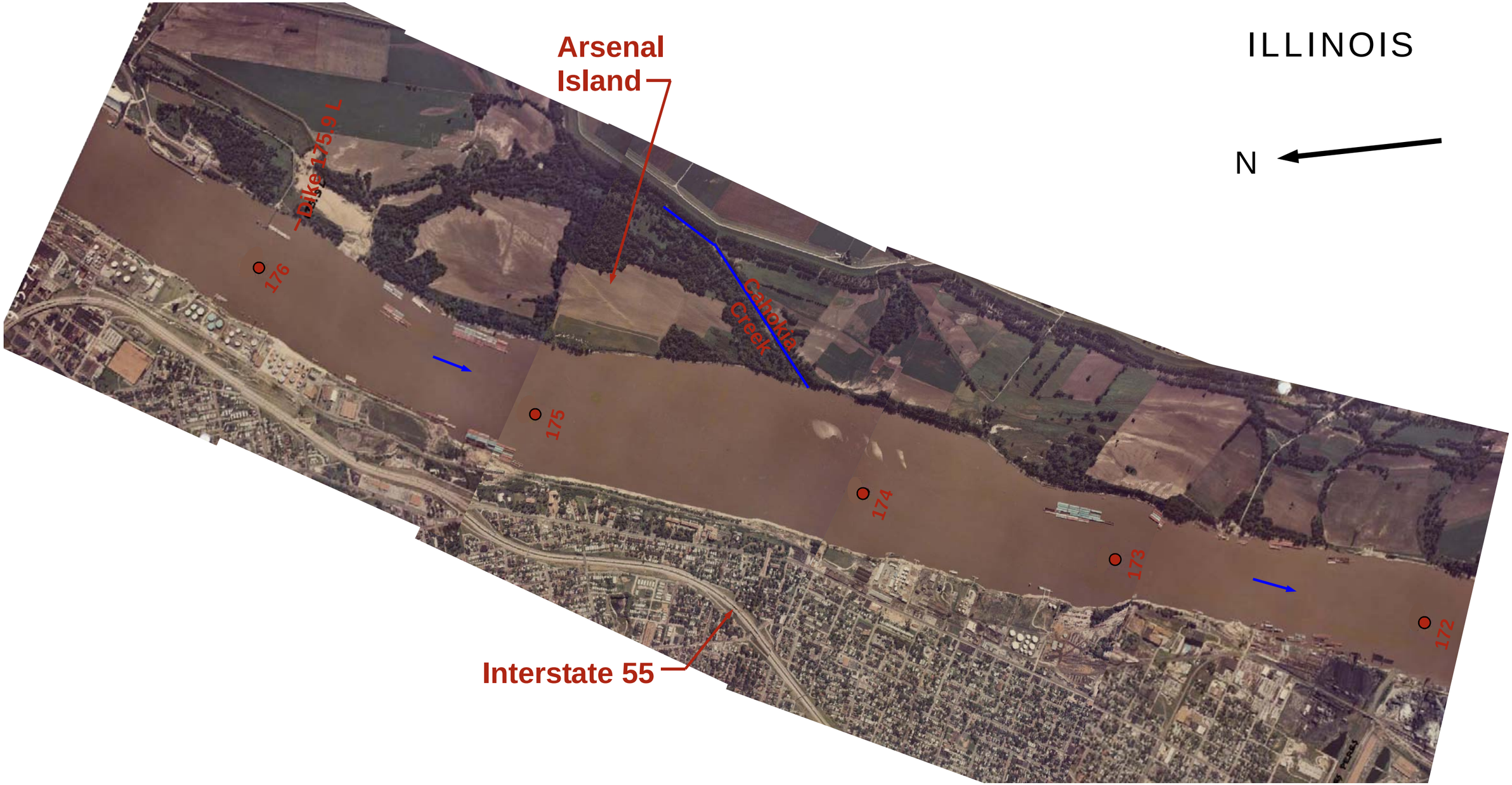
1969/1971 HYDROGRAPHIC SURVEY
MISSISSIPPI RIVER MILES 192-187

2100 1680 1260 840 420 0 1050 2100

FILE NAME: 1969 192-186.PUB

DATE PLOTTED: 03/03

PLATE NO. 15



MISSOURI

CITY OF ST. LOUIS

PHOTO TAKEN ON 09/05/1974 AT +11.9 FEET LWRP ACCORDING TO THE ST. LOUIS, MISSOURI GAGE

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

PREPARED BY: E. RIIFF
DRAWN BY: E. RIIFF
CHECKED BY: R. DAVINROY

APPLIED RIVER ENGINEERING CENTER

ST. LOUIS HARBOR MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 192-172

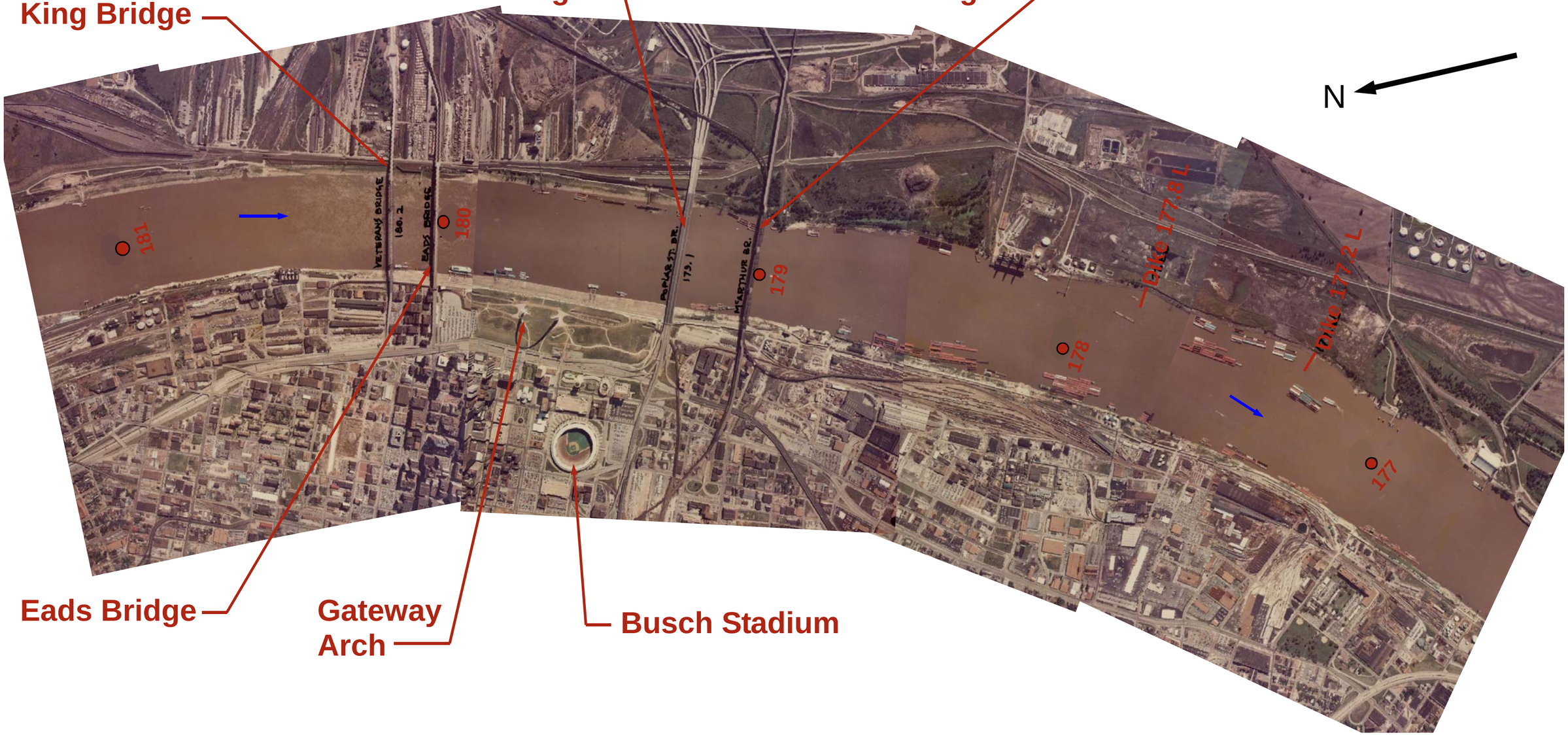
1974 AERIAL PHOTOGRAPH
MISSISSIPPI RIVER MILES 176-172

2000 1600 1200 800 400 0 1000 2000

FILE NAME: 1974 176-172.PUB

DATE PLOTTED: 03/03

PLATE NO. 22



MISSOURI

CITY OF ST. LOUIS

PHOTO TAKEN ON 09/05/1974 AT +11.9 FEET LWRP ACCORDING TO THE ST. LOUIS, MISSOURI GAGE

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

PREPARED BY: E. RIIFF
DRAWN BY: E. RIIFF
CHECKED BY: R. DAVINROY

APPLIED RIVER ENGINEERING CENTER

ST. LOUIS HARBOR MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 192-172

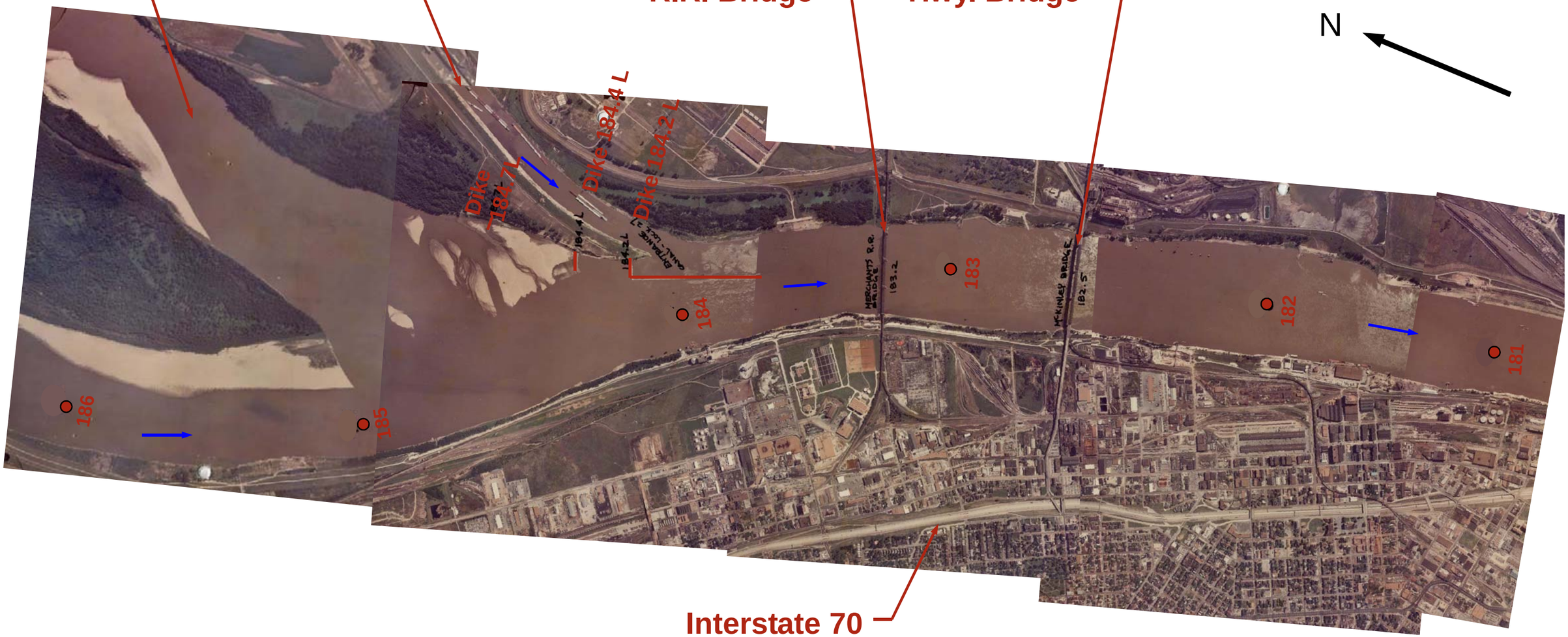
1974 AERIAL PHOTOGRAPH
MISSISSIPPI RIVER MILES 181-177

1625 1300 975 650 325 0 812.5 1625

FILE NAME: 1974 181-177.PUB

DATE PLOTTED: 03/03

PLATE NO. 21



MISSOURI

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

PREPARED BY: E. RIIFF
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CHECKED BY: R. DAVINROY

APPLIED RIVER ENGINEERING CENTER

ST. LOUIS HARBOR MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 192-172

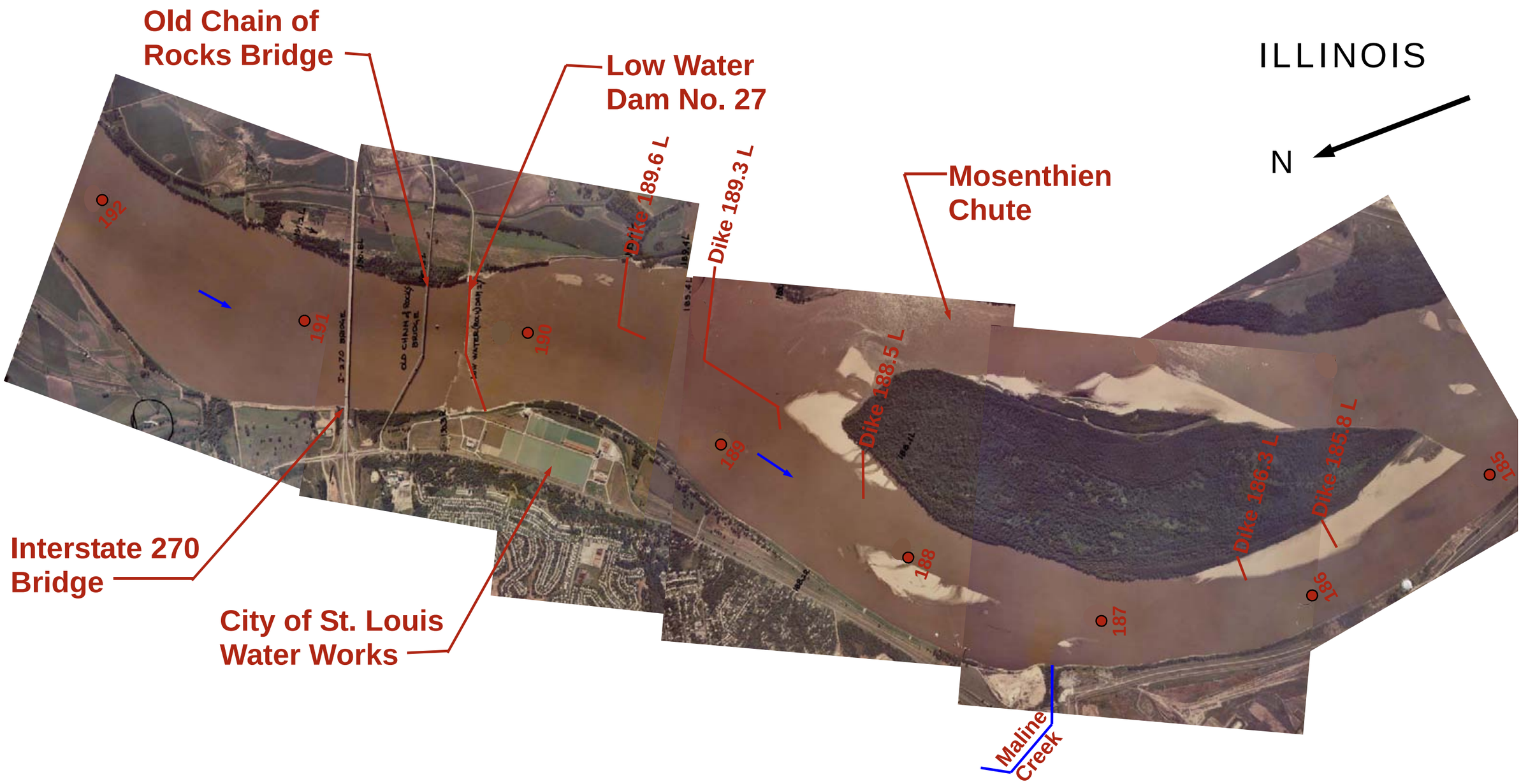
1974 AERIAL PHOTOGRAPH
MISSISSIPPI RIVER MILES 186-181

1760 1408 1056 704 352 0 880 1760

FILE NAME: 1974 186-181.PUB

DATE PLOTTED: 03/03

PLATE NO. **20**



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CITY OF ST. LOUIS

PHOTO TAKEN ON 09/05/1974 AT +11.9 FEET LWRP ACCORDING TO THE ST. LOUIS, MISSOURI GAGE

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

PREPARED BY: E. RIIFF
DRAWN BY: E. RIIFF
CHECKED BY: R. DAVINROY

APPLIED RIVER ENGINEERING CENTER

ST. LOUIS HARBOR MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 192-172

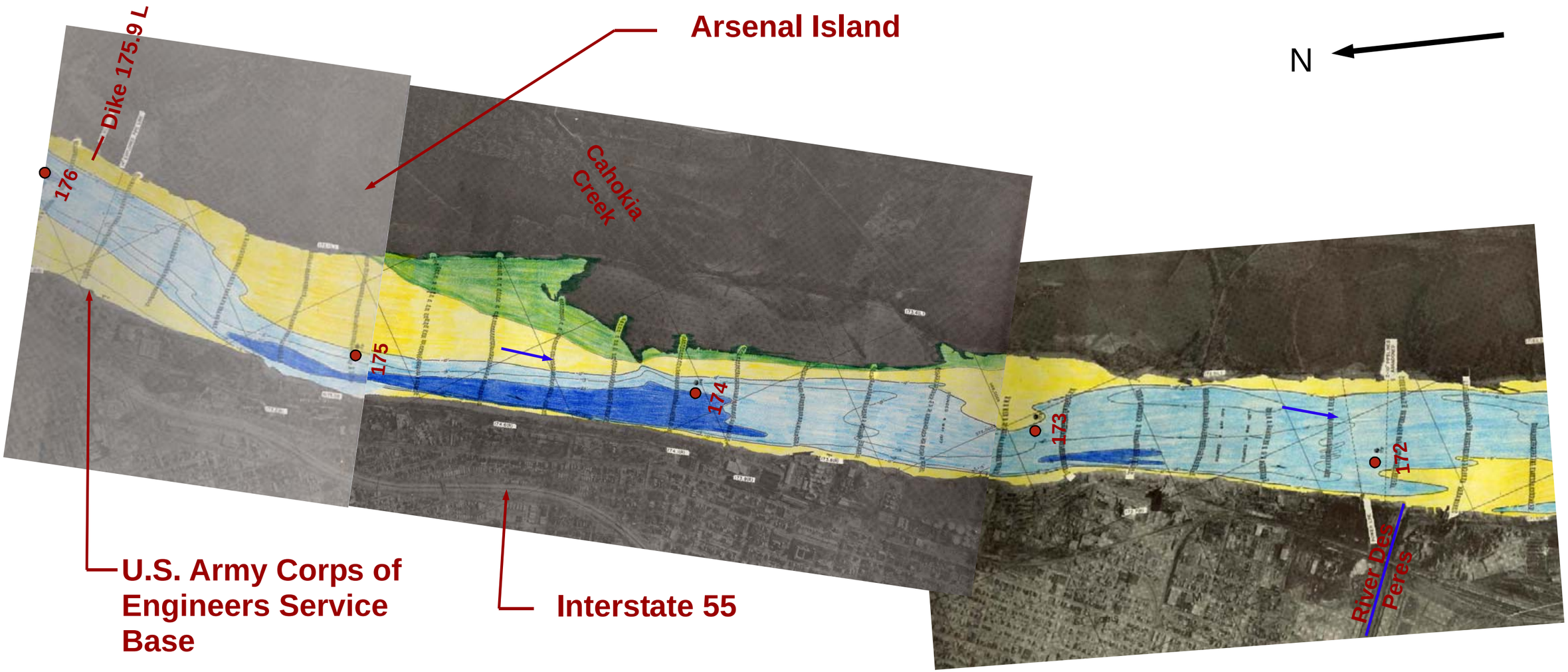
1974 AERIAL PHOTOGRAPH
MISSISSIPPI RIVER MILES 192-186

2400 1920 1440 960 480 0 1200 2400

FILE NAME: 1974 192-186.PUB

DATE PLOTTED: 03/03

PLATE NO. 19



MISSOURI

CITY OF ST. LOUIS

PHOTO TAKEN 1/22/1976 AT +5.50 LWRP ACCORDING TO THE ST. LOUIS, MISSOURI GAGE. SURVEY TAKEN MAY 1977.

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

PREPARED BY: E. RIIFF
DRAWN BY: E. RIIFF
CHECKED BY: D. LAMM

APPLIED RIVER ENGINEERING CENTER

ST. LOUIS HARBOR MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 192-172

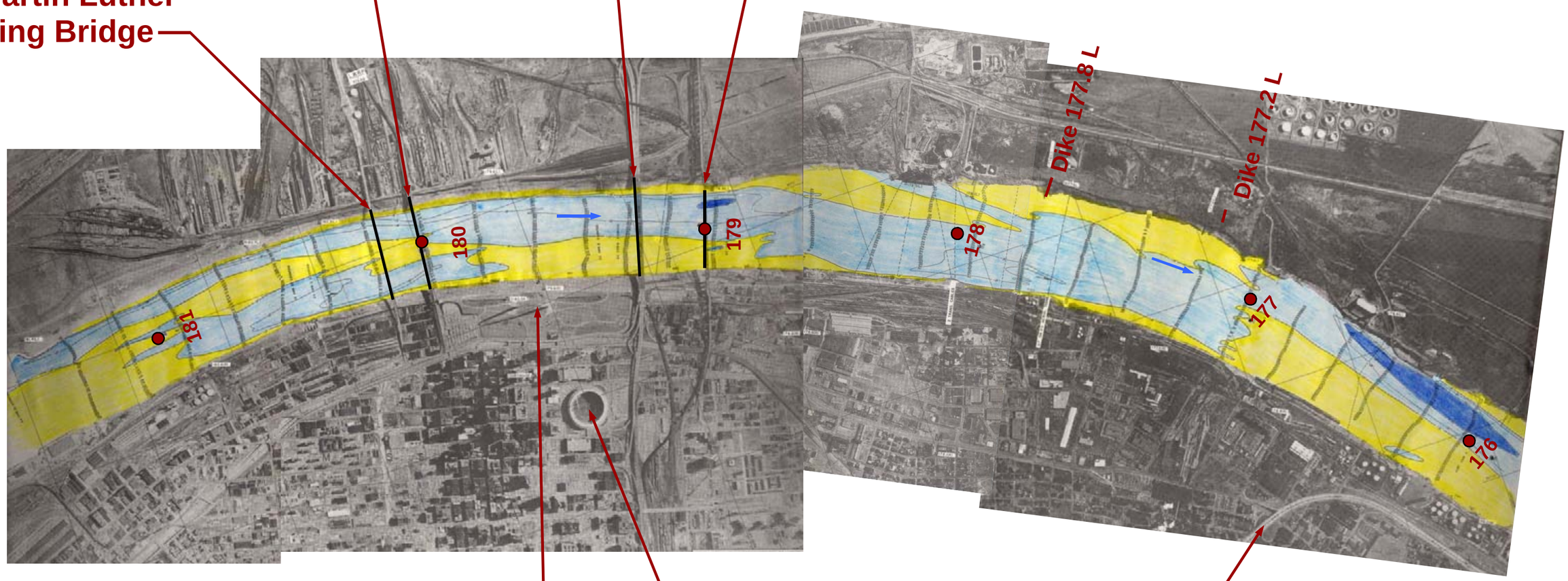
1977 AERIAL PHOTOGRAPH
MISSISSIPPI RIVER MILES 176-172

1500 1200 900 600 300 0 750 1500

FILE NAME: 1977 176-172.PUB

DATE PLOTTED: 3/03

PLATE NO. 26



MISSOURI

CITY OF ST. LOUIS

PHOTO TAKEN 1/22/1976 AT +5.50 LWRP ACCORDING TO THE ST. LOUIS, MISSOUTI GAGE. SURVEY TAKEN MAY 1977.

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

PREPARED BY: E. RIIFF
DRAWN BY: E. RIIFF
CHECKED BY: D. LAMM

APPLIED RIVER ENGINEERING CENTER

ST. LOUIS HARBOR MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 192-172

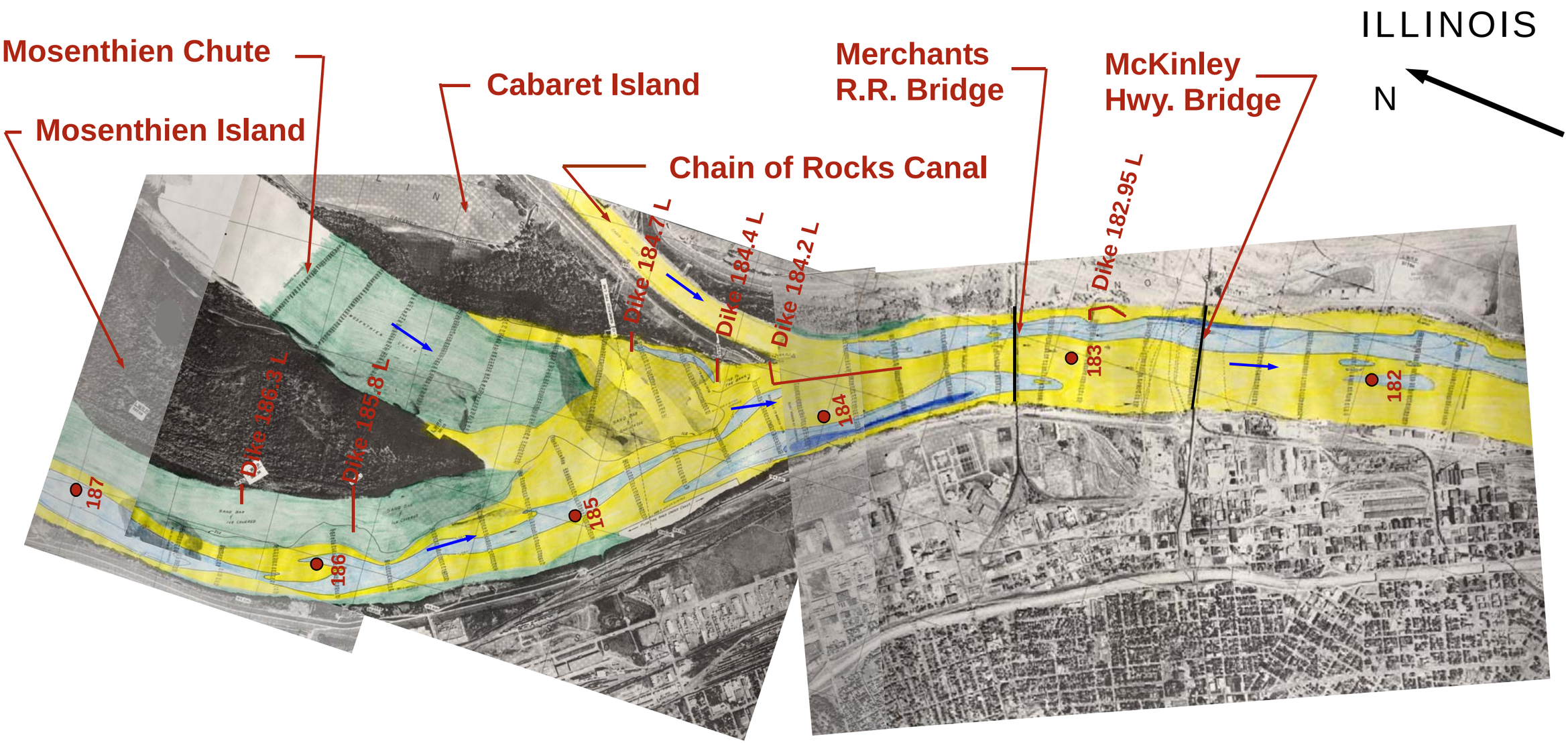
1977 HYDROGRAPHIC SURVEY
MISSISSIPPI RIVER MILES 181-176

2100 1680 1260 840 420 0 1050 2100

FILE NAME: 1977 181-177.PUB

DATE PLOTTED:

PLATE NO. 25



MISSOURI

CITY OF ST. LOUIS

PHOTO TAKEN 1/22/1976 AT +5.50 FEET LWRP ACCORDING TO THE ST. LOUIS, MISSOURI GAGE. SURVEY TAKEN MAY 1977.

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

PREPARED BY: E. RIIFF
DRAWN BY: E. RIIFF
CHECKED BY: D. LAMM

APPLIED RIVER ENGINEERING CENTER

ST. LOUIS HARBOR MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 192-172

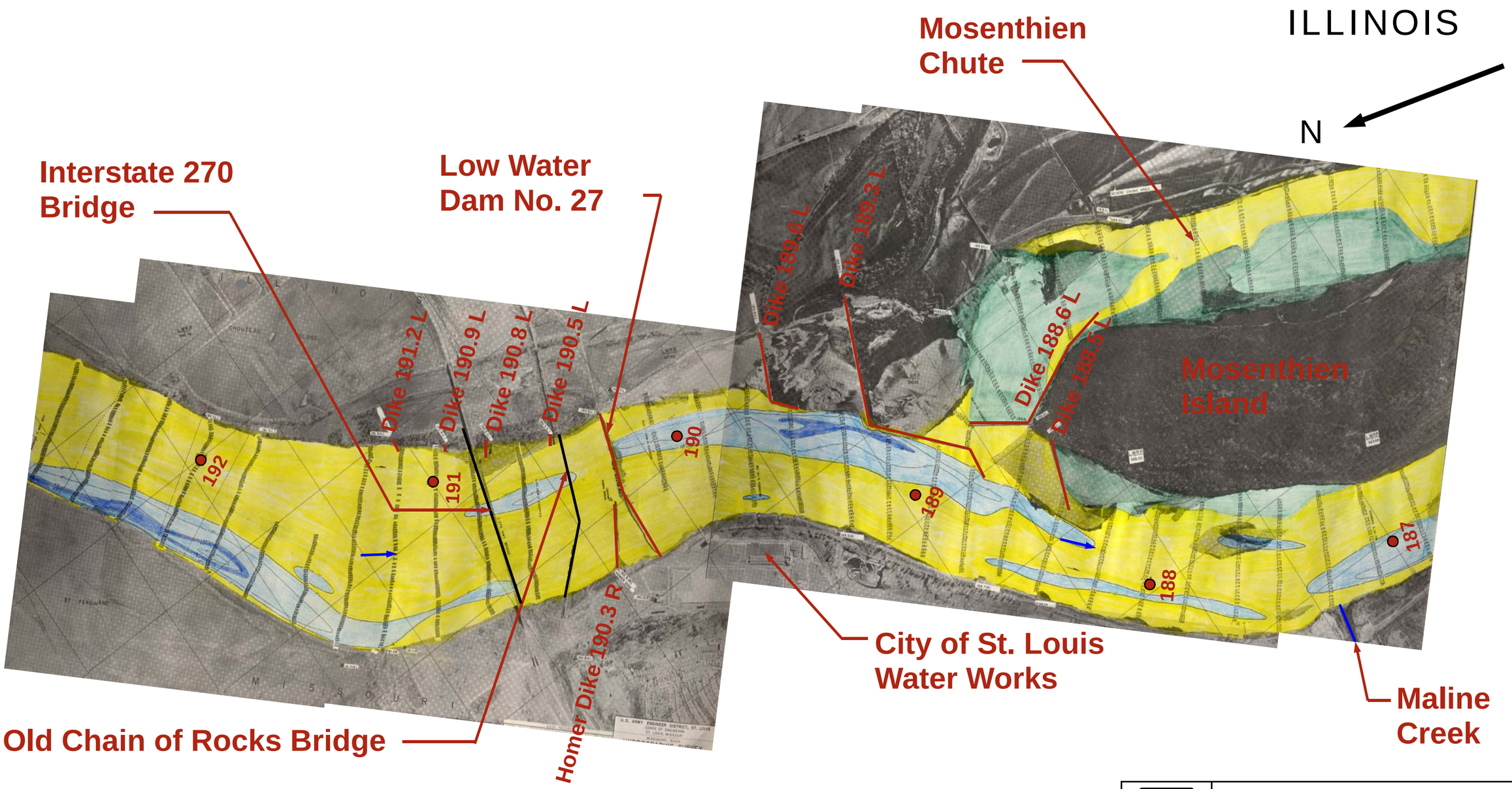
1977 HYDROGRAPHIC SURVEY
MISSISSIPPI RIVER MILES 187-182

1760 1408 1056 704 352 0 880 1760

FILE NAME: 1977 187-182.PUB

DATE PLOTTED:03/03

PLATE NO. 24



MISSOURI

CITY OF ST. LOUIS

PHOTO TAKEN 1/22/1976 AT +5.50 FEET LWRP ACOORDING TO THE ST. LOUIS, MISSOURI GAGE. SURVEY TAKEN MAY 1977.

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

PREPARED BY: E. RIIFF
DRAWN BY: E. RIIFF
CHECKED BY: D. LAMM

APPLIED RIVER ENGINEERING CENTER

ST. LOUIS HARBOR MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 192-172
1977 HYDROGRAPHIC SURVEY
MISSISSIPPI RIVER MILES 192-187

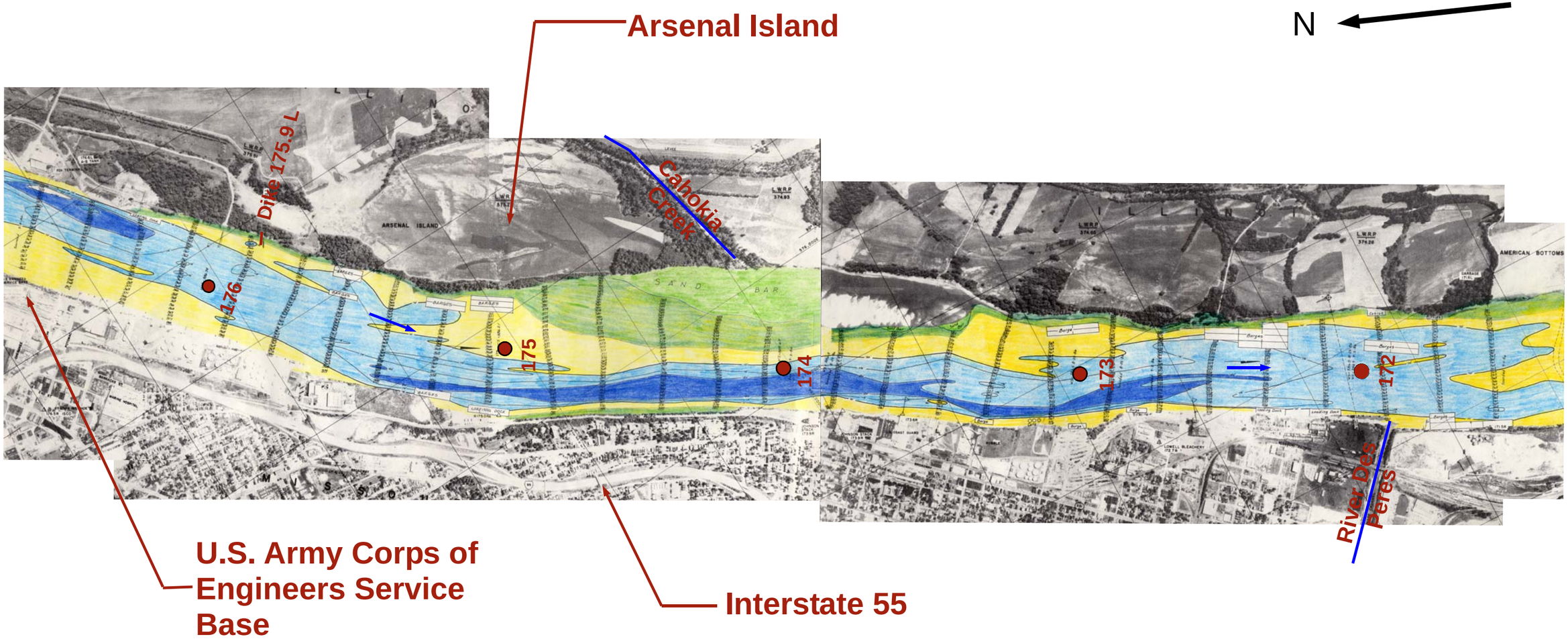
3000 2400 1800 1200 600 0 1500 3000

FILE NAME: 1977 192-187.PUB
DATE PLOTTED: 03/03

PLATE NO. 23

ILLINOIS

N



MISSOURI

CITY OF ST. LOUIS

PHOTO TAKEN 09/16/1983 AT +7.50 LWRP ACCORDING TO THE ST. LOUIS, MISSOURI GAGE. SURVEY TAKEN AUGUST/SEPTEMBER 1986.

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

PREPARED BY: E. RIIFF
DRAWN BY: E. RIIFF
CHECKED BY: R. DAVINROY

APPLIED RIVER ENGINEERING CENTER

ST. LOUIS HARBOR MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 192-172

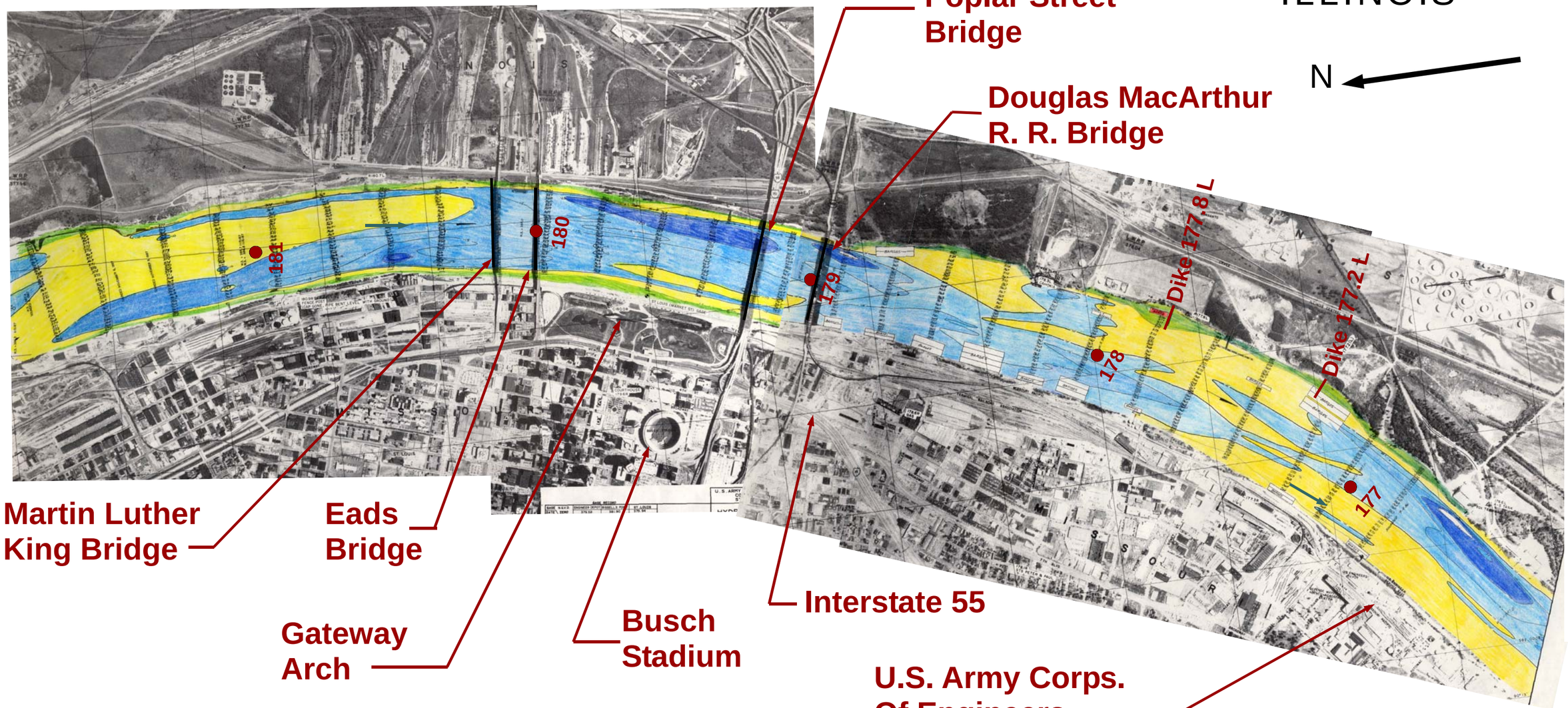
1987 HYDROGRAPHIC SURVEY
MISSISSIPPI RIVER MILES 176-172

1885 1508 1131 754 377 0 942.5 1885

FILE NAME: 1987 176-172.PUB

DATE PLOTTED: 03/03

PLATE NO. 30



MISSOURI

CITY OF ST. LOUIS

PHOTO TAKEN 09/16/1983 AT +7.50 LWRP ACCORDING TO ST. LOUIS, MISSOURI GAGE. SURVEY TAKEN SEPTEMBER 1986/NOVEMBER 1987.

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

PREPARED BY: E. RIIFF
DRAWN BY: E. RIIFF
CHECKED BY: R. DAVINROY

APPLIED RIVER ENGINEERING CENTER

ST. LOUIS HARBOR MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 192-172

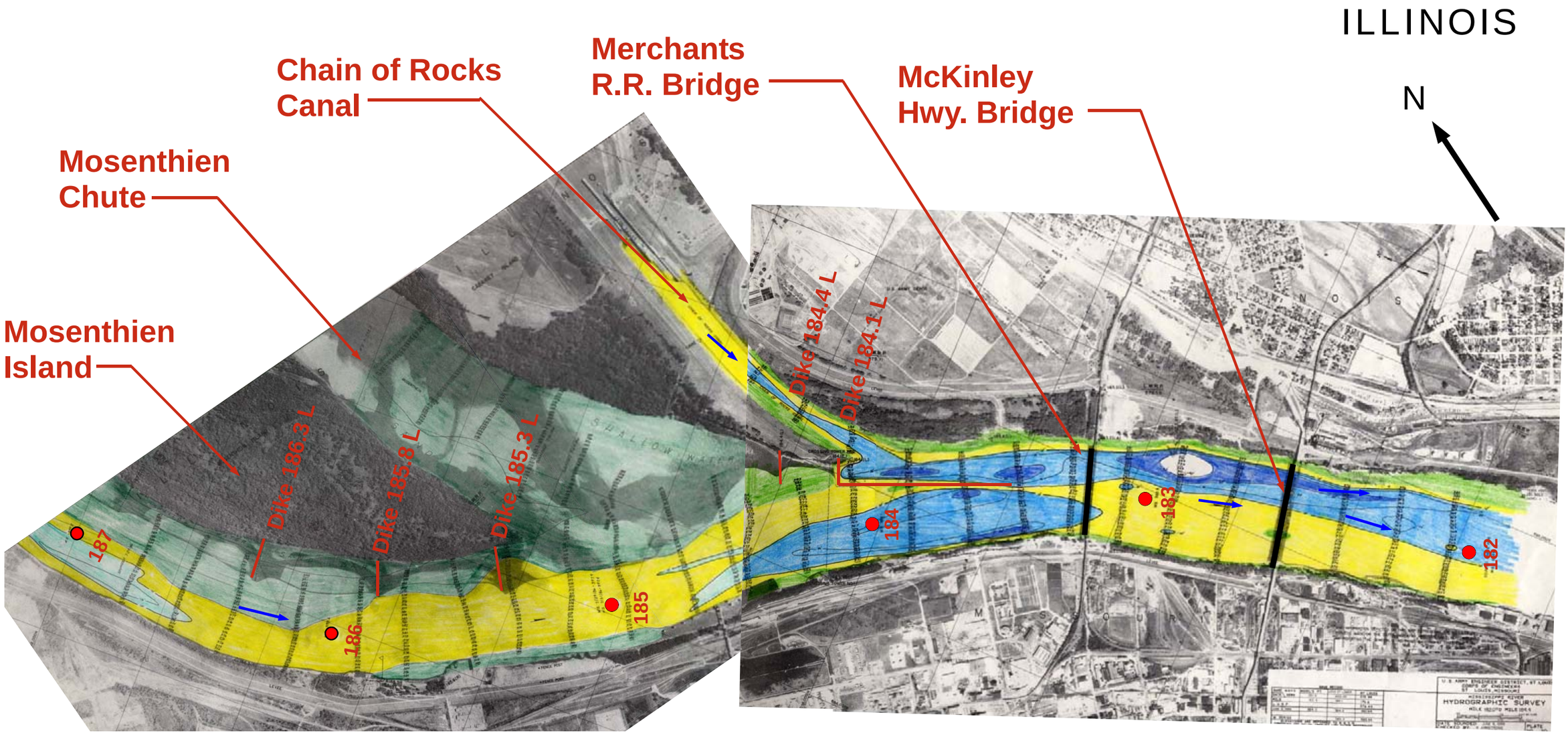
1987/1986 HYDROGRAPHIC SURVEY
MISSISSIPPI RIVER MILES 181-177

1885 1508 1131 754 377 0 942.5 1885

FILE NAME: 1987 181-177.PUB

DATE PLOTTED: 03/03

PLATE NO. 29



MISSOURI

CITY OF ST. LOUIS

PHOTO TAKEN ON 09/16/1983 AT +7.50 FEET LWRP ACCORDING TO THE ST. LOUIS, MISSOURI GAGE. SURVEY TAKEN JULY 1986.

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

PREPARED BY: E. RIIFF
DRAWN BY: E. RIIFF
CHECKED BY: R. DAVINROY

APPLIED RIVER ENGINEERING CENTER

ST. LOUIS HARBOR MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 192-172

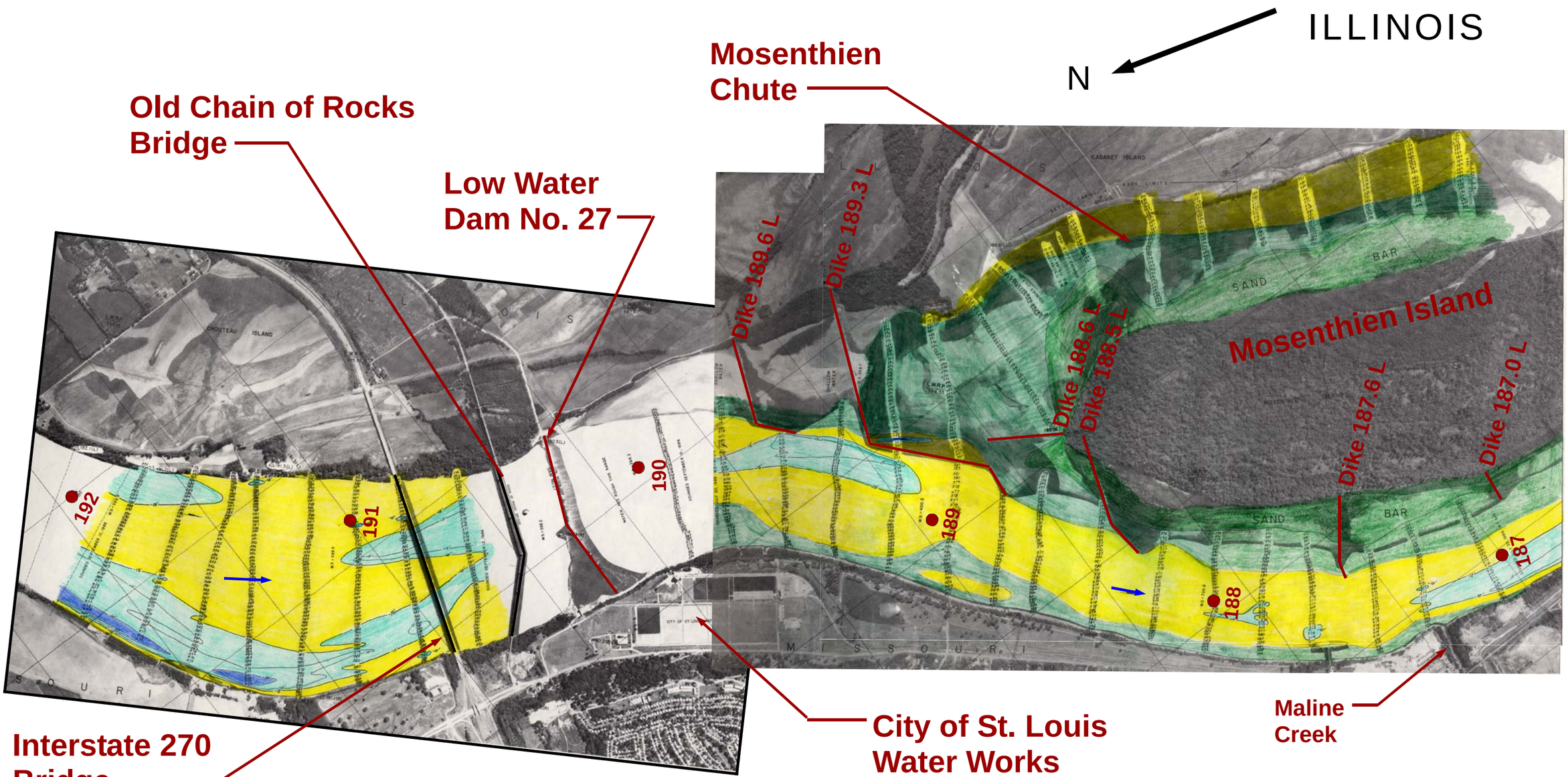
1986/1987 HYDROGRAPHIC SURVEY
MISSISSIPPI RIVER MILES 187-182

2000 1600 1200 800 400 0 1000 2000

FILE NAME: 1987 187-182.PUB

DATE PLOTTED: 03/03

PLATE NO. 28



MISSOURI

CITY OF ST. LOUIS

PHOTO TAKEN 09/16/1983 AT +7.50 FEET LWRP ACCORDING TO THE ST. LOUIS, MISSOURI GAGE. SURVEY TAKEN JULY 1986.

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

PREPARED BY: E. RIIFF
DRAWN BY: E. RIIFF
CHECKED BY: R. DAVINROY

APPLIED RIVER ENGINEERING CENTER

ST. LOUIS HARBOR MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 192-172

1986/1987 HYDROGRAPHIC SURVEY
MISSISSIPPI RIVER MILES 192-187

3000 2400 1800 1200 600 0 1500 3000

FILE NAME: 1987 192-187.PUB

DATE PLOTTED: 03/03

PLATE NO. 27

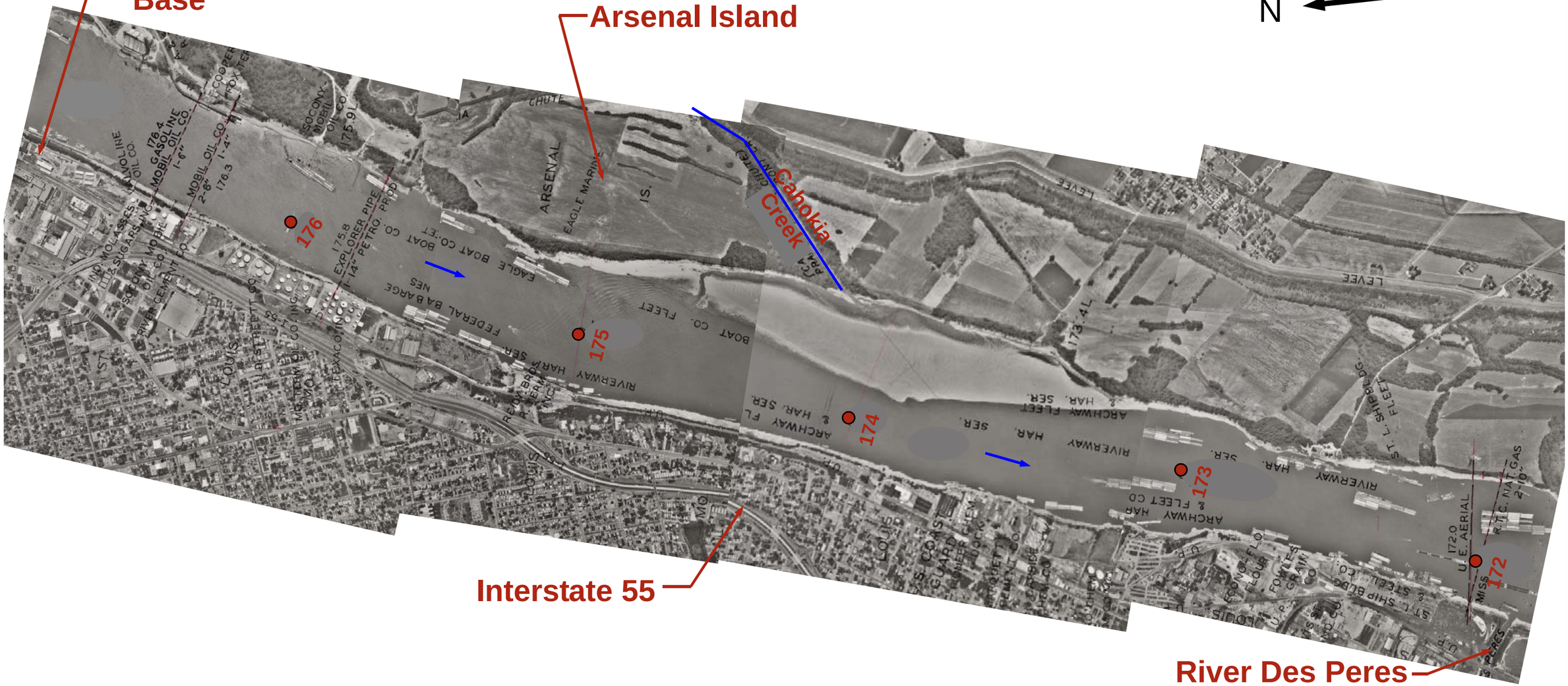


PHOTO TAKEN ON 06/22/1988 AT +3.6 FEET LWRP ACCORDING TO THE ST. LOUIS, MISSOURI GAGE

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

PREPARED BY: D. LAMM
DRAWN BY: D. LAMM
CHECKED BY: R. DAVINROY

APPLIED RIVER ENGINEERING CENTER

ST. LOUIS HARBOR MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 192-172

1988 AERIAL PHOTOGRAPH
MISSISSIPPI RIVER MILES 177-172

1700 1360 1020 680 340 0 850 1700

FILE NAME: 1988 178-172.PUB
DATE PLOTTED: 11/02

PLATE NO. 34

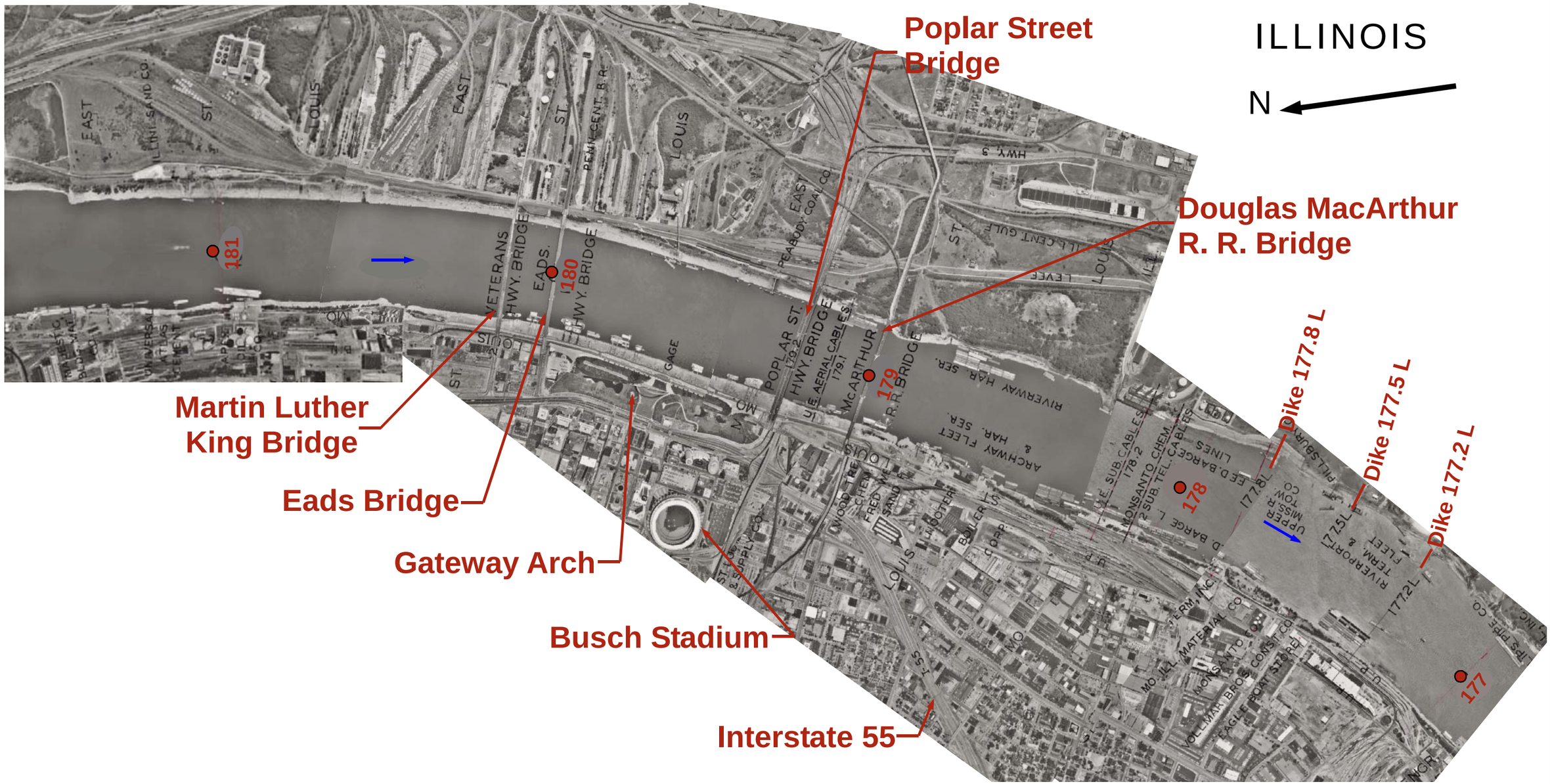


PHOTO TAKEN ON 06/22/1988 AT +3.6 FEET LWRP ACCORDING TO THE ST. LOUIS, MISSOURI GAGE.

MISSOURI

CITY OF ST. LOUIS

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

PREPARED BY: D. LAMM
DRAWN BY: D. LAMM
CHECKED BY: R. DAVINROY

APPLIED RIVER ENGINEERING CENTER

ST. LOUIS HARBOR MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 192-172

1988 AERIAL PHOTOGRAPH
MISSISSIPPI RIVER MILES 181-177

1650 1320 990 660 330 0 825 1650

FILE NAME: 1988 181-177.PUB

DATE PLOTTED: 11/02

PLATE NO. 33

ILLINOIS

N

Chain of Rocks Canal

Merchants R.R. Bridge

McKinley Hwy. Bridge

Mosenthien Chute

MISSOURI

CITY OF ST. LOUIS

PHOTO TAKEN ON 06/22/1988 AT +3.6 FEET LWRP ACCORDING TO THE ST. LOUIS, MISSOURI GAGE

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

PREPARED BY: D. LAMM
DRAWN BY: D. LAMM
CHECKED BY: R. DAVINROY

APPLIED RIVER ENGINEERING CENTER

ST. LOUIS HARBOR MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 192-172

1988 AERIAL PHOTOGRAPH
MISSISSIPPI RIVER MILES 186-182

1650 1320 990 660 330 0 825 1650

FILE NAME: 1988 186-182.PUB

DATE PLOTTED: 11/02

PLATE NO. 32

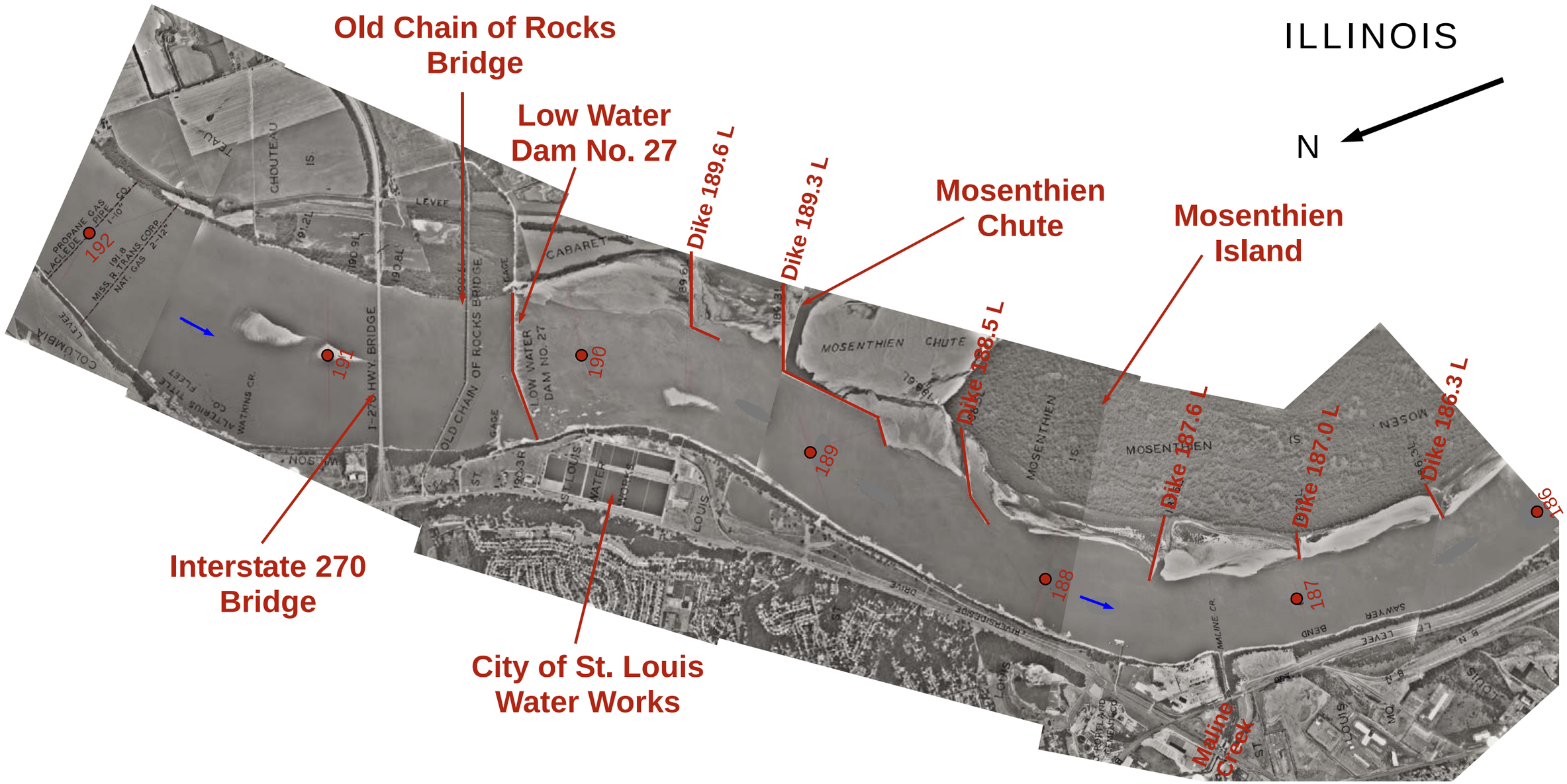


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PHOTO TAKEN ON 06/22/1988 AT +3.6 FEET LWRP ACCORDING TO THE ST. LOUIS, MISSOURI GAGE

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

PREPARED BY: D. LAMM
DRAWN BY: D. LAMM
CHECKED BY: R. DAVINROY

APPLIED RIVER ENGINEERING CENTER

ST. LOUIS HARBOR MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 192-172

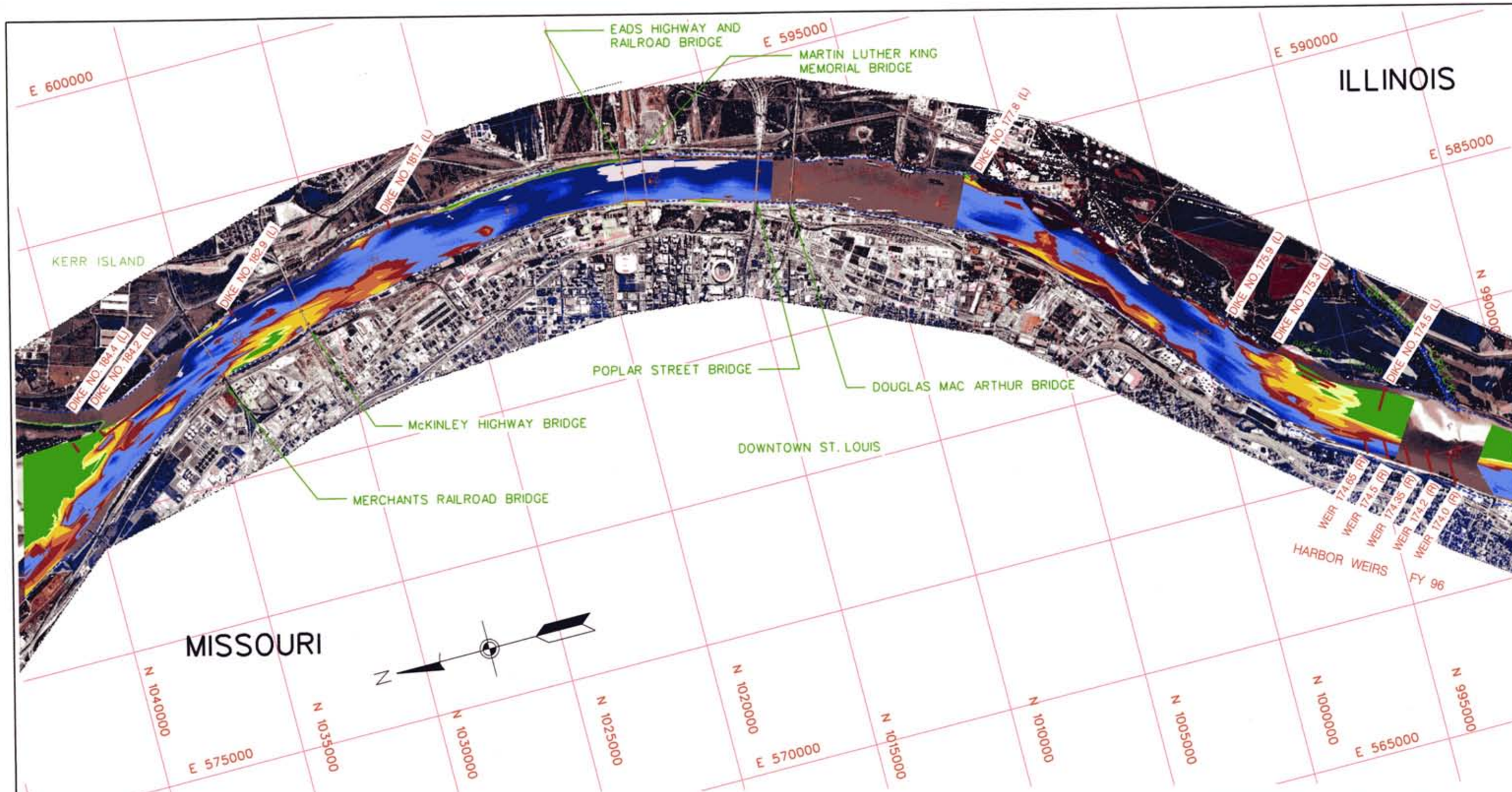
1988 AERIAL PHOTOGRAPH
MISSISSIPPI RIVER MILES 192-186

2000 1600 1200 800 400 0 1000 2000

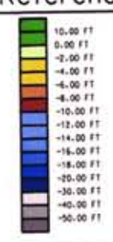
FILE NAME: 1988 192-186.PUB

DATE PLOTTED: 11/02

PLATE NO. 31



Elevations Referenced to LWRP



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

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

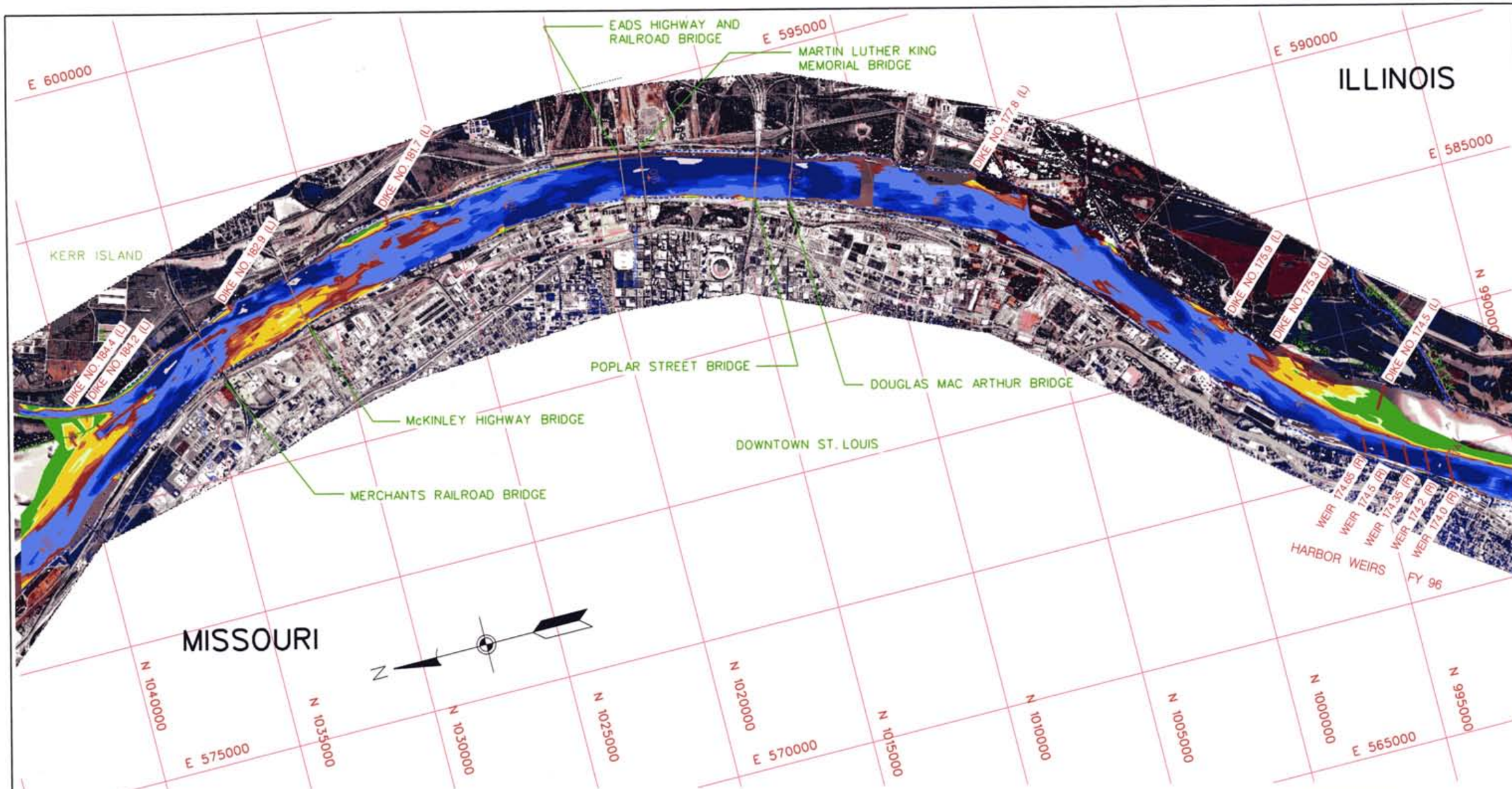
ST. LOUIS HARBOR MICRO MODEL STUDY
RIVER MILES 191.0 TO 172.0

1993 HYDROGRAPHIC SURVEY

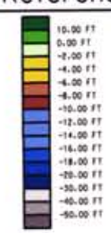
3600' 2700' 1800' 900' 0 1800' 3600'

DESIGN FILE: 93SURVEY.DGN
SCALE : 1" = 3600'

PLATE NO. 35



Elevations Referenced to LWRP



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

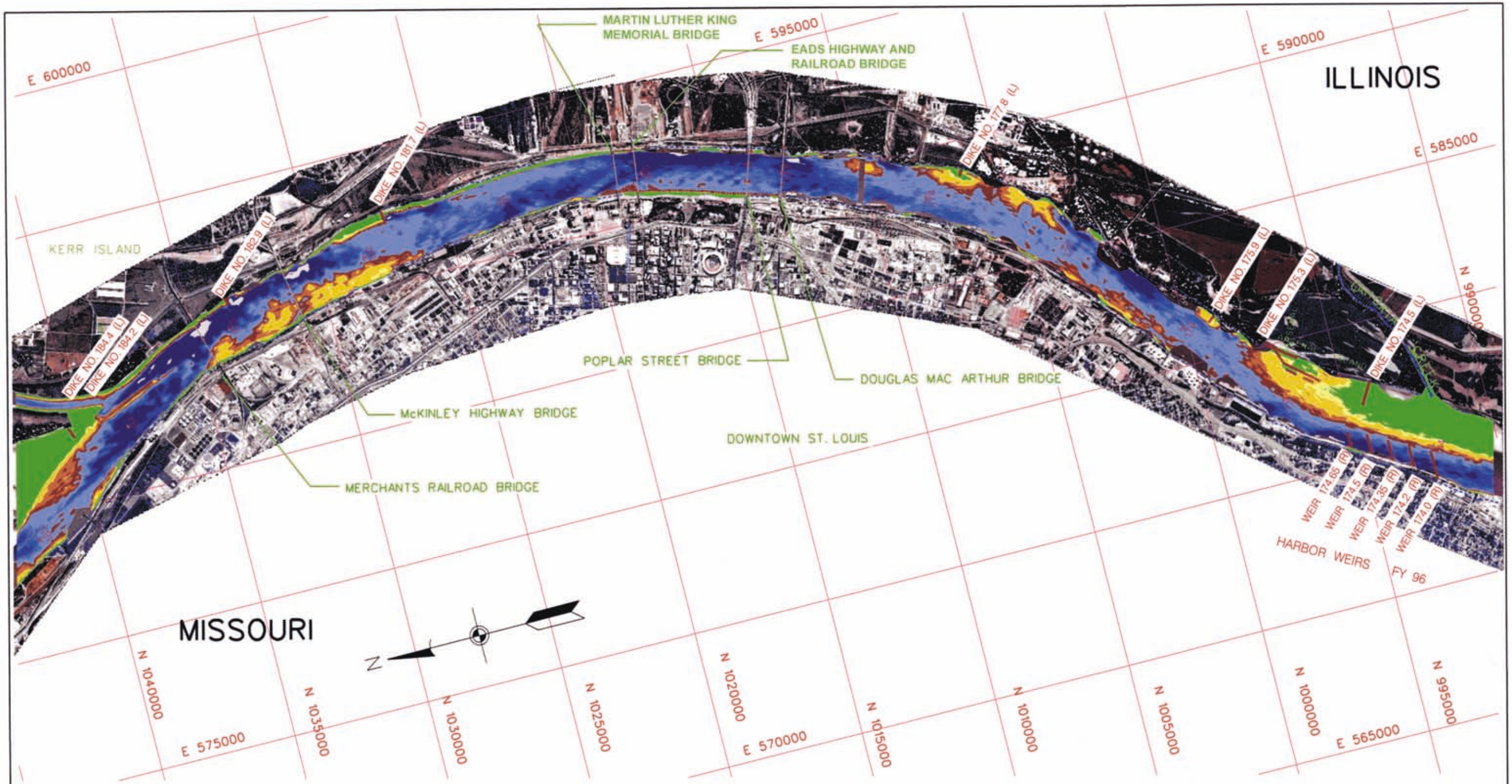
PREPARED BY: D. LAMM
DRAWN BY: E. RIFF
CHECKED BY: R. DAVINROY

ST. LOUIS HARBOR MICRO MODEL STUDY
RIVER MILES 191.0 TO 172.0

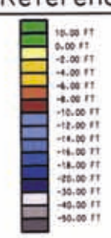
1996 HYDROGRAPHIC SURVEY

3600' 2700' 1800' 900' 0 1800' 3600'

DESIGN FILE: 96SURVEY.DGN
SCALE: 1" = 3600'
PLATE NO. 36



Elevations Referenced to LWRP



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

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

ST. LOUIS HARBOR MICRO MODEL STUDY
RIVER MILES 191.0 TO 172.0

2001 HYDROGRAPHIC SURVEY

3600' 2700' 1800' 900' 0 1800' 3600'

DESIGN FILE: 01SURVEY.DGN
SCALE : 1" = 3600'

PLATE NO. 37

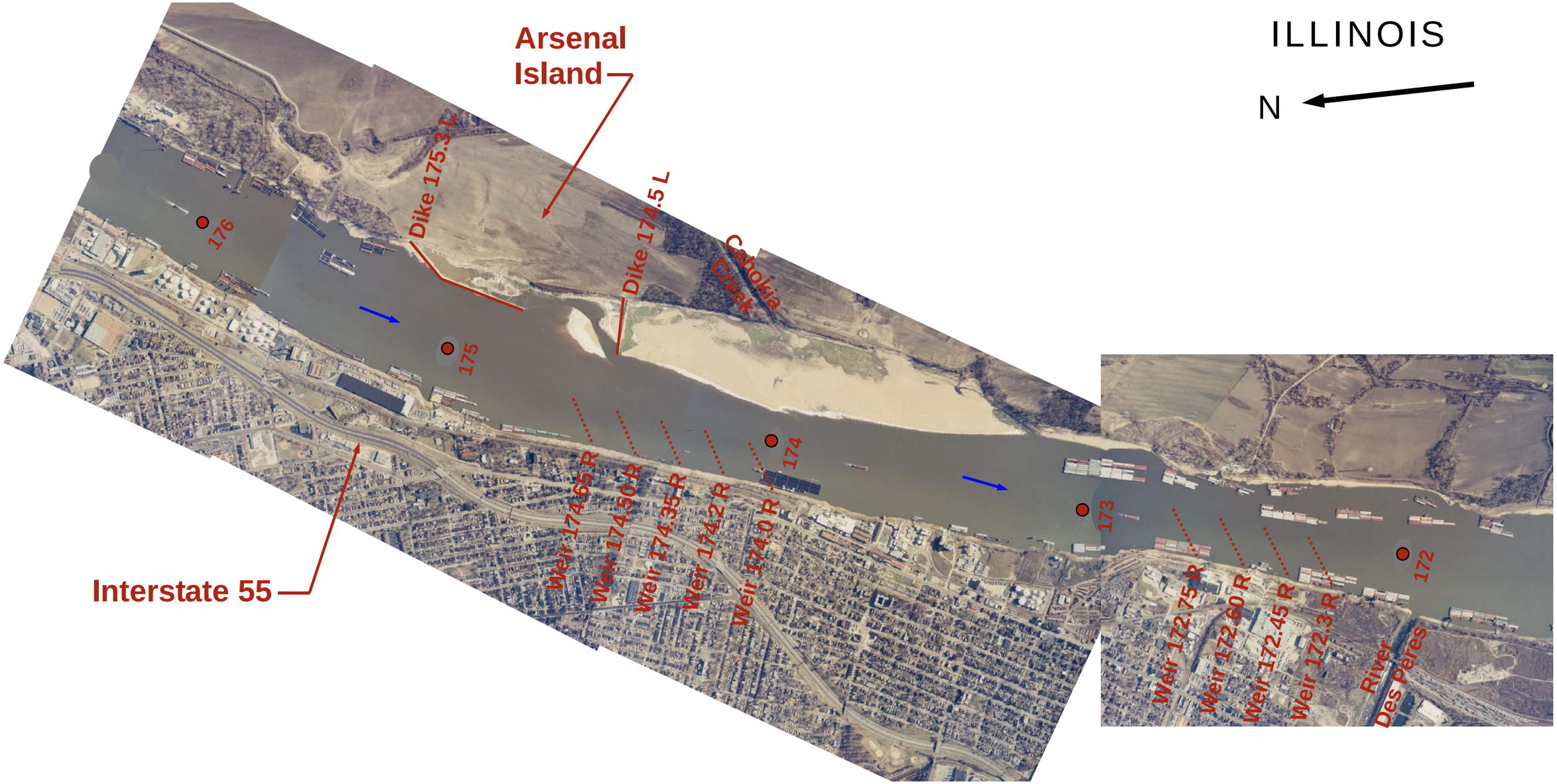


PHOTO TAKEN ON 01/02/2002 AT +4.21 FEET LWRP ACCORDING TO THE ST. LOUIS, MISSOURI GAGE

MISSOURI

CITY OF ST. LOUIS

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

PREPARED BY: D. LAMM
DRAWN BY: D. LAMM
CHECKED BY: R. DAVINROY

ST. LOUIS HARBOR MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 192-172

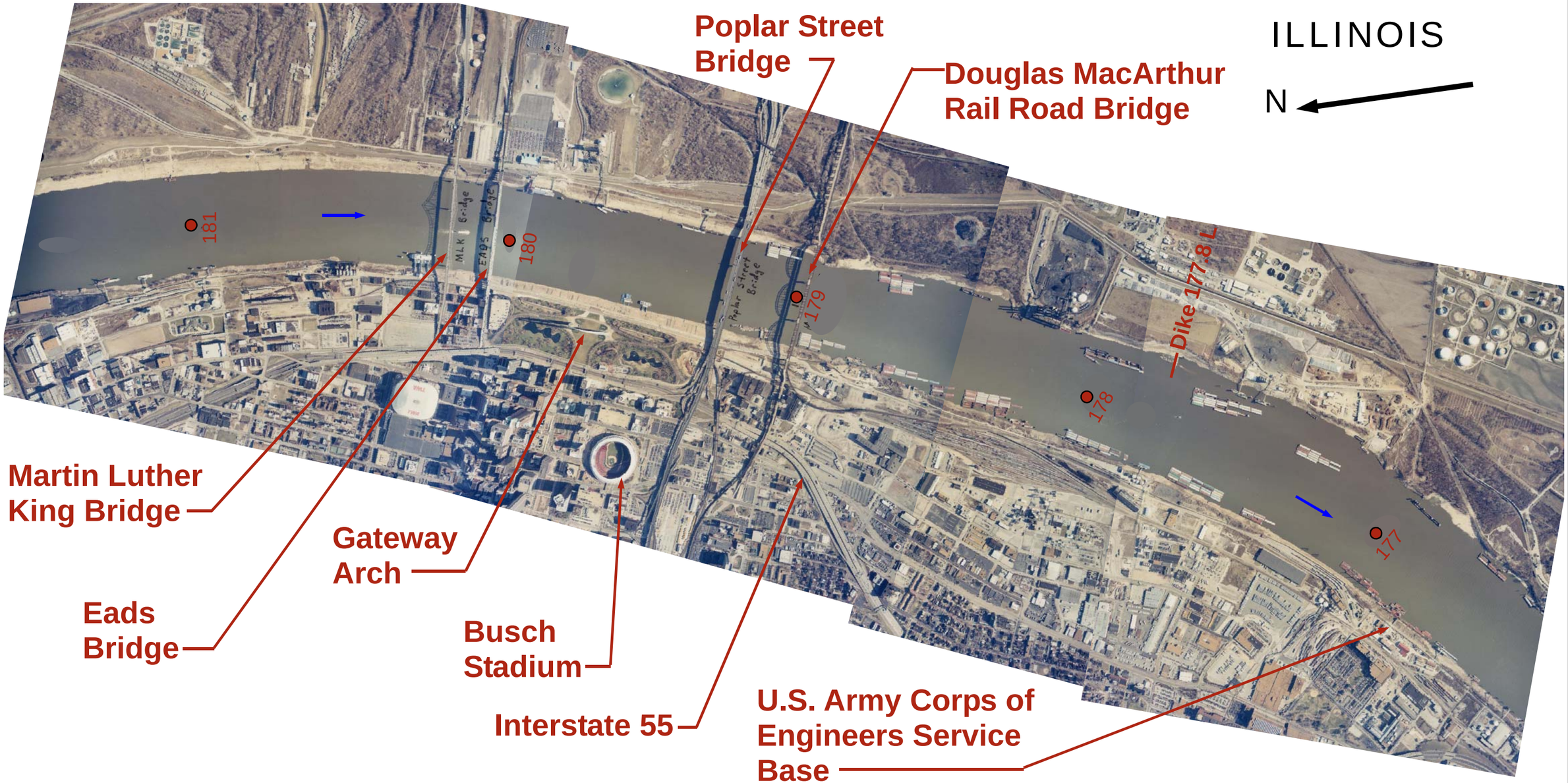
2002 AERIAL PHOTOGRAPH
MISSISSIPPI RIVER MILES 176-172

1650 1320 990 660 330 0 825 1650

FILE NAME: 2002 176-172.PUB

DATE PLOTTED: 11/02

PLATE NO. 41



MISSOURI

CITY OF ST. LOUIS

PHOTO TAKEN ON 01/02/2002 AT +4.21 FEET LWRP ACCORDING TO THE ST. LOUIS, MISSOURI GAGE

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

PREPARED BY: D. LAMM
DRAWN BY: D. LAMM
CHECKED BY: R. DAVINROY

ST. LOUIS HARBOR MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 192-172

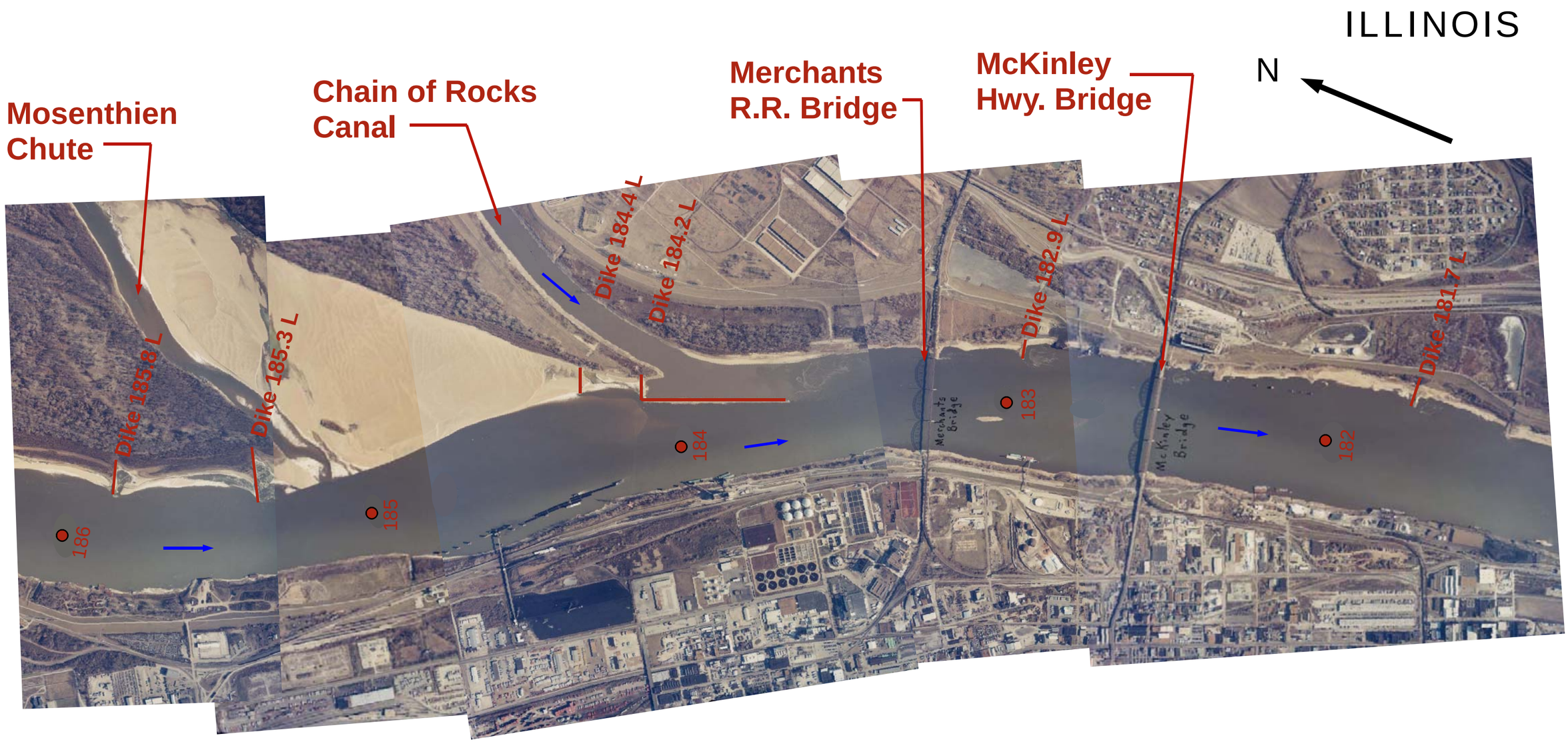
2002 AERIAL PHOTOGRAPH
MISSISSIPPI RIVER MILES 181-177

1650 1320 990 660 330 0 825 1650

FILE NAME: 2002 181-177.PUB

DATE PLOTTED: 11/02

PLATE NO. 40



MISSOURI

CITY OF ST. LOUIS

PHOTO TAKEN ON 01/03/2002 AT +4.04 FEET LWRP ACCORDING TO THE ST. LOUIS, MISSOURI GAGE

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

PREPARED BY: D. LAMM
DRAWN BY: D. LAMM
CHECKED BY: R. DAVINROY

ST. LOUIS HARBOR MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 192-172

2002 AERIAL PHOTOGRAPH
MISSISSIPPI RIVER MILES 186-182

1760 1408 1056 704 352 0 880 1760

FILE NAME: 2002 186-182.PUB

DATE PLOTTED: 11/02

PLATE NO. 39

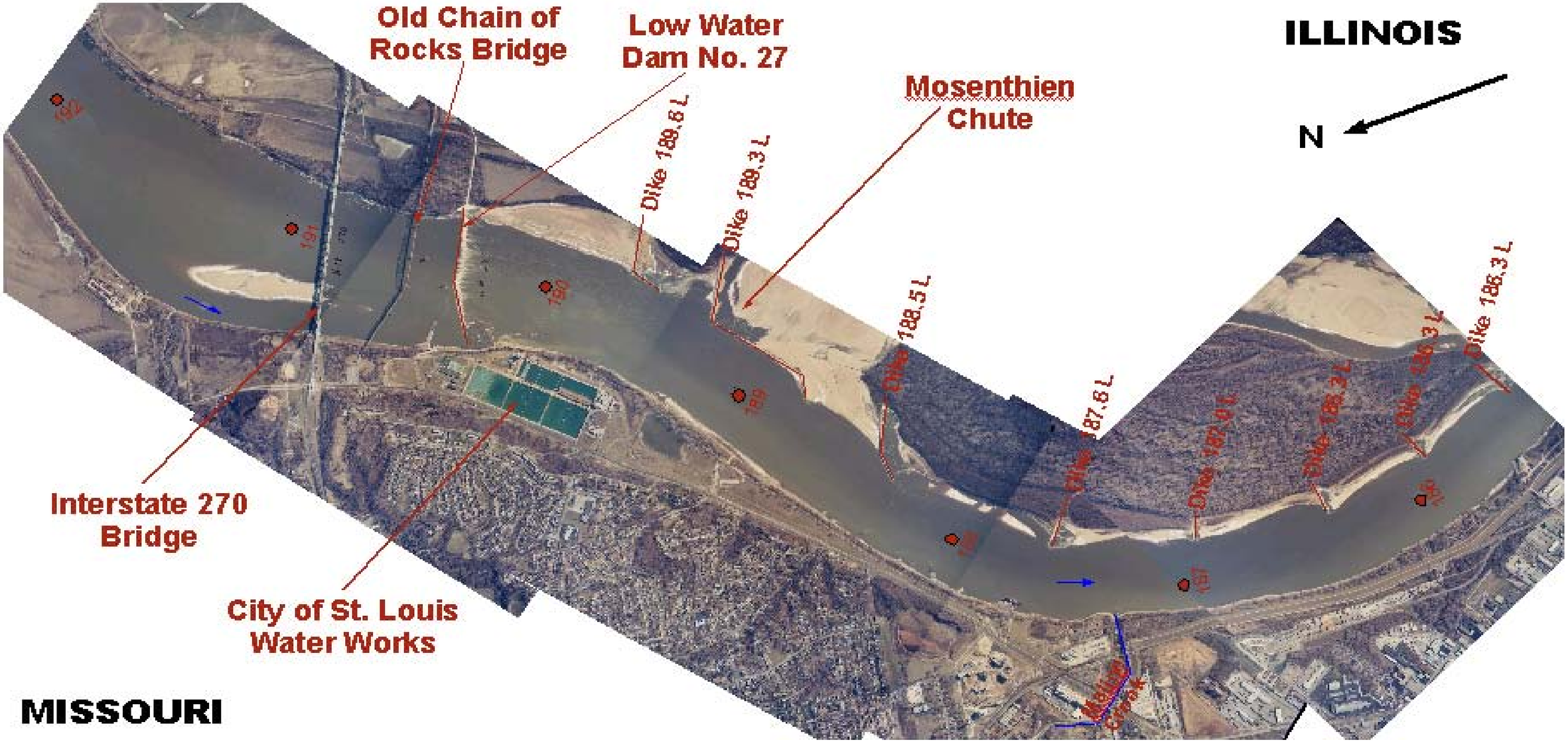


PHOTO TAKEN ON 01/03/2002 AT +4.04 FEET LWRP
ACCORDING TO THE ST. LOUIS, MISSOURI GAGE

MISSOURI

CITY OF ST. LOUIS

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

PREPARED BY: D. LAMM
DRAWN BY: D. LAMM
CHECKED BY: R. DAVINROY

ST. LOUIS HARBOR MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 192-172

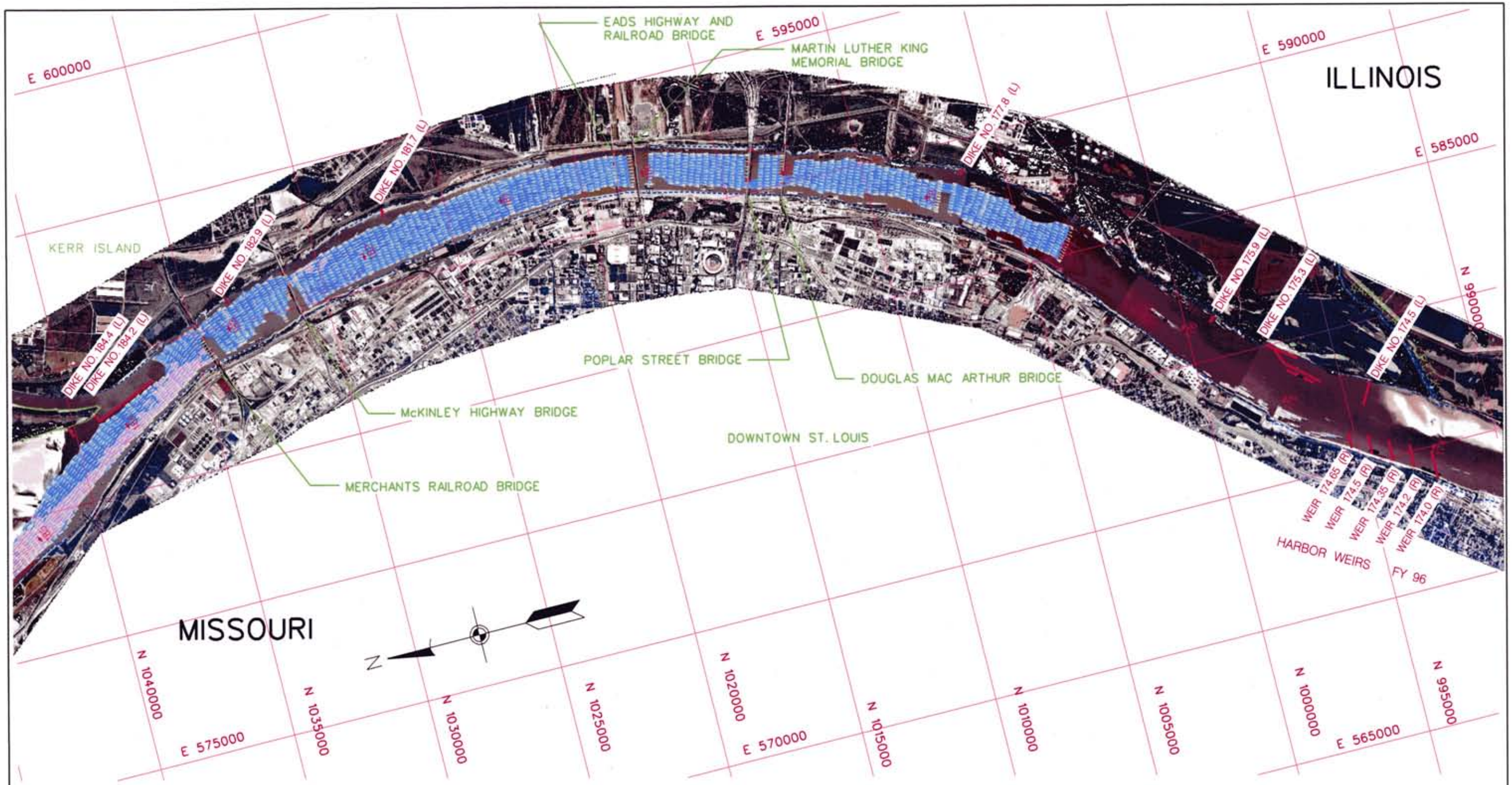
2002 AERIAL PHOTOGRAPH
MISSISSIPPI RIVER MILES 192-186

1760 1408 1056 704 352 0 880 1760

FILE NAME: 2002 186-182.PUB

DATE PLOTTED: 11/02

PLATE NO. 38



Velocities are Feet/Second

Legend:
- 0.0 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- 4.0 - 5.0
- 5.0 - 6.0
- 6.0 - 7.0
- 7.0 - 8.0
- 8.0 - 9.0
- 9.0 - 10.0

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
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ST. LOUIS, MISSOURI

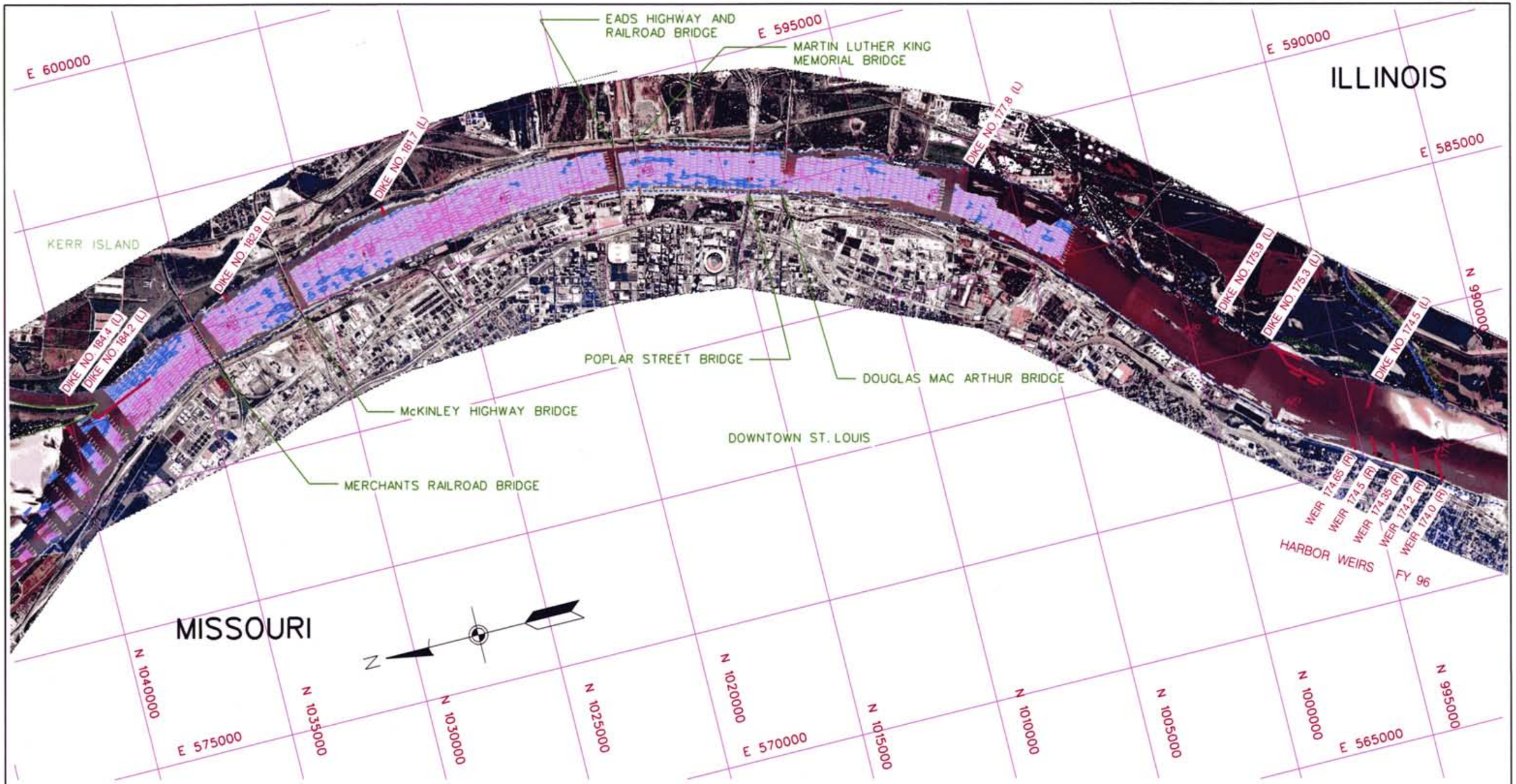
PREPARED BY: D. LAMM
DRAWN BY: E. RIFF
CHECKED BY: R. DAVINROY

ST. LOUIS HARBOR MICRO MODEL STUDY
RIVER MILES 191.0 TO 172.0

LOW WATER ADCP DATA

3600' 2700' 1800' 900' 0 1800' 3600'

DESIGN FILE: LOWWATER4.DGN
SCALE : 1" = 3600'
PLATE NO. 47



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RIVER MILES 191.0 TO 172.0

MIDBANK ADCP DATA

3600' 2700' 1800' 900' 0 1800' 3600'

DESIGN FILE: MIDWATER6.DGN
SCALE: 1" = 3600'

PLATE NO. 43

Deposition at Mile 182.7

Fleeting and Loading Operations in Downtown St. Louis.

Pictures taken on 01/30/03 at –0.11 LWRP, According to the St. Louis, Missouri Gage.

	U.S ARMY ENGINEER DISTRICT, ST. LOUIS CORPS OF ENGINEERS ST. LOUIS, MISSOURI
PREPARED BY: E. RIIFF DRAWN BY: E. RIIFF CHECKED BY: R. DAVINROY APPLIED RIVER ENGINEERING CENTER	ST. LOUIS HARBOR MICRO MODEL STUDY MISSISSIPPI RIVER MILES 192-172 DOWNTOWN HELICOPTER PICTURES
	FILE NAME: DOWNTOWN.PUB DATE PLOTTED: 12/03 PLATE NO. 44

Rock Outcropping Downstream of the Douglas MacArthur Bridge

The two pictures above where taken on 04/05/03 at +7.62 feet LWRP according to the St. Louis, Missouri Gage.

The picture above was taken on 05/27/03 at +22.4 feet LWRP according to the St. Louis, Missouri Gage.

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RIVER MILES 191.0 TO 172.0

ROCK OUTCROPPING AT MILE 178.9 L

DESIGN FILE: ROCK.PUB

PLATE NO.
45

Entrance to Mosenthien Chute, Looking Downstream

Exit of Mosenthien Chute, Looking Upstream

Pictures taken on 05/27/03 at +22.4 LWRP According to the St. Louis, Missouri Gage.

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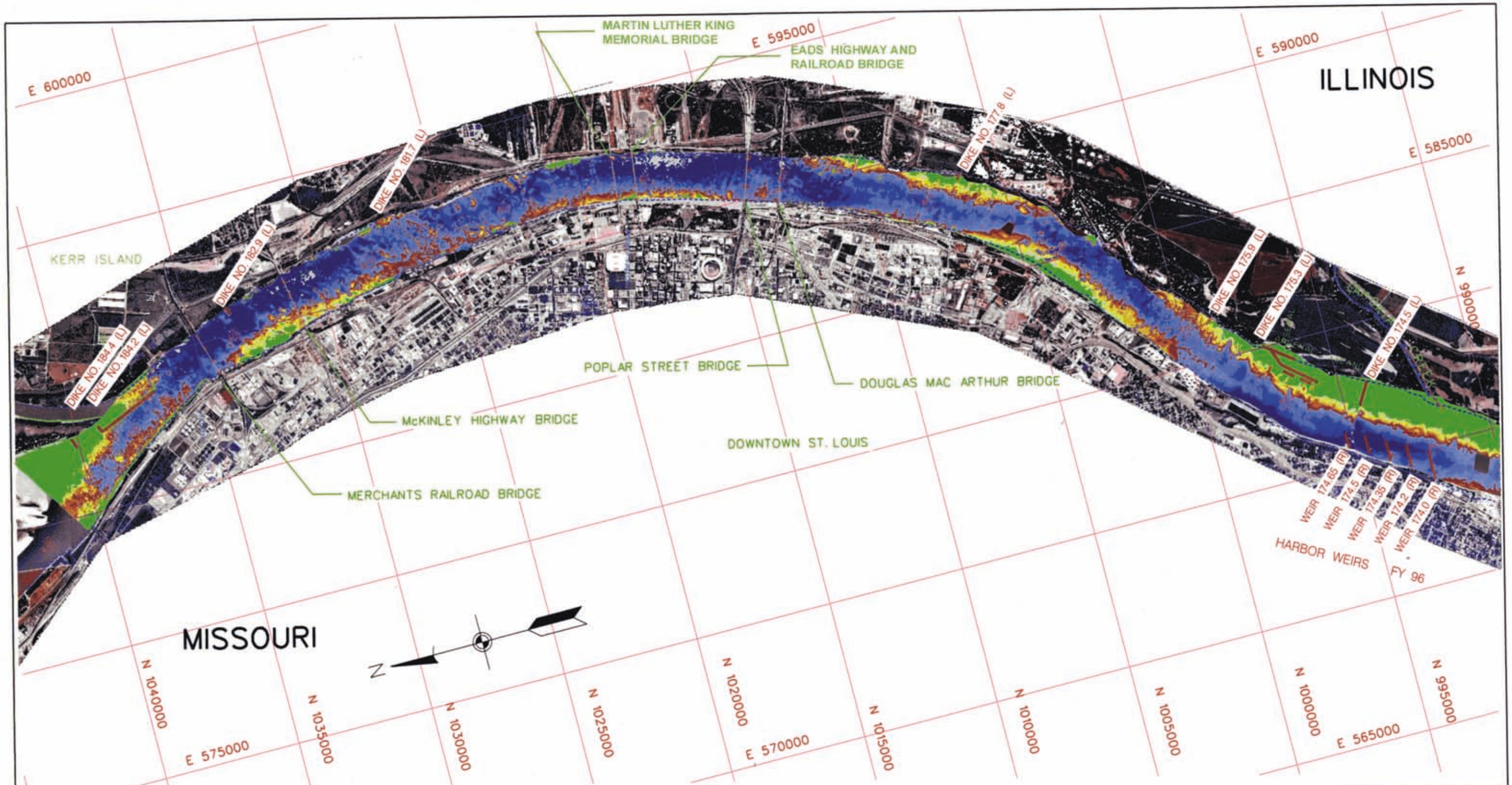
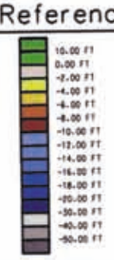
	FILE NAME: MOSENTHIEN.PUB / DATE PLOTTED: 12/03 / PLATE NO. 46

Insert is 134” x 34”

	U.S ARMY ENGINEER DISTRICT, ST. LOUIS **CORPS OF ENGINEERS** **ST. LOUIS, MISSOURI**
PREPARED BY: E. RIIFF DRAWN BY: E. RIIFF CHECKED BY: R. DAVINROY APPLIED RIVER ENGINEERING CENTER	**ST. LOUIS HARBOR MICRO MODEL STUDY** **MISSISSIPPI RIVER MILES 192-172** ST. LOUIS HARBOR FLUME
FILE NAME: FLUME.PUB	DATE PLOTTED: 12/03
	PLATE NO. **47**



Elevations Referenced to LWRP



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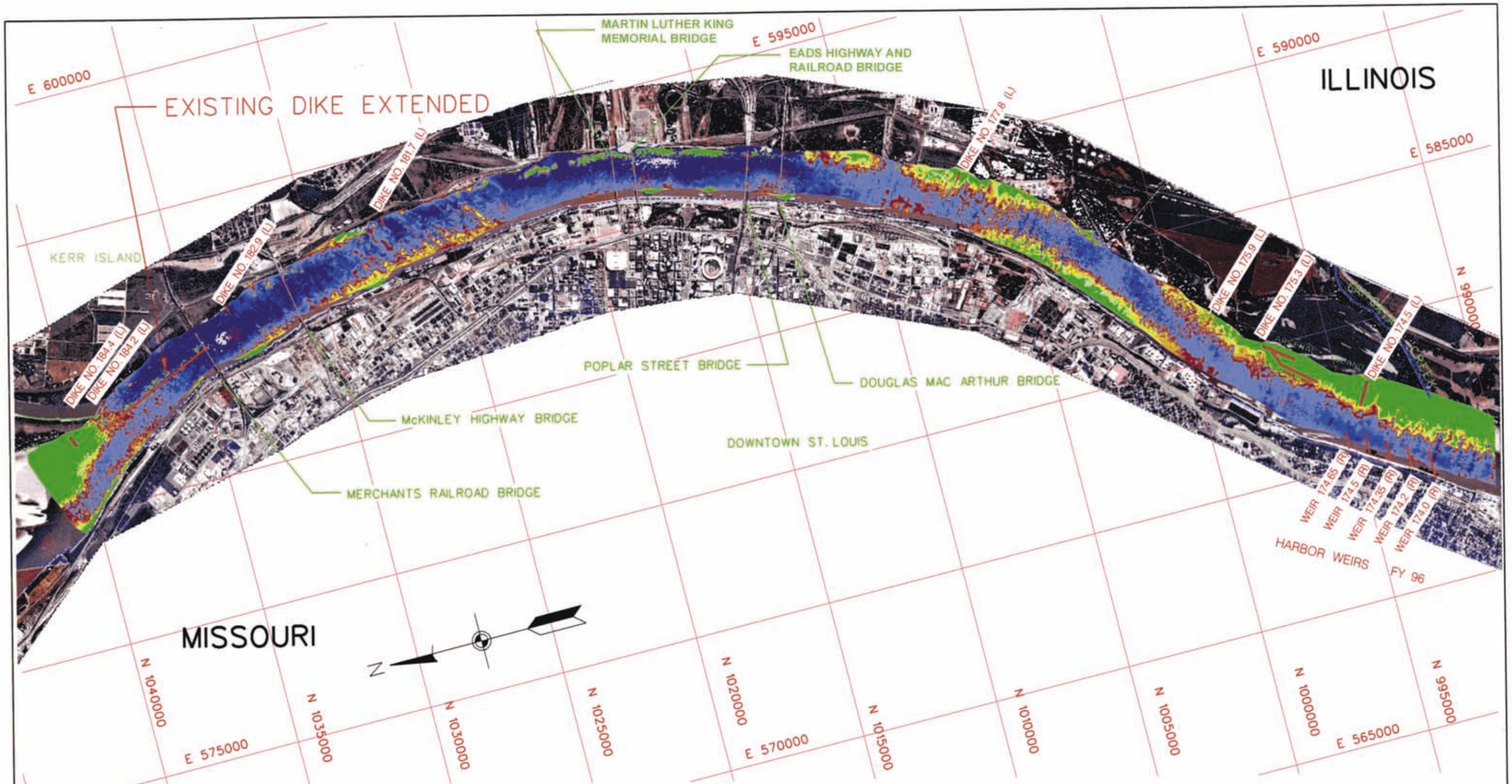
RIVER MILES 191.0 TO 172.0

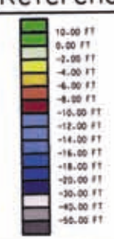
BASE TEST

3600' 2700' 1800' 900' 0 1800' 3600'

DESIGN FILE: STLBASE3.DGN
SCALE: 1" = 3600'
PLATE NO. 48



Elevations Referenced to LWRP



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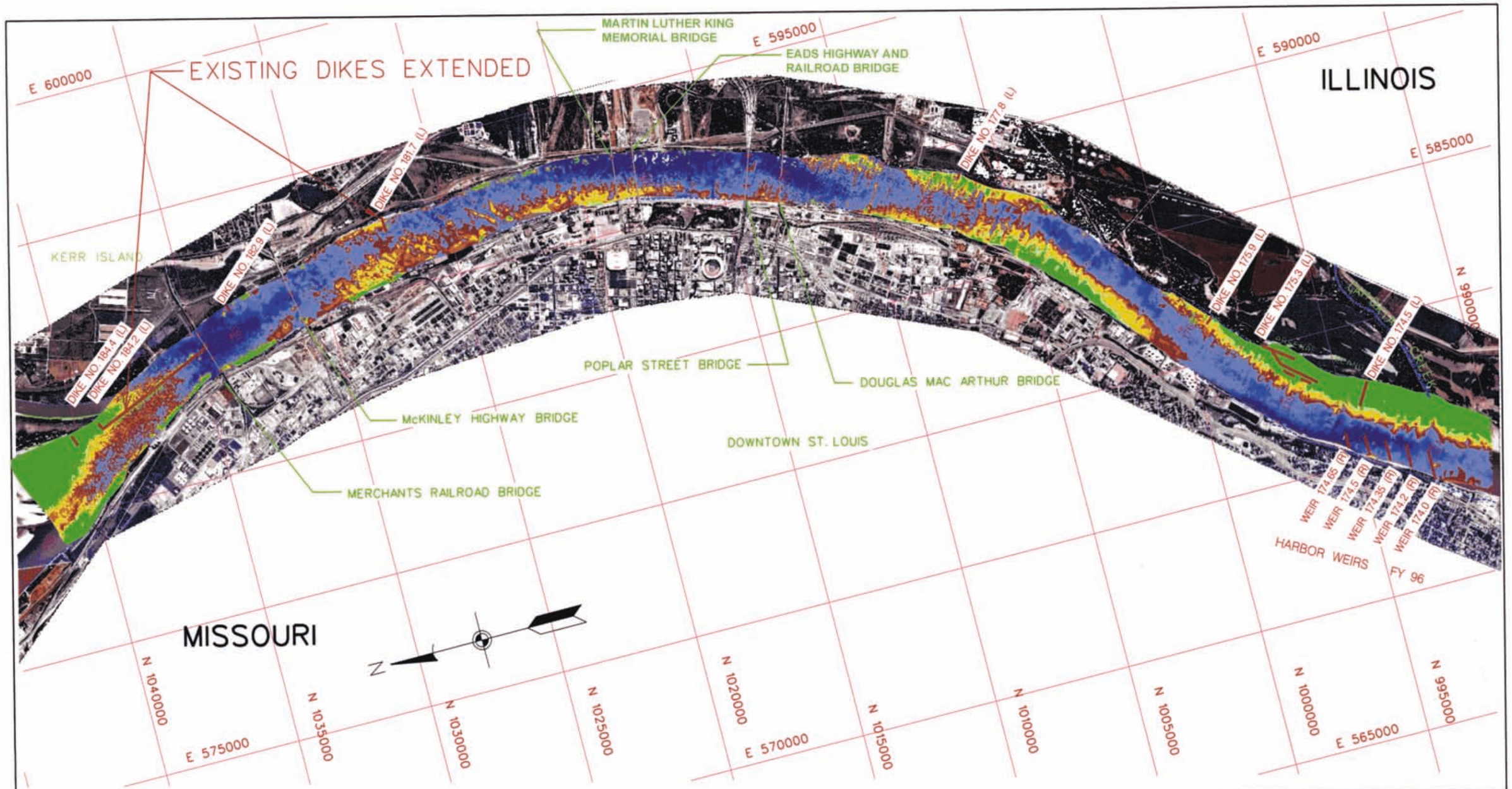
RIVER MILES 191.0 TO 172.0

ALTERNATIVE 1

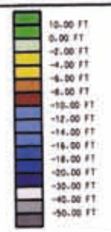
3600' 2700' 1800' 900' 0 1800' 3600'

DESIGN FILE: STLALT1A.DGN
SCALE : 1" = 3600'

PLATE NO. 49



Elevations Referenced to LWRP



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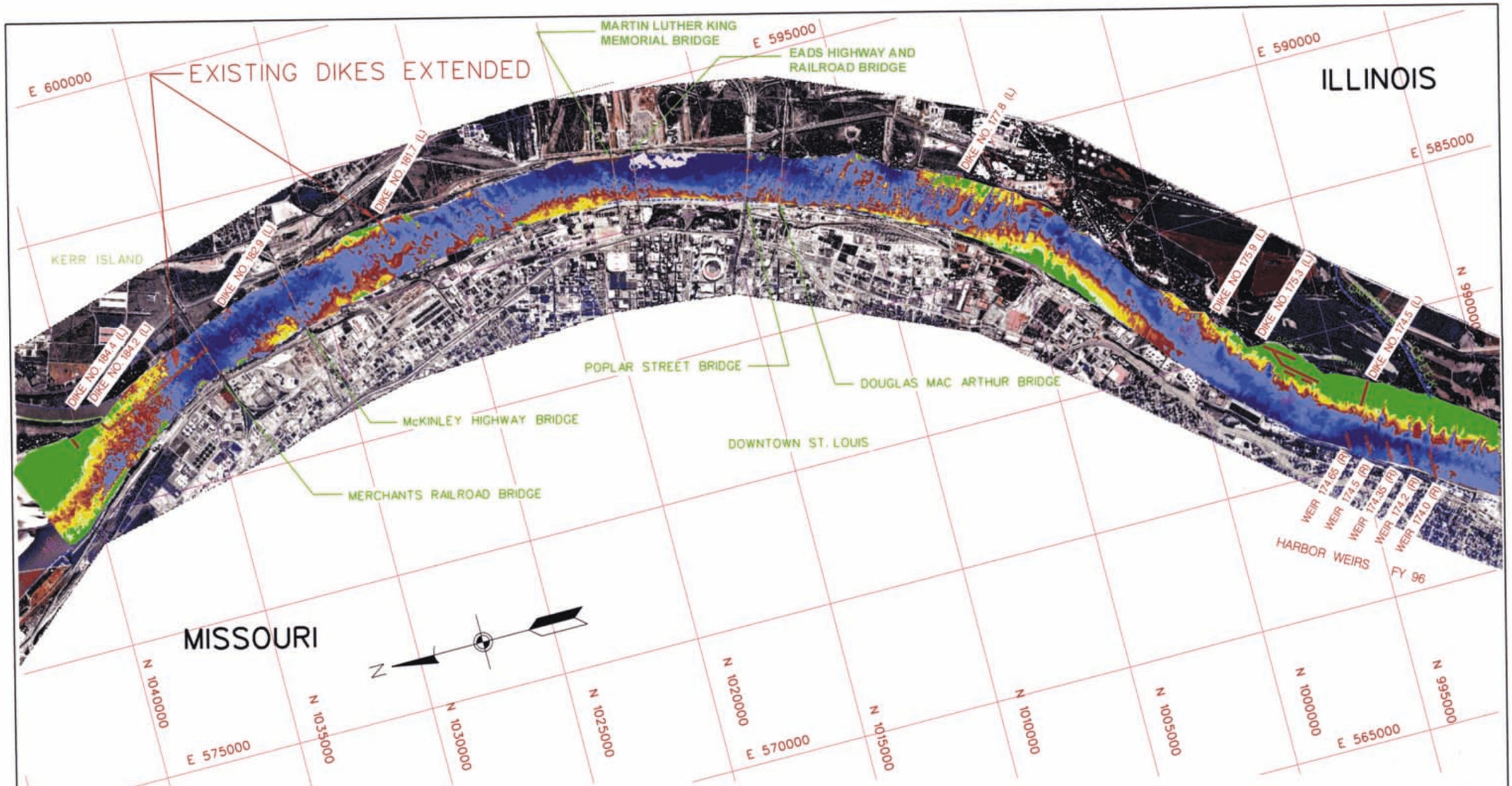
ALTERNATIVE 2

3600' 2700' 1800' 900' 0 1800' 3600'

DESIGN FILE: STLALT2B.DGN
SCALE: 1" = 3600'
PLATE NO. 50



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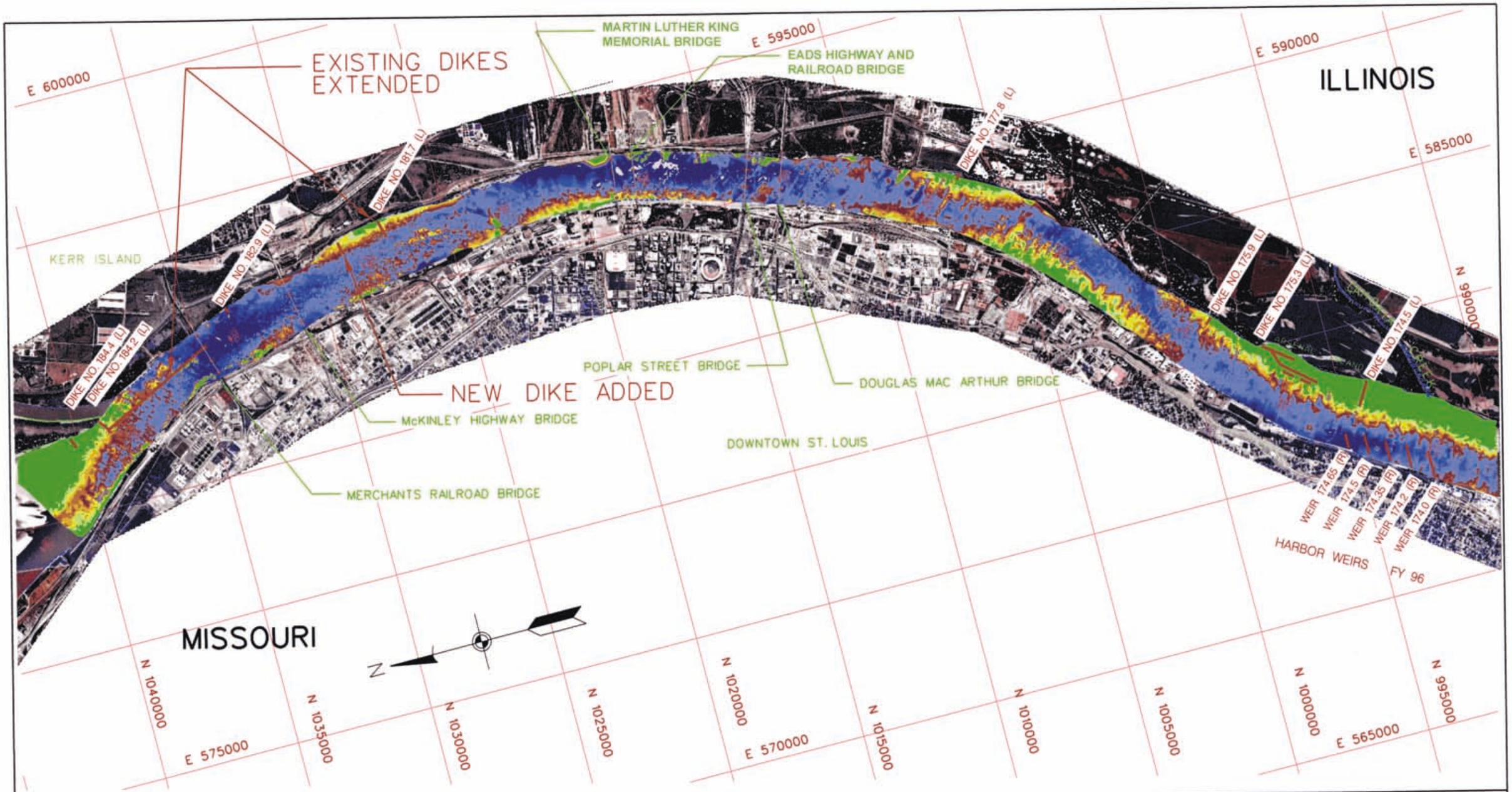
ALTERNATIVE 3

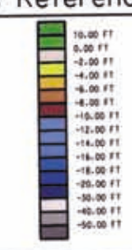
3600' 2700' 1800' 900' 0 1800' 3600'

DESIGN FILE: STLALT3.DGN
SCALE 1" = 3600'

PLATE NO. 51



Elevations Referenced to LWRP



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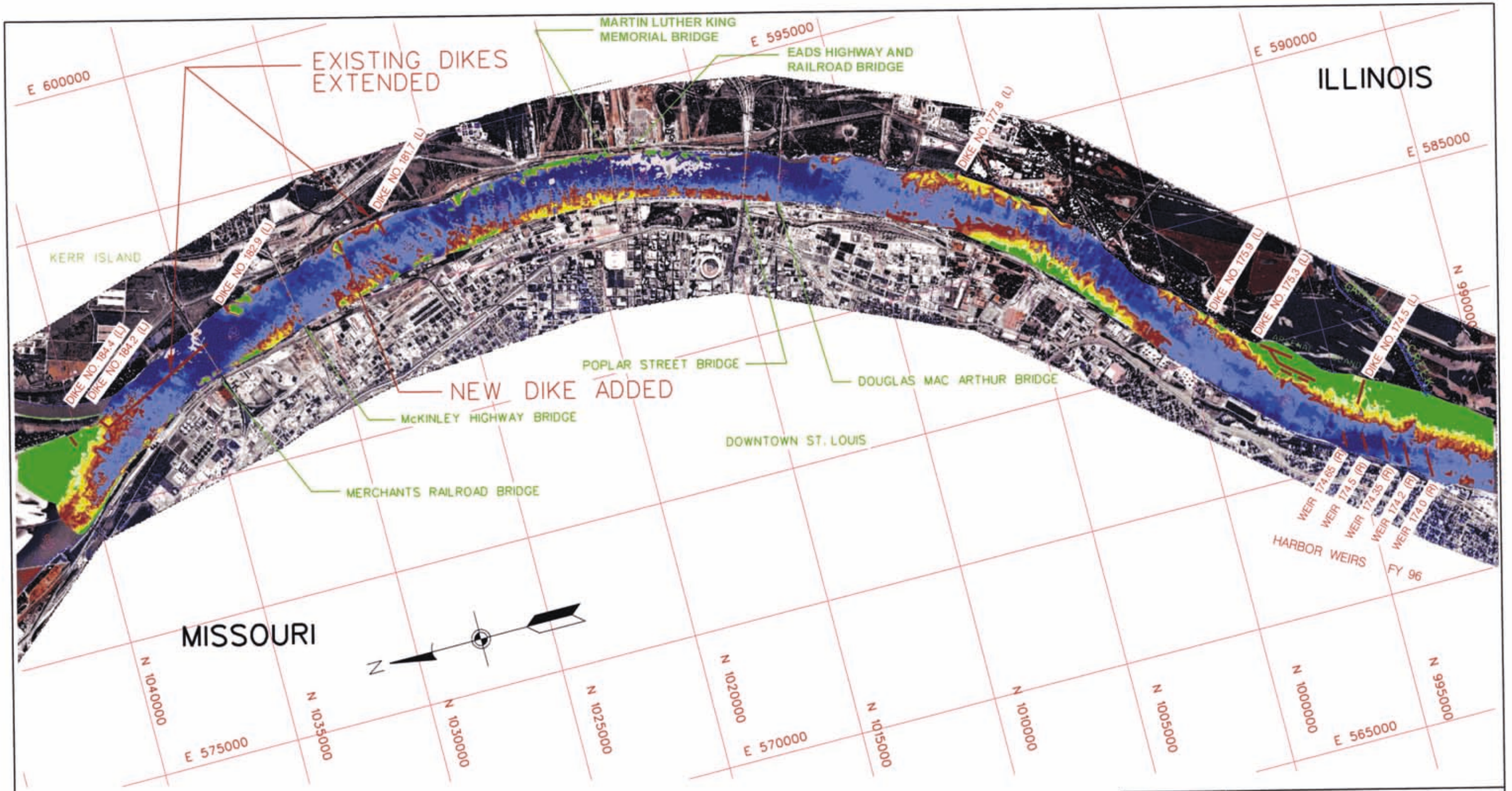
RIVER MILES 191.0 TO 172.0

ALTERNATIVE 4

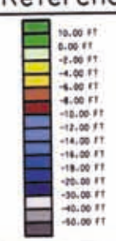
3600' 2700' 1800' 900' 0 1800' 3600'

DESIGN FILE: STLALT4.DGN
SCALE: 1" = 3600'

PLATE NO. 52



Elevations Referenced to LWRP



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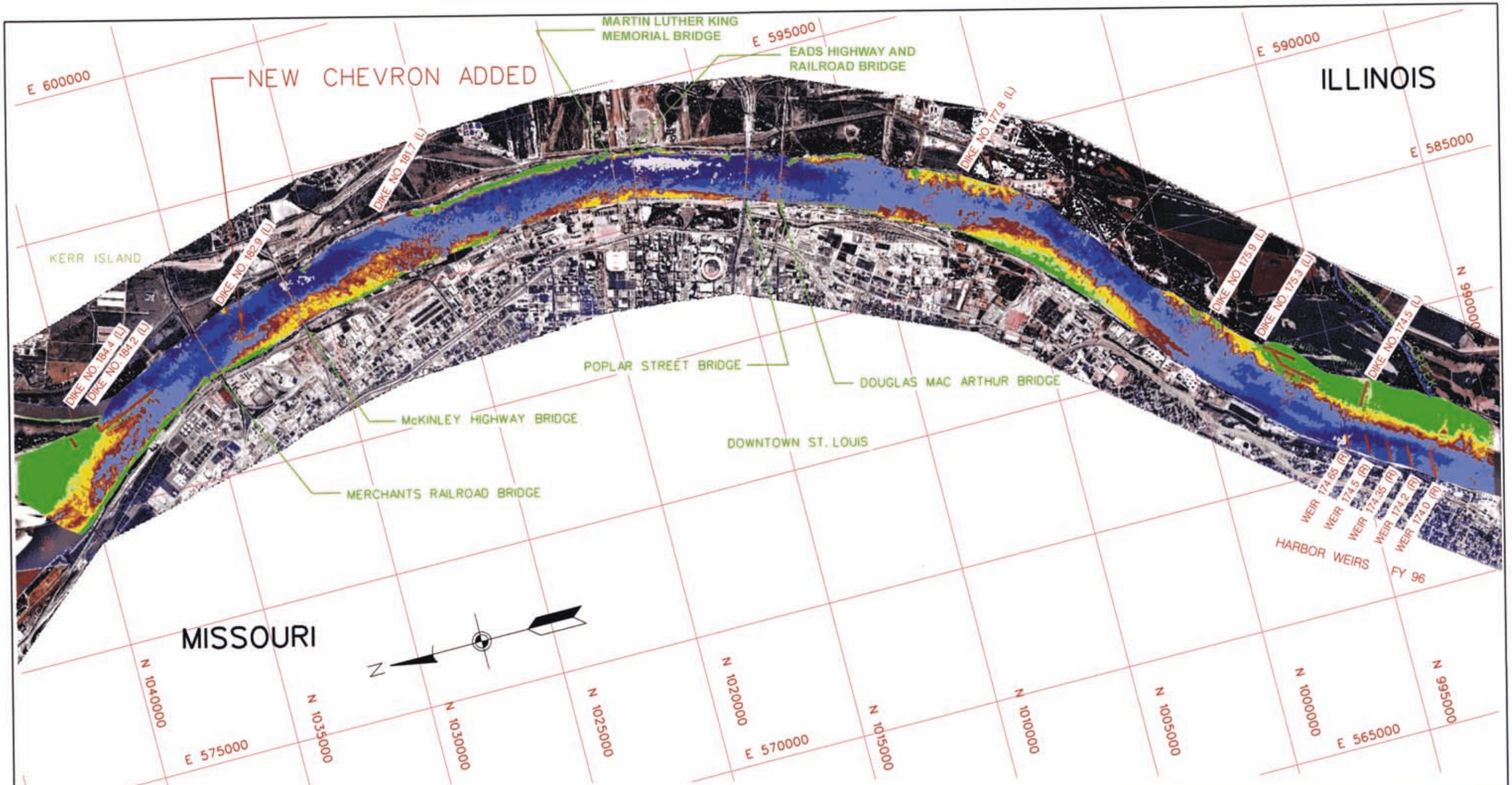
ALTERNATIVE 5

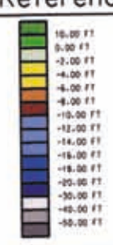
3600' 2700' 1800' 900' 0 1800' 3600'

DESIGN FILE: STLALT5B.DGN
SCALE: 1" = 3600'

PLATE NO. 53



Elevations Referenced to LWRP



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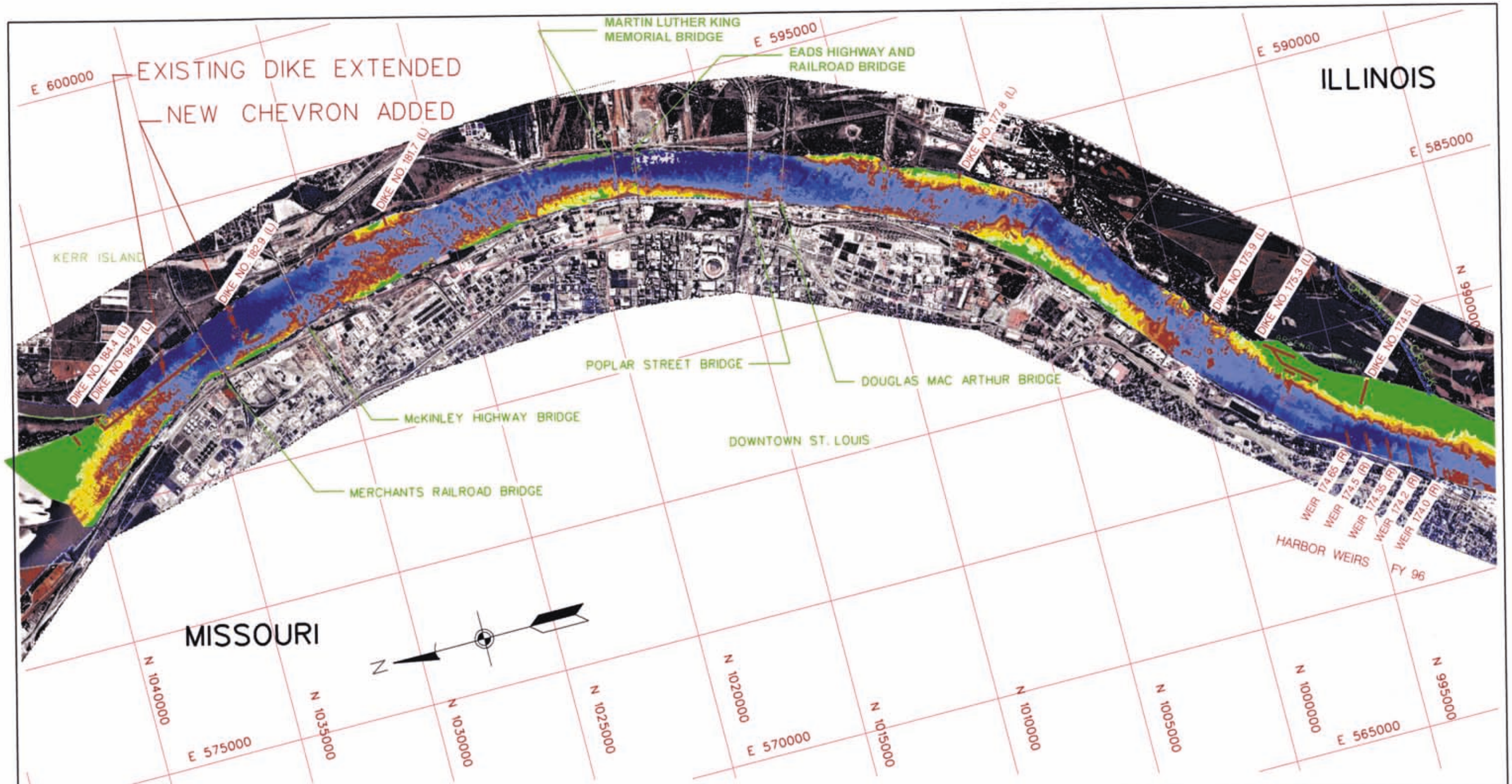
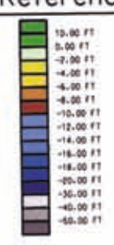
ALTERNATIVE 6

3600' 2700' 1800' 900' 0 1800' 3600'

DESIGN FILE: STLALT6.DGN
SCALE 1" = 3600'
PLATE NO. 54



Elevations Referenced to LWRP



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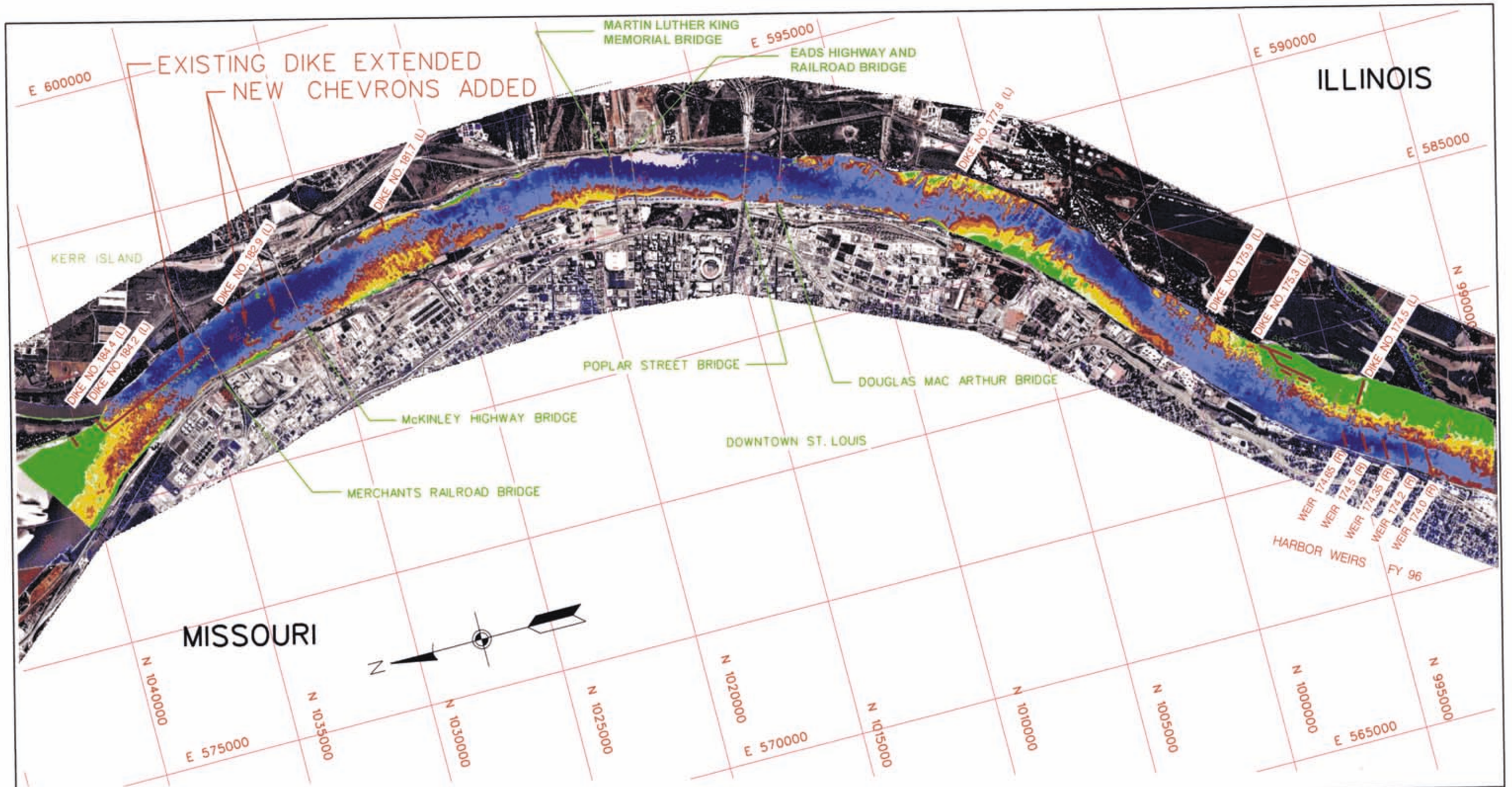
RIVER MILES 191.0 TO 172.0

ALTERNATIVE 7

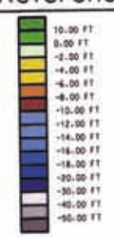
3600' 2700' 1800' 900' 0 1800' 3600'

DESIGN FILE: STLALT7.DGN
SCALE : 1" = 3600'

PLATE NO. 55



Elevations Referenced to LWRP



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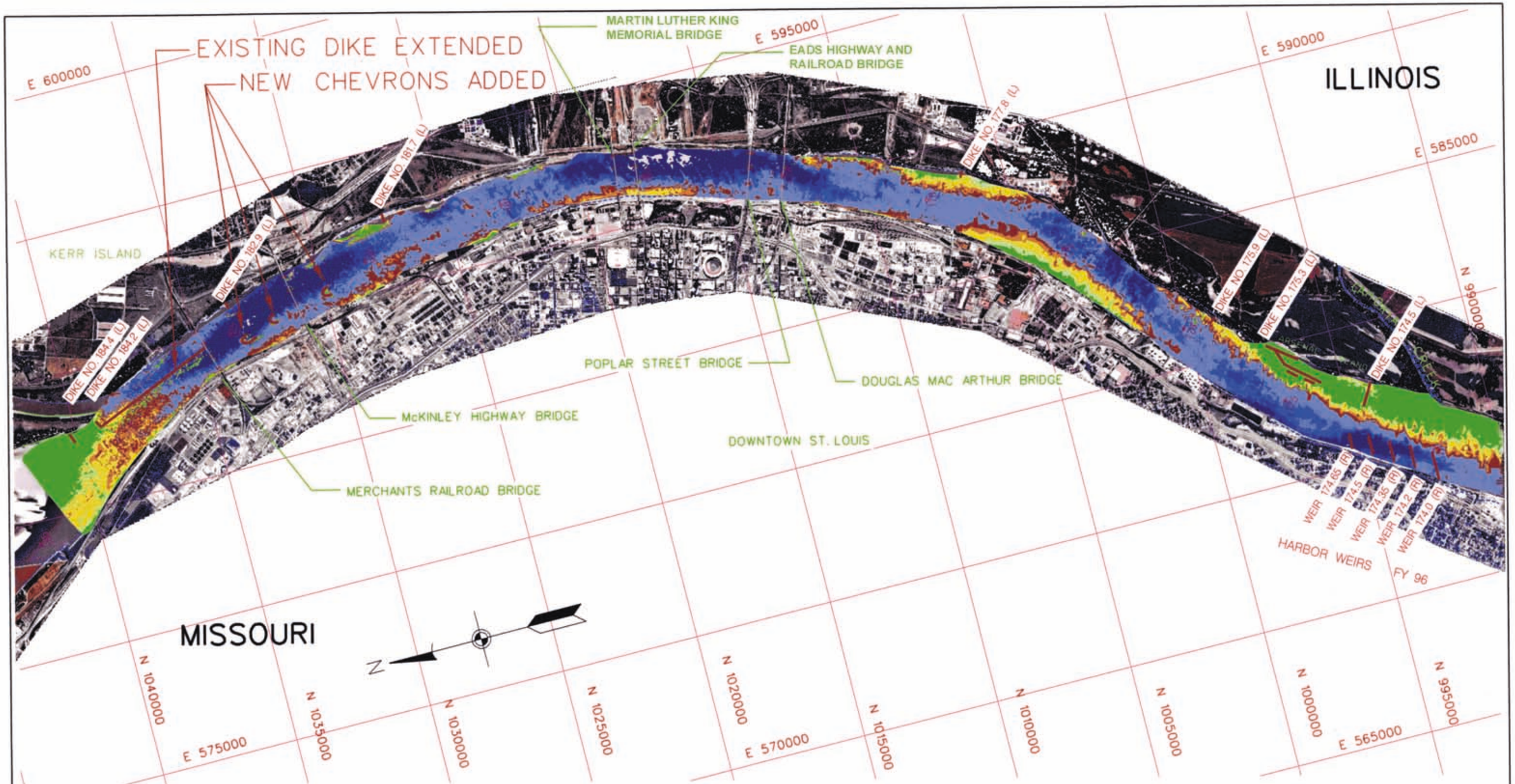
RIVER MILES 191.0 TO 172.0

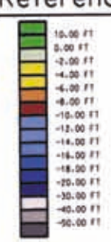
ALTERNATIVE 8

3600' 2700' 1800' 900' 0 1800' 3600'

DESIGN FILE: STLALT8.DGN
SCALE : 1" = 3600'
PLATE NO. 56



Elevations Referenced to LWRP



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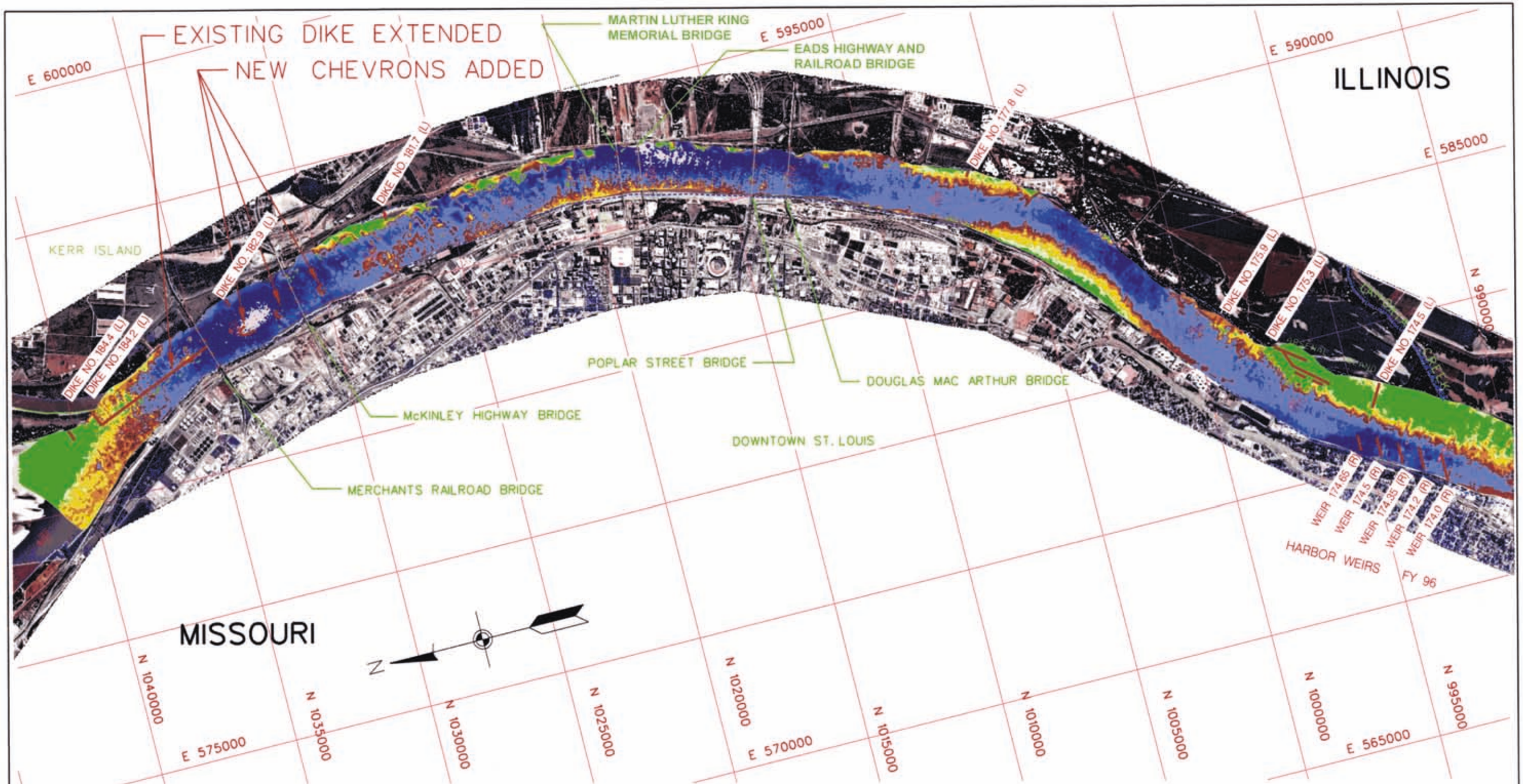
RIVER MILES 191.0 TO 172.0

ALTERNATIVE 9

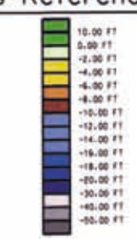
3600' 2700' 1800' 900' 0 1800' 3600'

DESIGN FILE: STLALT9.DGN
SCALE: 1" = 3600'

PLATE NO. 57



Elevations Referenced to LWRP



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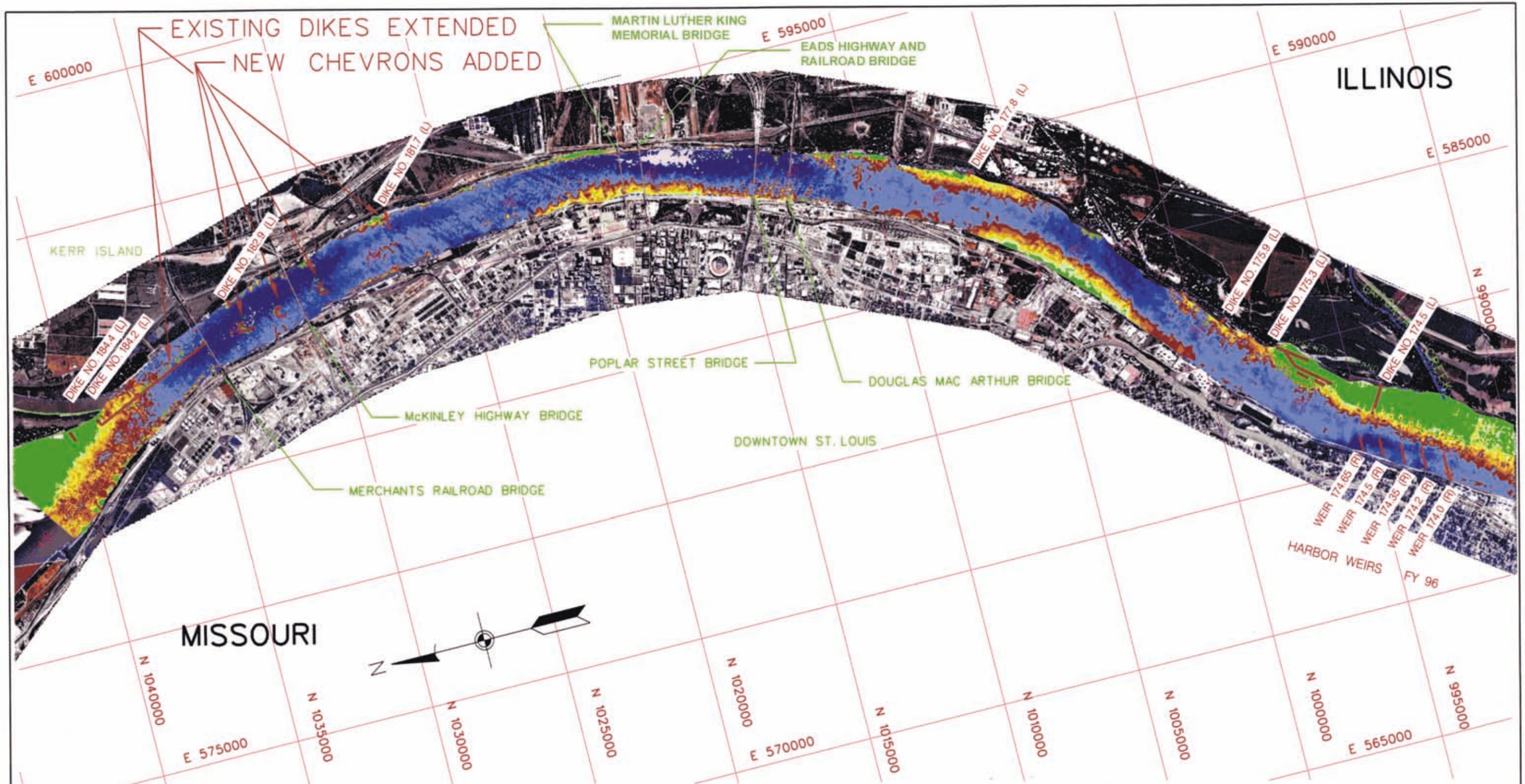
RIVER MILES 191.0 TO 172.0

ALTERNATIVE 10

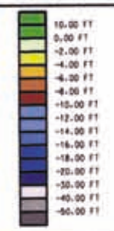
3600' 2700' 1800' 900' 0 1800' 3600'

DESIGN FILE: STLALT10.DGN
SCALE: 1" = 3600'

PLATE NO. 58



Elevations Referenced to LWRP



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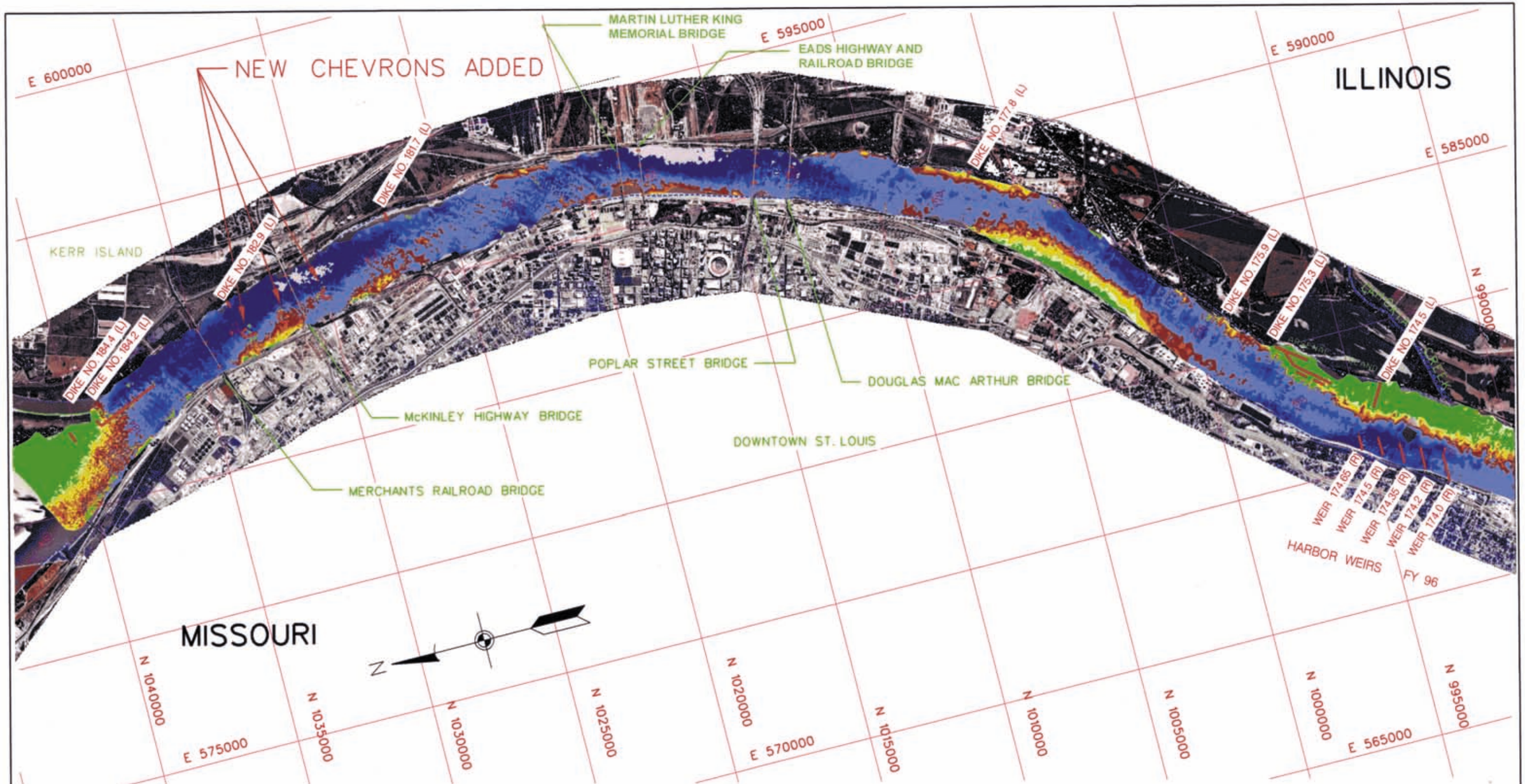
RIVER MILES 191.0 TO 172.0

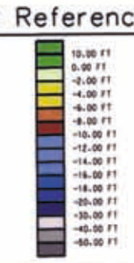
ALTERNATIVE 11

3600' 2700' 1800' 900' 0 1800' 3600'

DESIGN FILE:STLALT11.DGN
SCALE : 1" = 3600'
PLATE NO. 59



Elevations Referenced to LWRP



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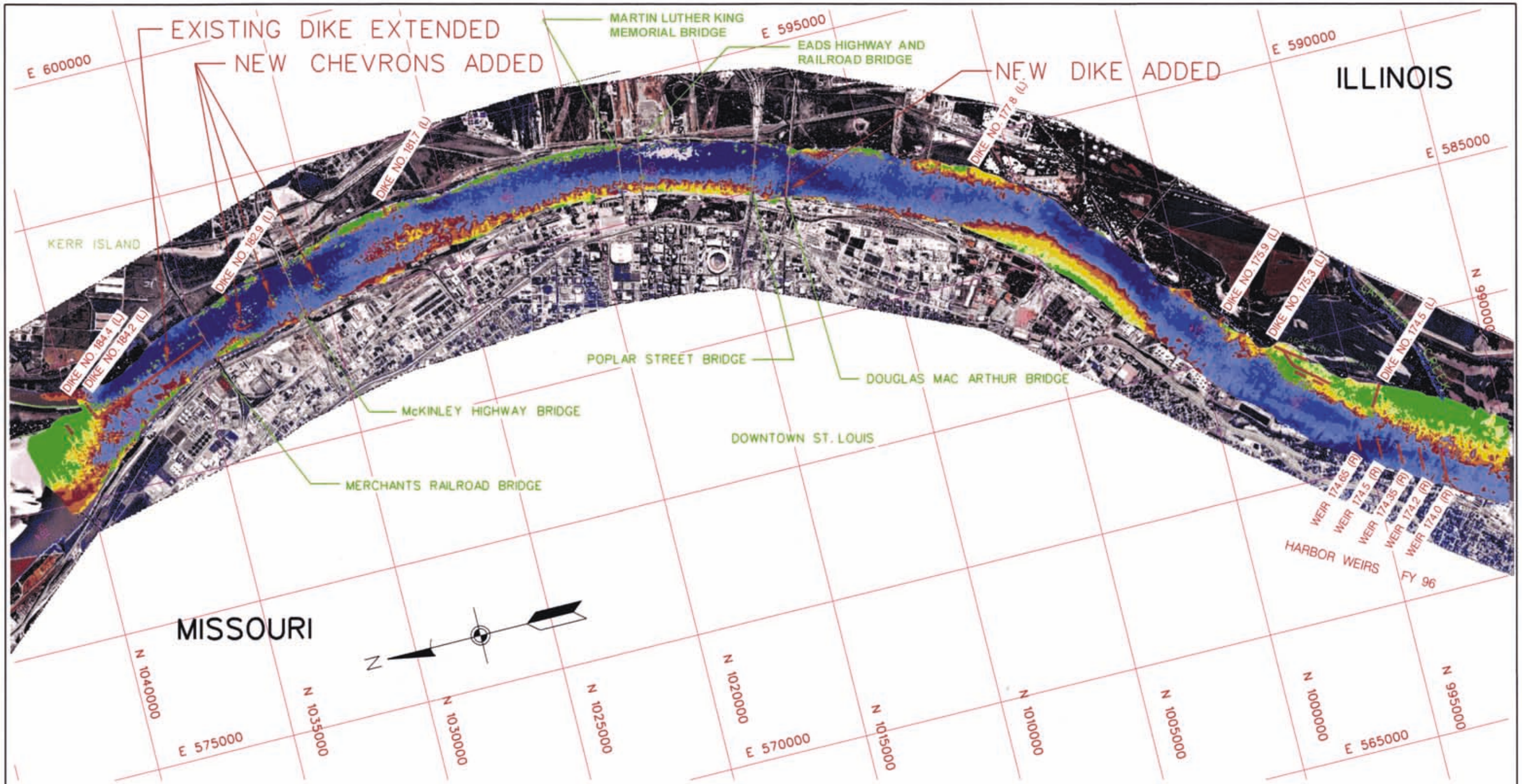
RIVER MILES 191.0 TO 172.0

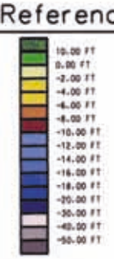
ALTERNATIVE 12

3600' 2700' 1800' 900' 0 1800' 3600'

DESIGN FILE: STLALT12.DGN
SCALE 1" = 3600'
PLATE NO. 60



Elevations Referenced to LWRP



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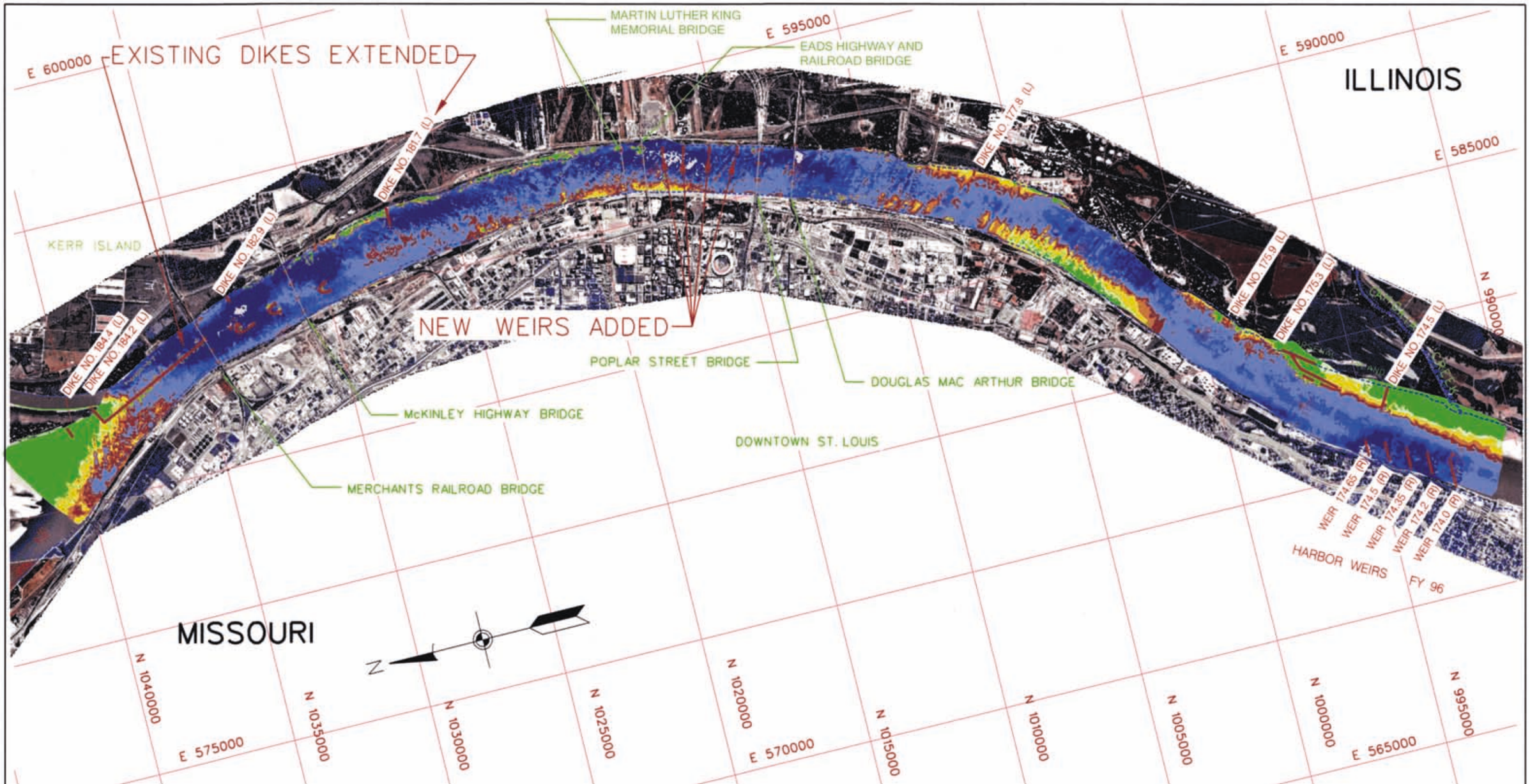
RIVER MILES 191.0 TO 172.0

ALTERNATIVE 13

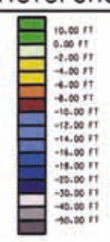
3600' 2700' 1800' 900' 0 1800' 3600'

DESIGN FILE: STLALT13.DGN
SCALE: 1" = 3600'

PLATE NO. 61



Elevations Referenced to LWRP



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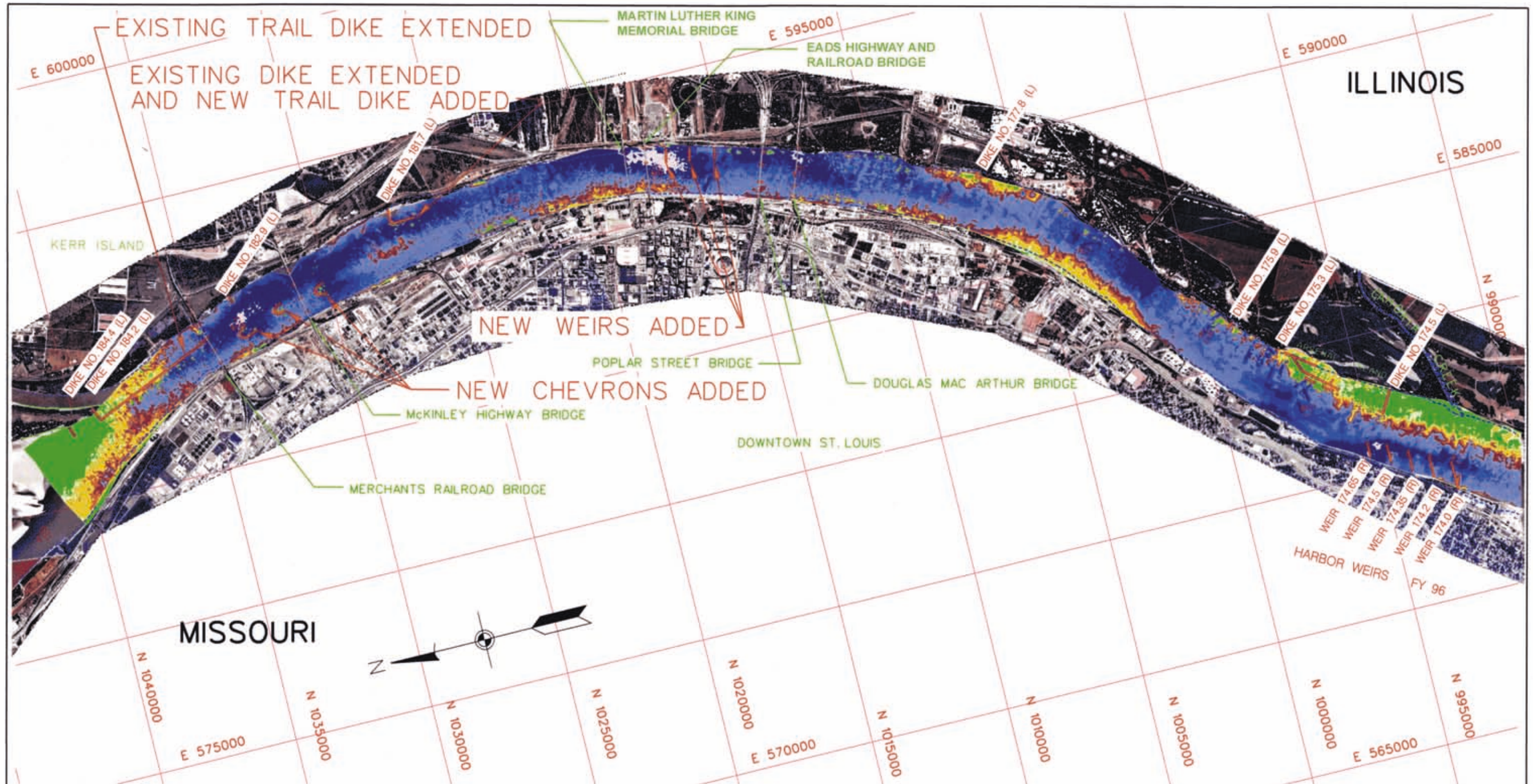
RIVER MILES 191.0 TO 172.0

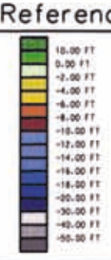
ALTERNATIVE 14

3600' 2700' 1800' 900' 0 1800' 3600'

DESIGN FILE: STLALT14.DGN
SCALE: 1" = 3600'
PLATE NO. 62



Elevations Referenced to LWRP



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RIVER MILES 191.0 TO 172.0

ALTERNATIVE 15

3600' 2700' 1800' 900' 0 1800' 3600'

DESIGN FILE: STLALT15.DGN
SCALE: 1" = 3600'

PLATE NO. 63

EXISTING TRAIL DIKE EXTENDED

EXISTING DIKE EXTENDED AND NEW TRAIL DIKE ADDED

MARTIN LUTHER KING MEMORIAL BRIDGE

EADS HIGHWAY AND RAILROAD BRIDGE

ILLINOIS

MISSOURI

KERR ISLAND

DIKE NO. 184.4 (L)

DIKE NO. 184.2 (L)

DIKE NO. 182.9 (L)

DIKE NO. 181.7 (L)

DIKE NO. 177.8 (L)

DIKE NO. 175.9 (L)

DIKE NO. 175.3 (L)

DIKE NO. 174.5 (L)

NEW WEIRS ADDED

NEW CHEVRONS ADDED

POPLAR STREET BRIDGE

DOUGLAS MAC ARTHUR BRIDGE

McKINLEY HIGHWAY BRIDGE

MERCHANTS RAILROAD BRIDGE

DOWNTOWN ST. LOUIS

NEW WEIRS ADDED

WEIR 174.65 (R)

WEIR 174.5 (R)

WEIR 174.35 (R)

WEIR 174.2 (R)

WEIR 174.0 (R)

HARBOR WEIRS FY 96

E 595000

E 590000

E 585000

E 575000

E 570000

E 565000

N 1040000

N 1035000

N 1030000

N 1025000

N 1020000

N 1015000

N 1010000

N 1005000

N 1000000

N 995000

N

Elevations Referenced to LWRP

10.00 FT
0.00 FT
-2.00 FT
-4.00 FT
-6.00 FT
-8.00 FT
-10.00 FT
-12.00 FT
-14.00 FT
-16.00 FT
-18.00 FT
-20.00 FT
-30.00 FT
-40.00 FT
-50.00 FT

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

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

ST. LOUIS HARBOR MICRO MODEL STUDY
RIVER MILES 191.0 TO 172.0

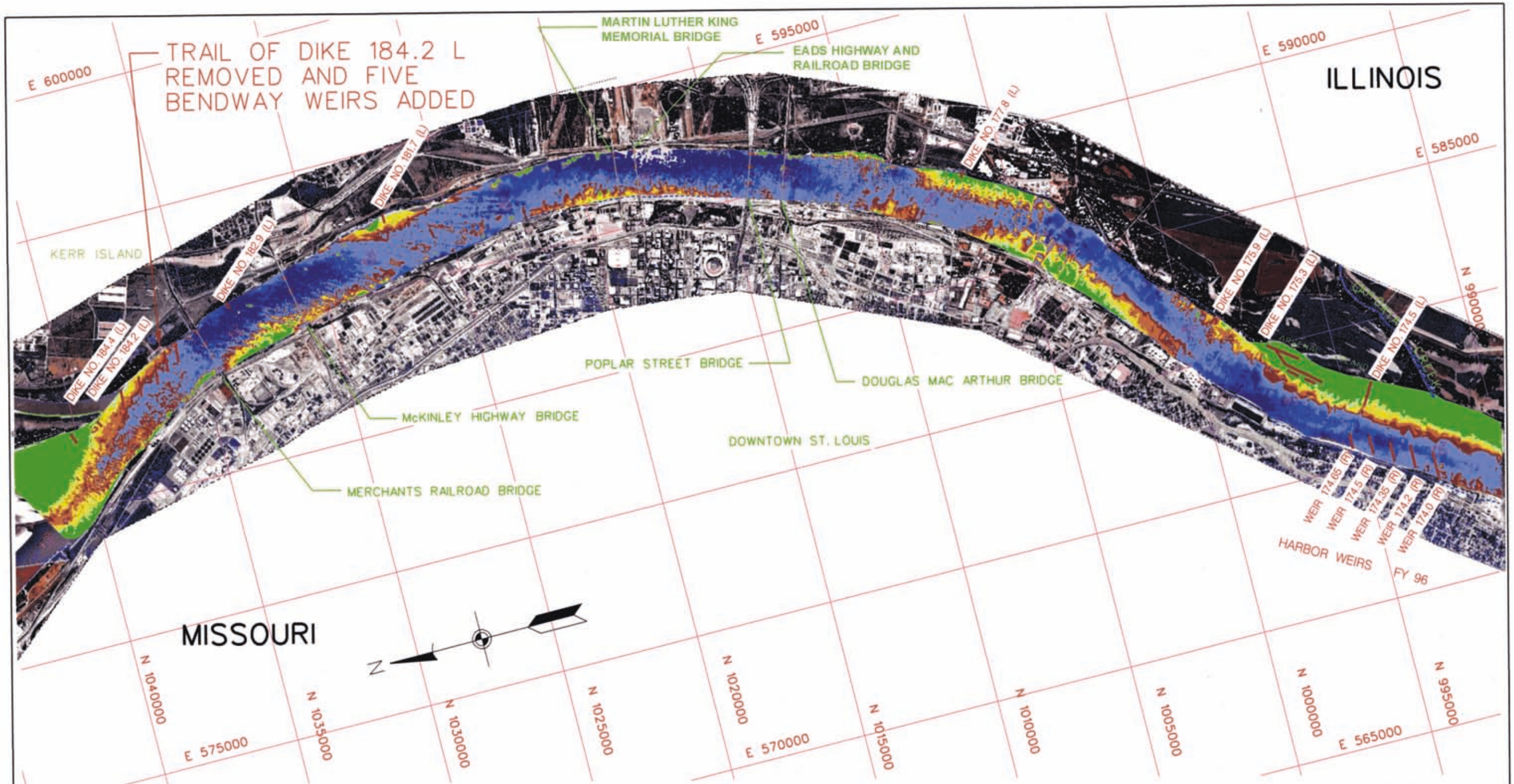
ALTERNATIVE 16

3600' 2700' 1800' 900' 0 1800' 3600'

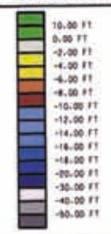
DESIGN FILE: STLALT16.DGN

SCALE 1" = 3600'

PLATE NO. 64



Elevations Referenced to LWRP



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

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

ST. LOUIS HARBOR MICRO MODEL STUDY
RIVER MILES 191.0 TO 172.0

ALTERNATIVE 17

3600' 2700' 1800' 900' 0 1800' 3600'

DESIGN FILE: STLALT17.DGN
SCALE: 1" = 3600'

PLATE NO. 65