Technical Report M17

SEDIMENTATION STUDY OF THE MIDDLE MISSISSIPPI RIVER AT JEFFERSON BARRACKS RIVER MILES 176.0 TO 166.0

HYDRAULIC MICRO MODEL INVESTIGATION

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INTRODUCTION

The U.S. Army Corps of Engineers, St. Louis District initiated a side channel study of the Middle Mississippi River between Miles 176.0 and 166.0 near Jefferson Barracks, Missouri. The purpose of the study was to evaluate environmental design alternatives for the development of side channel and island habitat, utilizing an existing dike field on the Mississippi River.

The study was conducted between June 2000 and February 2001 by Ms. Dawn Lamm, Hydraulic Engineer, and Mr. Aron Rhoads, Engineering Technician, under direct supervision of Mr. David C. Gordon, Hydraulic Engineer and Mr. Robert D. Davinroy, District Potamologist. Other personnel also involved with the study included: Mr. Stephen Redington and Mr. Leonard Hopkins from the River Engineering Unit of the Hydrologic and Hydraulics Branch; Mr. T. Miller, Mr. Brian Johnson, Mr. Kenneth Dalrymple, and Mr. Eric Laux from the Environmental Branch of the Planning, Programs, and Project Management Division; Mr. Mike Thompson, Mr. Thomas Quigley, and Mr. Michael Kruckeberg of the Project Management Division; and Mr. Gary Lee of the Engineering Division, Design Branch. Personnel from other agencies involved in the study included: Mr. Scott Stuewe and Mr. Butch Atwood from the Illinois Department of Natural Resources, and Ms. Joyce Collins and Ms. Myra Miyoshi from the U.S. Fish and Wildlife Service.

Personnel representing the river industry included: Mr. Tommy Seals, private consultant; 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 Mr. Matt French and Mr. David Cook of ARTCO.

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BACKGROUND

This report details the investigation of a side channel study of the Middle Mississippi River using a physical hydraulic micro model. Micro modeling methodology was used to evaluate the existing sediment transport conditions and the impact of various design measures to improve environmental conditions in the Jefferson Barracks reach of the Mississippi River.

1. Study Reach

The study reach was located approximately three miles south of downtown St. Louis, Missouri. The study comprised a 10-mile stretch of the Middle Mississippi River, between Miles 176.0 and 166.0. Plate 1 is a location and vicinity map of the study reach. The study area was located in St. Louis County in Missouri, and St. Clair and Monroe Counties in Illinois. The reach is part of the greater St. Louis Harbor, which is an important fleeting area for the large amount of terminal facilities located in the St. Louis area.

At the time of this study, the Jefferson Barracks (JB) Dike Field consisted of five rock structures located along the left descending bankline (LDB). Plate 2 shows oblique aerial photographs depicting the upstream and downstream views of this dike field. The structures were located at Miles 170.9 L, 170.4 L, 170.0 L, 169.45 L, and 169.5 L. The structures ranged from 800 feet to 1000 feet in length with trails ranging from 400 feet to 500 feet in length. Each dike had one to three notches and barge anchors were located at the end of each trail. A large depositional area was located within the dike field.

Plate 3 is a 1994 aerial photograph illustrating the characteristics, configuration, and nomenclature of the Mississippi River between Miles 176.0 and 166.0. Additional features in the study reach included the JB Bridge, at Mile 168.6, and the mouth of

River Des Peres, at Mile 171.9 R. JB Chute was located at the lower end of the reach, between Miles 167.6 L and 166.7 L.

Fleeting areas and loading/unloading facilities were located throughout this section of the river. Dike 168.5 L, located immediately downstream from JB Bridge, had a small fleet of barges anchored to the trail at the time of the study.

The following table details the specific dimensions and characteristics of the JB Dikes. (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.)

Dike/Mile	Elevation (Feet LWRP)	Dike Length	Trail Length	Notch Width	Notch Invert Elevation (Feet LWRP)
170.9 L	+ 13	1000 ft.	400 ft.	200 ft.	+ 9
170.4 L	+ 14	1000 ft.	500 ft.	150 ft. 100 ft.	+ 8 + 9
170.0 L	+ 15	900 ft.	500 ft.	100 ft. 150 ft.	+ 11 + 10
169.45 L	+ 15	1000 ft.	400 ft.	100 ft. 100 ft. 100 ft.	+ 12 + 10 + 10
169.5 L	+ 18	800 ft.	400 ft.	150 ft.	+ 13

2. Problem Description

The area of concern in the study reach began along the LDB at Mile 172.0 and extended downstream to Mile 168.0. There have been two problems associated with this area. The first involved a lack of aquatic diversity within the existing dike field. The high elevations of the existing sandbar meant that the area was dry a majority of the time. Although the dikes had been notched in the past, there was still a lack of depth diversity and side channel formation throughout the dike field. The second problem involved recurring deposition in the adjacent navigation channel, between Miles 172.0 and 170.5. Repetitive maintenance dredging had been required in this reach to maintain adequate depths in the navigation channel. Over the past 10 years, nearly 2,245,000 cubic yards of material was dredged at an approximate cost of $3,600,000. Dredging issues within the St. Louis Harbor have always been difficult to address due to the presence of numerous fleeting areas and facilities located throughout the river channel. In the past, the navigation industry had been reluctant to relinquish these fleeting areas for additional dike construction.

3. History

Past hydrographic surveys of the study reach have indicated that the navigation channel has historically remained along the right descending bank (RDB). However in recent years, depths in the thalweg appeared to have decreased, particularly between Miles 171.6 and 169.3. Hydrographic surveys from 1959 showed adequate depths in the navigation channel at Mile 171.0. However, surveys from 1969/1971 and 1987 indicated that the navigation channel had experienced significant deposition with a subsequent decrease in depth. There were no obvious indicators as to the cause of the decrease in depth in this reach of the river. Because the channel width in this area was significantly larger than other areas, slight increases in width could possibly explain the development of this problem. To contend with the repetitive maintenance dredging needed to artificially increase depths, the JB Dike Field was constructed in 1992.

4. Study Purpose and Goals

The purpose of this study was to design structural modifications to the existing JB Dike Field to enhance the physical diversity and flow dynamics within the reach. The study was performed to address two separate sediment transport goals. The first goal was to create island and side channel aquatic habitat within the dike field. The second goal was to increase depths in the adjacent navigation channel to reduce repetitive maintenance dredging.

5. Mile 100 Dike Field and Islands

The creation of isolated islands within a dike field was successfully accomplished at the Mile 100 Dike Field on the Middle Mississippi River (Plate 4). This area was the only known reach where small islands were purposely formed by a set of notched dikes. Therefore, the dimensions of these dikes were researched and their bathymetric influences were studied. These dikes and islands were examined for the purpose of designing notches in other dike fields that would possibly have a similar effect. Although it was desired that a comparable set of islands be developed at Jefferson Barracks, greater depths in the secondary channels were required.

The Mile 100 Dike Field was located between Mile 100.6 and Mile 98.9. The area consisted of 6-notched dikes and 5 islands. The dikes were built in the early 1970's for the purpose of sediment management and channel improvement. Notches were designed in the dikes at the time of construction with the intent of creating a scour pattern that would eventually form a secondary channel. The notches were designed to pass flows approximately 50% of the time. Scour holes developed immediately downstream of the notches with the scoured material depositing further downstream. These depositional areas eventually increased in size and elevation until vegetation became established. These areas finally became terrestrial with distinct island boundaries. The formation of backwater areas between the islands and the floodplain followed.

The entire Mile 100 Dike Field consisted of 8 dikes ranging in length from 500 to 1300 feet. Dike 100.6 had a top elevation of + 4 feet LWRP and Dike 100.4 was at +13 feet LWRP. The remaining dikes, Dikes 100.1R through 98.9 R, had an average elevation of +17 feet LWRP. Dikes 100.6 R, 100.1 R, and 98.9 R, had trails that ranged in length from 200 to 1300 feet. Dikes 100.1 R through 98.9 R contained notches that ranged in width from 150 to 320 feet with invert elevations of

+10 to +11 feet LWRP. The following table describes the dimensions of these dikes in detail:

Dike/Mile	Element	Elevation (Feet LWRP)	Dike Length	Trail Length	Notch Width	Notch Invert Elevation (Feet LWRP)
100.6 R	Dike with Trail	+4	500 ft.	200 ft.	No Notch	
100.4 R	Dike	+13	900 ft.		No Notch	
100.1 R	Notched Dike with Trail	+15 to +25 Average = +17	900 ft.	500 ft.	150 ft.	+10
99.9 R	Notched Dike	+15 to +20 Average = +17	900 ft.		150 ft.	+11
99.8 R	Notched Dike	+10 to +22 Average = +17	900 ft.		150 ft.	+11
99.6 R	Notched Dike	+14 to +22 Average = +17	1000 ft.		200 ft.	+10
99.2 R	Notched Dike	+14 to +22 Average = +17	1300 ft.		320 ft.	+10
98.9 R	Notched Dike with Trail	+10 to +21 Average = +18	1200 ft.	1300 ft.	300 ft.	+10

In 2000, a field survey (Plates 5, 6, and 7) was conducted of the islands and dikes. In 1999, a hydrographic channel sweep survey (Plate 8) was conducted of the dike field and secondary channels. The surveys indicated that depths in the side channels between the islands and floodplain were generally between +5 and +15 feet LWRP. However, these areas were connected to the main channel through a series of deep plunge pools formed downstream of the dikes. Depths in these scour areas were between –25 and –35 feet LWRP.

The Mile 100 Islands were located at Mile 100.0 R, 99.85 R, 99.7 R, 99.4 R, and 99.0 R. The islands ranged in size from 2.0 acres to as large as 11.0 acres. It has been estimated that vegetation probably became established on these depositional areas 10 to 20 years after dike construction. Denser vegetation assisted in greater deposition, which raised the islands to even higher elevations. The highest average point on the islands was just over +30 feet LWRP, with vegetation beginning as low as +19 feet LWRP. The wetted perimeter of the islands ranged between 460 and 1290 feet. The following table describes the dimensions of the islands:

Island/ Mile	Approximate Size of Island (acres)	Highest Elevation (Feet LWRP)	Elevation Vegetation Begins at (Feet LWRP)	Approximate Wetted Perimeter (Feet)
100.0 R	~ 2.5	+30	+21	460
99.85 R	~ 2.0	+30	+20 to +30	440
99.7 R	~ 2.5	+31	+19 to +21	700
99.4 R	~ 5.5	+31	+13 to +27	1200
99.0 R	~ 11.0	+29	+19 to +21	1290

The dimensions of the Mile 100 Dikes, including dike height, notch configuration, and distance between dikes, were considered for the alternative designs of the JB Dike Field. However, the multiple differences between the two reaches of river were also considered. While the Mile 100 Dike Field encompassed a distance of 1.7 miles and contained 8 dikes, the JB Dike Field encompassed 2.5 miles and contained 5 dikes. The Mile 100 Dike Field was located on the inside of the beginning of a slight bend, while the JB Dike Field was located in a relatively straight reach. The Mile 100 Dikes were also angled slightly downstream as opposed to the perpendicular orientation of the JB Dikes. In addition, the Mile 100 Dike Field was located in a rural area, while the JB Dike Field was located in a functioning harbor where proposed designs would have to accommodate fleeting and terminal operations.

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 9 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 = 100 feet, or 1:1200, for an 8 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 plastic urea, Type II, with a specific gravity of 1.40.

2. Appurtenances

The micro model insert was constructed according to the 1998 high-resolution aerial photography of the study reach shown on Plate 3. 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. Rotational jacks located within the hydraulic flume controlled the slope of the model. The measured slope of the insert and flume was approximately 0.006 inch/inch. 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 0.9 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 10 through 16 are plan view hydrographic survey maps of the Mississippi River from 1959, 1969/1971, 1986/1987, 1993, 1995, 1996, and 1998, respectively. Detailed channel sweep surveys were also conducted over the dike field, between Miles 171.0 and 168.0, in 1995 and 1999 (Plates 17 and 18). All of these surveys showed that the thalweg of the main channel had always been located along the RDB throughout the reach. However, a minor shoaling area was also always observed downstream of the confluence with the River Des Peres along the RDB.

The bathymetry of the most recent prototype surveys (1995, 1996, and 1998) were very similar to each other and were used to calibrate the micro model. The thalweg was well defined along the RDB, with depths below -20 feet LWRP, between Miles 172.8 and 172.1. A large sandbar was located along the LDB in each survey, from Miles 171.5 to below the JB Bridge at Mile 167.7. A scour hole was observed off the end of Dike 170.9L, with depths below –20 feet LWRP.

Plate 19 shows bathymetric elevation changes that occurred between the 1995 and 1999 channel sweep surveys. The various colors on the map represent either aggradation or degradation of the riverbed during this period of time. The warm colors (yellows, oranges, and reds) represent aggradation. The cool colors (shades of blue) represent degradation. Gray represents areas that contained elevation changes between +2 and –2 feet, which was considered normal fluctuations in the riverbed and did not represent long-term trends. This analysis indicated that the dike field had experienced significant aggradation just upstream and downstream of the JB Bridge with a maximum increase of over 18 feet. Other areas of aggradation were located between Dikes 170.4L, 170.0L and 169.45L. Minor aggradation occurred in areas between Dikes 170.9 L and 170.4 L. Minor areas of degradation occurred throughout the dike field. The comparison did not indicate possible development of isolated islands or side channels within the current dike field.

2. Base Test

Model calibration was achieved once favorable qualitative comparisons of the prototype surveys were made to several surveys of the model. The resultant bathymetry of this bed response served as the base test of the micro model.
Plate 20 shows the resultant bed configuration of the micro model base test. The base test was developed once bed stability was reached and a similar bed response

was achieved as compared with prototype surveys. This survey then served as the comparative bathymetry for all design alternative tests.

Results of the micro model base test bathymetry and a comparison to the 1995 through 1998 prototype surveys indicated the following trends:

- The thalweg was located along the RDB from Mile 174.6 to 173.7 in a pattern similar to the prototype, but with slightly greater depths of over –30 feet LWRP as compared to the prototype depths of over –20 feet LWRP. The sandbar along the LDB within this reach was very similar in size and shape to the prototype, with depths between –10 and +10 feet LWRP.

- Between Miles 172.0 and 171.0, depths in the navigation channel along the RDB were between 0 and –10 feet LWRP. These depths were shallower than those observed in the prototype surveys. However, the prototype surveys represented an artificially maintained bed that had been repetitively dredged. The elevations in the model represented natural depths that may have occurred in the prototype without periodic dredging. The earlier historical prototype surveys indicated elevations similar to that achieved in the micro model base test in this area.

- Between Miles 170.8 and 168.0, the thalweg formed along the RDB with depths over -20 feet LWRP. This was similar to the prototype but slightly deeper.

- A large sandbar was observed along the LDB, between Miles 171.5 to below the JB Bridge at Mile 167.7, which is very similar to the bar shown in the prototype surveys. Depths on the sandbar were between –10 and +20 feet LWRP and followed trends observed on the isopach of increased aggradation at the lower end of the dike field near the bridge. A scour hole was observed off the end of Dike 170.9L, with depths between –20 and –30 feet LWRP. These depths were approximately 10 feet deeper than the depths in the prototype.

Overall, the trends of the model as observed in the base test were similar to those observed from the prototype surveys, especially within the JB Dike Field reach.

3. Design Alternative Tests

All design alternatives studied in the micro model utilized the existing dike configurations. This was due to environmental concerns and the cost required in either removing or relocating the dikes. Fifteen design alternative plans were model tested to examine methods of modifying the sediment transport response trends that would create both side channel and island habitat while also reducing dredging within the navigation channel. The effectiveness of each design was evaluated by comparing the resultant bed configuration to that of the base condition. Impacts or changes induced by each alternative were evaluated by observing the sediment response of the model. A qualitative evaluation of the ramifications to the main channel and the side channel was made during team participation meetings at the Applied River Engineering Center in St. Louis, Missouri. Personnel from the St. Louis District Corps of Engineers, Missouri Department of Conservation, Illinois Department of Natural Resources, and the U.S. Fish and Wildlife Service carefully examined and discussed each alternative.

Alternative 1: *In an attempt to simulate the bed configuration of the Mile 100 Islands, the existing dikes were raised to a height of +17 feet LWRP and had 150-foot wide notches with invert elevations of +5 feet LWRP, located near the bankline. Dike trails were not altered.*

- *Dike 1: 1050 feet in Length on the Left Descending Bankline (LDB) at Mile 170.9, 150-foot notch near the bankline*
- *Dike 2: 1100 feet in Length on the LDB at Mile 170.4, 150-foot notch near the bankline.*
- *Dike 3: 900 feet in Length on the LDB at Mile 170.0, 150-foot notch near the bankline.*

- *Dike 4: 1100 feet in Length on the LDB at Mile 169.45, 150-foot notch near the bankline.*
- *Dike 5: 1150 feet in Length on the LDB at Mile 168.5, 150-foot notch near the bankline.*

Plate 21 is a plan view map of the resultant bed configuration of Alternative 1. The test results indicated that this design was not effective in creating a side channel complex. The notches in the dikes along the bankline did not allow sufficient flow to form a distinct side channel. The design also did not increase depths in the navigation channel adjacent to and upstream of Dike 170.9 L. Depths in the navigation channel near the JB Bridge decreased slightly.

Alternative 2: *The existing dikes were maintained at a height of +17 feet LWRP. The dikes had 150-foot wide notches with invert elevations of +5 feet LWRP, located near the bankline. Additional notches with the same dimensions were located near the midpoint of each dike.*

Plate 22 is a plan view map of the resultant bed configuration of Alternative 2. The test results indicated that this design was not effective in creating a side channel complex. The notches in the dikes did not allow sufficient flow to form a distinct side channel. The design also did not increase depths in the navigation channel adjacent to and upstream of Dike 170.9 L. Depths in the navigation channel near the JB Bridge decreased slightly.

Alternative 3: *Existing dikes were raised to +25 feet LWRP and had 150-foot wide notches with invert elevations of +5 feet LWRP, located near the midpoint of each dike.*

Plate 23 is a plan view map of the resultant bed configuration of Alternative 3. The test results indicated that this design was not effective in creating a side channel complex. The notches in the dikes did not allow sufficient flow to form a distinct side channel. The design also did not increase depths in the navigation channel adjacent to and upstream of Dike 170.9 L. Depths in the navigation channel near the JB Bridge decreased slightly.

Alternative 4-A: *Dike 170.9 L was raised to +19 feet LWRP and the subsequent dikes were gradually lowered. Dike 169.45 L was lowered to an elevation of +13 feet LWRP. The dikes had 200-foot wide notches that were located 100 feet from the bankline with invert elevations of +9 feet LWRP.*

- *Dike 1: 1050 feet in Length at Mile 170.9 L, +19 feet LWRP, 200-foot notch, invert elevation of +9 feet LWRP, starting 100 feet from the bankline.*
- *Dike 2: 1100 feet in Length at Mile 170.4 L, +17 feet LWRP, 200-foot notch, invert elevation of +9 feet LWRP, starting 100 feet from the bankline.*
- *Dike 3: 900 feet in Length at Mile 170.0 L, +15 feet LWRP, 200-foot notch, invert elevation of +9 feet LWRP, starting 100 feet from the bankline.*
- *Dike 4: 1100 feet in Length at Mile 169.45 L, +13 feet LWRP, 200-foot notch, invert elevation of +9 feet LWRP, starting 100 feet from the bankline.*
- *Dike 5: 1150 feet in Length at Mile 168.5 L, +18 feet LWRP, not altered.*

Plate 24 is a plan view map of the resultant bed configuration of Alternative 4-A. The test results indicated that this design was not effective in creating a side channel complex. The notches in the dikes near the bankline did not allow sufficient flow to form a distinct side channel. However, some scouring did occur downstream of all the dikes except Dike 170.4 L. The design also did not increase depths in the navigation channel adjacent to and upstream of Dike 170.9 L. In fact, additional deposition occurred in this area. Depths in the navigation channel near the JB Bridge decreased slightly.

Alternative 4-B: *Alternative 4-A was modified with deeper notches.*

- *Dike 1: 1050 feet in Length at Mile 170.9 L, +19 feet LWRP, 200 foot notch, invert elevation +5 feet LWRP, starting 100 feet from the bankline*
- *Dike 2: 1100 feet in Length at Mile 170.4 L, +17 feet LWRP, 200 foot notch, invert elevation +5 feet LWRP, starting 100 feet from the bankline*
- *Dike 3: 900 feet in Length at Mile 170.0 L, +15 feet LWRP, 200 foot notch, invert elevation +9 feet LWRP, starting 100 feet from the bankline*

- *Dike 4: 1100 feet in Length at Mile 169.45 L, +13 feet LWRP, 200 foot notch, invert elevation +5 feet LWRP, starting 100 feet from the bankline*
- *Dike 5: 1150 feet in Length at Mile 168.5 L, +18 feet LWRP, not altered*

Plate 25 is a plan view map of the resultant bed configuration of Alternative 4-B. The test results indicated that this design was not effective in creating a side channel complex. The notches in the dikes near the bankline did not allow sufficient flow to form a distinct side channel. The design also did not increase depths in the navigation channel adjacent to and upstream of Dike 170.9 L. In fact, significant additional deposition occurred in this area. Depths in the navigation channel near the JB Bridge decreased slightly.

Alternative 5: *Four additional dikes at an elevation of +17 feet LWRP placed between existing dikes at Miles 170.65 L, 170.2 L, 169.7L, and 168.8 L. Existing dikes raised to +17 feet LWRP. The dikes had 150-foot wide notches with invert elevations of +5 feet LWRP, located at the bankline in both the existing and additional dikes.*

Plate 26 is a plan view map of the resultant bed configuration of Alternative 5. The test results indicated that this design was not effective in creating a side channel complex. The notches in the dikes along the bankline did not allow sufficient flow to form a distinct side channel. The design also did not increase depths in the navigation channel adjacent to and upstream of Dike 170.9 L. In fact, significant additional deposition occurred in this area. Depths in the navigation channel near the JB Bridge decreased slightly.

Alternative 6: *Three additional dikes placed along the RDB and upstream of JB Dike Field. The dikes were 500 feet long, at an elevation of +17 feet LWRP, and located at Miles 171.7 R, 171.5 R, and 171.3 R. The existing dikes (excluding dike 168.5 L) were raised to +17 feet LWRP and had 150-foot wide notches with invert elevations of +5 feet LWRP, located along the bankline.*

Plate 27 is a plan view map of the resultant bed configuration of Alternative 6. The test results indicated that this design was not effective in creating a side channel complex. The notches in the dikes along the bankline did not allow sufficient flow to form a distinct side channel. The additional dikes placed upstream of the existing dikes and along the RDB did not significantly increase depths in the navigation channel adjacent to Dike 170.9 L. However, substantial deposition occurred within the additional dike field.

__Alternative 7:__ *Dike 170.9 L was removed. Dikes 170.4 L, 170.0 L and 169.45 L were raised to an elevation of +17 feet LWRP and had 150-foot wide notches with invert elevations of +5 feet LWRP, located near the bankline.*

Plate 28 is a plan view map of the resultant bed configuration of Alternative 7. The test results indicated that this design was not effective in creating a side channel complex. The notches in the dikes along the bankline did not allow sufficient flow to form a distinct side channel. Depths decreased and deposition occurred in the navigation channel between Miles 171.2 and 170.0.

__Alternative 8__: *Existing dikes were raised to +17 feet LWRP and converted to rootless structures.*

- *Dike 170.9 L, +17 feet LWRP, 400-foot wide notch from the bankline without an invert.*
- *Dikes 170.4 L, 170.0 L and 169.45 L, +17 feet LWRP, 300-foot wide notch from the bankline without an invert.*
- *Dike 168.5 L was not altered.*
- *An initial side channel was artificially dredged to an elevation of –10 feet LWRP with the material placed within the intended island area.*
- *The scour hole that formed just upstream and downstream of the notch in Dike 170.0 L was armored during the test.*

Plate 29 is a plan view map of the resultant bed configuration of Alternative 8. The test results indicated that this design was not effective in sustaining the dredged side channel complex. The notches in the dikes along the bankline did not allow sufficient flow to maintain a distinct side channel. During the test a large scour hole formed at Dike 170.0 L. To eliminate the additional material that was entering the side channel from the scour hole, the area was armored to an elevation of –10 feet LWRP. However, the influx of bed load from the main channel returned most of the dredged areas back to previous depths and elevations. The design also did not increase depths in the navigation channel adjacent to and upstream of Dike 170.9 L. In fact, additional deposition occurred in this area.

Alternative 9: *Existing dikes were raised to +17 feet LWRP and converted to rootless structures. Two additional structures were added.*

- *Dike 170.9 L, +17 feet LWRP, 400-foot wide notch from the bankline without an invert.*
- *Dikes 170.4 L, 170.0 L and 169.45 L, +17 feet LWRP, 300-foot wide notch from the bankline without an invert.*
- *Dike 168.5 L was not altered.*
- *An initial side channel was artificially dredged to an elevation of –10 feet LWRP with the material placed within the intended island area.*
- *Added two 600-foot long angled rootless dikes at an elevation of +17 feet LWRP with the midpoint of the structures located at Miles 169.85 L and 169.75 L*.
- *The scour hole that formed just upstream and downstream of the notch in Dike 170.0 L was armored during the test.*

Plate 30 is a plan view map of the resultant bed configuration of Alternative 9. The test results indicated that this design was not effective in sustaining the dredged side channel complex. The notches in the dikes along the bankline did not allow sufficient flow to maintain a distinct side channel. During the test a large scour hole formed at Dike 170.0 L. To eliminate the additional material that was entering the side channel from the scour hole, the area was armored to an elevation of –10 feet LWRP. However, the influx of bed load from the main channel returned most of the dredged areas back to previous depths and elevations. The design also did not increase depths in the navigation channel adjacent to and upstream of Dike 170.9 L. In fact, additional deposition occurred in this area. Depths in the thalweg adjacent to the dike field increased slightly.

Alternative 10: *Existing dikes were raised to +17 feet LWRP and converted to rootless structures. Three additional structures were added.*

- *Dike 170.9 L, +17 feet LWRP, 400-foot wide notch from the bankline without an invert.*
- *Added a 700-foot long angled rootless dike at an elevation of +17 feet LWRP with the midpoint of the structure located at Mile 170.7.*
- *Dikes 170.4 L, 170.0 L and 169.45 L, +17 feet LWRP, 300-foot wide notch from the bankline without an invert.*
- *Added a longitudinal dike at +17 feet LWRP that was offset from the bankline by 300 feet. The dike was located between existing Dikes 170.0 L and 169.45 L and was connected to the structures where the notches ended.*
- *Added a 700-foot long rootless dike at an elevation of +17 feet LWRP and 300 feet from the bankline at Mile 169.2.*
- *Dike 168.5 L was not altered.*
- *An initial side channel was artificially dredged to an elevation of –10 feet LWRP with the material placed within the intended island area.*
- *The scour hole that formed just upstream and downstream of the notch in Dike 170.0 L was armored during the test.*

Plate 31 is a plan view map of the resultant bed configuration of Alternative 10. The test results indicated that this design was not effective in sustaining the dredged side channel complex. The notches in the dikes along the bankline did not allow sufficient flow to maintain a distinct side channel. During the test a large scour hole formed at Dike 170.0 L. To eliminate the additional material that was entering the side channel from the scour hole, the area was armored to an elevation of –10 feet LWRP. However, the influx of bed load from the main channel returned most of the dredged areas back to previous depths and elevations. The design slightly increased depths in the navigation channel adjacent to and upstream of Dike 170.9 L. Depths in the thalweg adjacent to the dike field increased slightly.

<u>Alternative 11:</u> *Existing dikes were raised to +17 feet LWRP and converted to rootless structures. One additional structure was added.*

- *Dike 170.9 L, +17 feet LWRP, 400-foot wide notch from the bankline without an invert.*
- *Added a 700-foot long angled rootless dike at an elevation of +17 feet LWRP with the midpoint of the structure located at Mile 170.7.*
- *Dikes 170.4 L, 170.0 L and 169.45 L, +17 feet LWRP, 300-foot wide notch from the bankline without an invert.*
- *Dike 168.5 L was not altered.*
- *An initial side channel was artificially dredged to an elevation of –10 feet LWRP with the material placed within the intended island area.*
- *The scour hole that formed just upstream and downstream of the notch in Dike 170.0 L was armored during the test.*

Plate 32 is a plan view map of the resultant bed configuration of Alternative 11. The test results indicated that this design was not effective in sustaining the dredged side channel complex. The notches in the dikes along the bankline did not allow sufficient flow to maintain a distinct side channel. During the test a large scour hole formed at Dike 170.0 L. To eliminate the additional material that was entering the side channel from the scour hole, the area was armored to an elevation of –10 feet LWRP. However, the influx of bed load from the main channel returned most of the dredged areas back to previous depths and elevations. The design slightly increased depths in the navigation channel adjacent to and upstream of Dike 170.9 L. Depths in the thalweg adjacent to the dike field also increased slightly.

<u>Alternative 12:</u> *Existing dikes were raised to +17 feet LWRP and converted to rootless structures. Four additional structures were added.*

- *Added a 200-foot long rootless dike at an elevation of +17 feet LWRP and 400 feet from the bankline at Mile 171.2 L (1650 feet upstream of Dike 170.9)*
- *Dike 170.9 L, +17 feet LWRP, 400-foot wide notch from the bankline without an invert.*

- *Added a 700-foot long angled rootless dike at an elevation of +17 feet LWRP with the midpoint of the structure located at Mile 170.7.*
- *Dikes 170.4 L and 170.0 L, +17 feet LWRP, 300-foot wide notch from the bankline without an invert.*
- *Added two 600-foot long angled rootless dikes at an elevation of +17 feet LWRP with the midpoint of the structures located at Miles 169.85 L and 169.75 L*.
- *Dike 169.45 L, +17 feet LWRP, 300-foot wide notch beginning 700 feet from the bank without an invert.*
- *Dike 168.5 L was not altered.*
- *An initial side channel was artificially dredged to an elevation of –10 feet LWRP with the material placed within the intended island area.*
- *The scour hole that formed just upstream and downstream of the notch in Dike 170.0 L was armored during the test.*

Plate 33 is a plan view map of the resultant bed configuration of Alternative 12. The test results indicated that this design was moderately effective in sustaining the dredged side channel complex. The notches in the dikes along the bankline directed flows that maintained somewhat of a distinct side channel. During the test a large scour hole formed at Dike 170.0 L. To eliminate the additional material that was entering the side channel from the scour hole, the area was armored to an elevation of –10 feet LWRP. However, the influx of bed load from the main channel decreased the depths in some of the dredged areas and returned some areas back to previous depths and elevations, mainly at the downstream end of the side channel. The design slightly increased depths in the navigation channel adjacent to and upstream of Dike 170.9 L.

Alternative 13: *Existing dikes were raised to +17 feet LWRP and converted to rootless structures. Four additional structures were added.*

- *Added a 200-foot long rootless dike at an elevation of +17 feet LWRP and 400 feet from the bankline at Mile 171.2 L (1650 feet upstream of Dike 170.9)*
- *Dike 170.9 L, +17 feet LWRP, 400-foot wide notch from the bankline without an invert.*

- *Added a 700-foot long angled rootless dike at an elevation of +17 feet LWRP with the midpoint of the structure located at Mile 170.7.*
- *Dikes 170.4 L and 170.0 L, +17 feet LWRP, 300-foot wide notch from the bankline without an invert.*
- *Added a 600-foot long angled rootless dike at an elevation of +17 feet LWRP with the midpoint of the structure located at Mile 169.85 L*.
- *Added a 1500-foot long angled dike at an elevation of +17 feet LWRP with the midpoint of the structure located at Mile 169.75 L. The beginning of the dike was located where Dike 169.45 L originates. The structure had a 300-foot wide notch beginning 600 feet from the bank without an invert.*
- *Dike 169.45 L, +17 feet LWRP, 300-foot wide notch beginning 700 feet from the bank without an invert.*
- *Dike 168.5 L was not altered.*
- *An initial side channel was artificially dredged to an elevation of –10 feet LWRP with the material placed within the intended island area.*
- *The scour hole that formed just upstream and downstream of the notch in Dike 170.0 L was armored during the test.*

Plate 34 is a plan view map of the resultant bed configuration of Alternative 13. The test results indicated that this design was moderately effective in sustaining the dredged side channel complex. The notches in the dikes along the bankline directed flows that maintained a distinct side channel. During the test a large scour hole formed at Dike 170.0 L. To eliminate the additional material that was entering the side channel from the scour hole, the area was armored to an elevation of –10 feet LWRP. However, the influx of bed load from the main channel decreased the depths in some of the dredged areas. The downstream end of the side channel experienced some deposition although elevations of +5 feet LWRP were still maintained. The design slightly increased depths in the navigation channel adjacent to and upstream of Dike 170.9 L. Plate 35 is a photo of this design being traced by the flow patterns with dye. This shows a distinct flow split and side channel complex within the dike field.

Alternative 14: *Alternative 13 was repeated without the addition of the Dike at Mile 171.2 L. Existing dikes were raised to +17 feet LWRP and converted to rootless structures. Three additional structures were added.*

- *Dike 170.9 L, +17 feet LWRP, 400-foot wide notch from the bankline without an invert.*
- *Added a 700-foot long angled rootless dike at an elevation of +17 feet LWRP with the midpoint of the structure located at Mile 170.7.*
- *Dikes 170.4 L and 170.0 L, +17 feet LWRP, 300-foot wide notch from the bankline without an invert.*
- *Added a 600-foot long angled rootless dike at an elevation of +17 feet LWRP with the midpoint of the structure located at Mile 169.85 L.*
- *Added a 1500-foot long angled dike at an elevation of +17 feet LWRP with the midpoint of the structure located at Mile 169.75 L. The beginning of the dike was located where Dike 169.45 L originates. The structure had a 300-foot wide notch beginning 600 feet from the bank without an invert.*
- *Dike 169.45 L, +17 feet LWRP, 300-foot wide notch beginning 700 feet from the bank without an invert.*
- *Dike 168.5 L was not altered.*
- *An initial side channel was artificially dredged to an elevation of –10 feet LWRP with the material placed within the intended island area.*
- *The scour hole that formed just upstream and downstream of the notch in Dike 170.0 L was armored during the test.*

Plate 36 is a plan view map of the resultant bed configuration of Alternative 14. The test results indicated that this design was effective in sustaining the dredged side channel complex. The notches in the dikes along the bankline directed some flows that maintained a distinct side channel. During the test a large scour hole formed at Dike 170.0 L. To eliminate the additional material that was entering the side channel from the scour hole, the area was armored to an elevation of –10 feet LWRP. However, the influx of bed load from the main channel decreased the depths in some of the dredged areas. The downstream end of the side channel experienced some deposition although elevations of +5 feet LWRP were still maintained. The design slightly increased depths in the navigation channel adjacent to and upstream of Dike 170.9 L. Depths in the thalweg adjacent to the dike field also increased slightly.

CONCLUSIONS

1. Summary and Recommendations

Several alternative design tests were conducted in the micro model. Each alternative was evaluated using the following three objectives:

1. The distribution of flow patterns resulting in the formation of a self-maintaining side channel complex.
2. The creation of a high elevation island area within the existing dike field.
3. The increase in depth within the navigation channel upstream and adjacent to existing Dike 170.9L.

Alternatives 1 through 9 did not did not definitively meet all of the above objectives. Alternatives 10 and 11 increased navigation depths slightly, but did not maintain a self-sustaining side channel. Alternatives 12, 13, and 14 were effective at achieving all three objectives. These alternatives provided significant side channel and island habitat development, although only slight depth improvements were made to the navigation channel. Of the three alternatives, Alternative 13 developed the most distinct, self-maintaining side channel with the greatest depths throughout. However, this alternative contained a small dike at Mile 171.2 L that would possibly impact an existing fleeting area. Alternative 12 produced comparable depths, but the downstream end of the side channel contained much higher elevations.

Alternative 14 did not produce depths as significant as those in Alternative 13, but the design did not include the small dike at Mile 171.2L. Without this critical dike, the plan still managed to create a continuous side channel and provide additional isolated island habitat. It is therefore recommended that this plan be implemented in the river. For comparison purposes, Alternative 14 produced a side channel complex approximately 1.9 miles long as compared to 2 miles at Mile 100. Continuous depths in the side channel were observed to be below +5 feet LWRP with this alternative as compared to +10 LWRP at Mile 100, and isolated island habitat was approximately 190 acres above +10 feet as compared to 24 acres at the Mile 100 Islands.

If the recommended plan is eventually constructed in the river, revetment of the bankline should also be carried out along the LDB, between Miles 171.0 L and 168.8 L. This measure will ensure protection of adjacent private floodplain lands and preserve flow energy necessary for the formation of the side channel.

2. 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 Smith at:

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Fax: (314) 263-4166

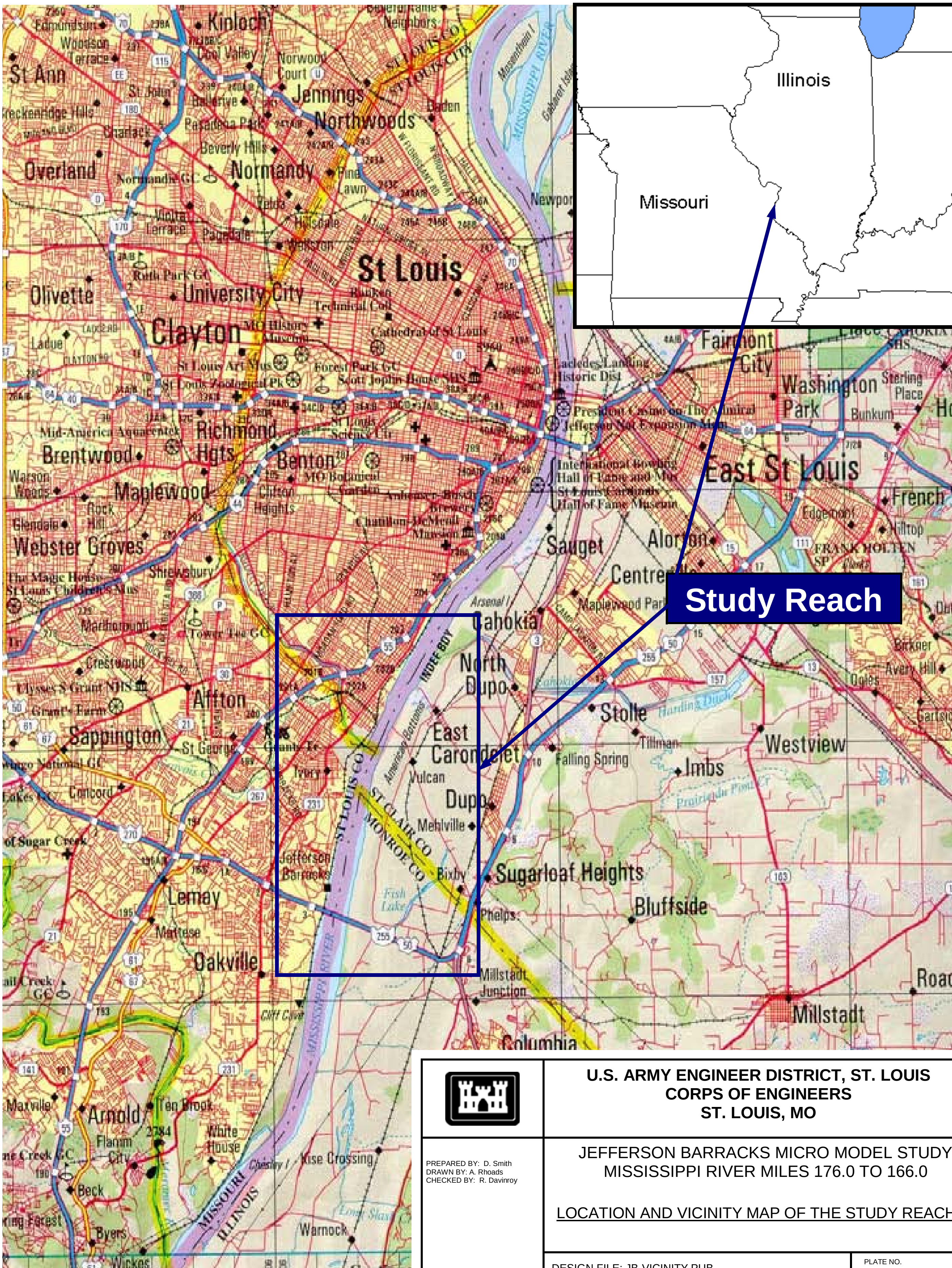
E-mail: Robert.D.Davinroy@mvs02.usace.army.mil
David.Gordon@mvs02.usace.army.mil
Dawn.Smith@mvs02.usace.army.mil

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 36 follow:



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

PREPARED BY: D. Smith
DRAWN BY: A. Rhoads
CHECKED BY: R. Davinroy

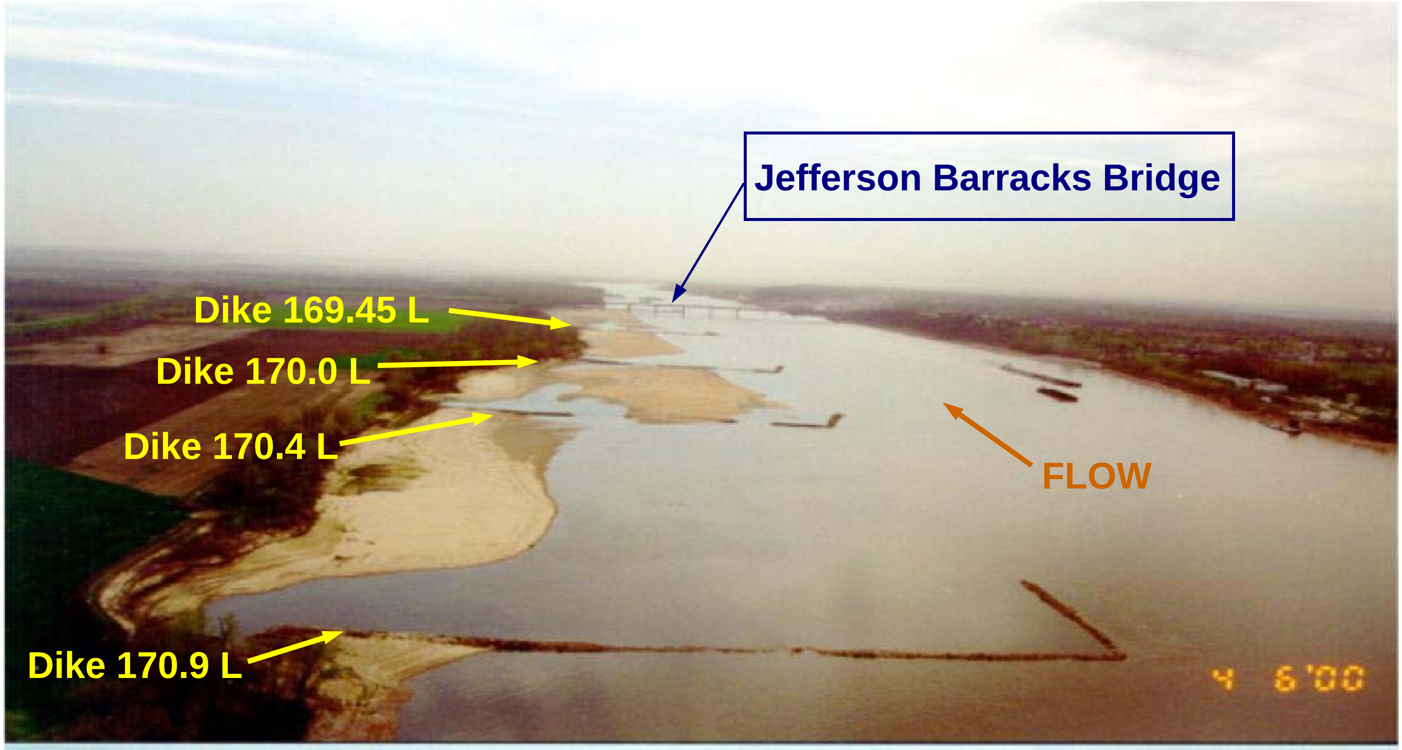
JEFFERSON BARRACKS MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 176.0 TO 166.0

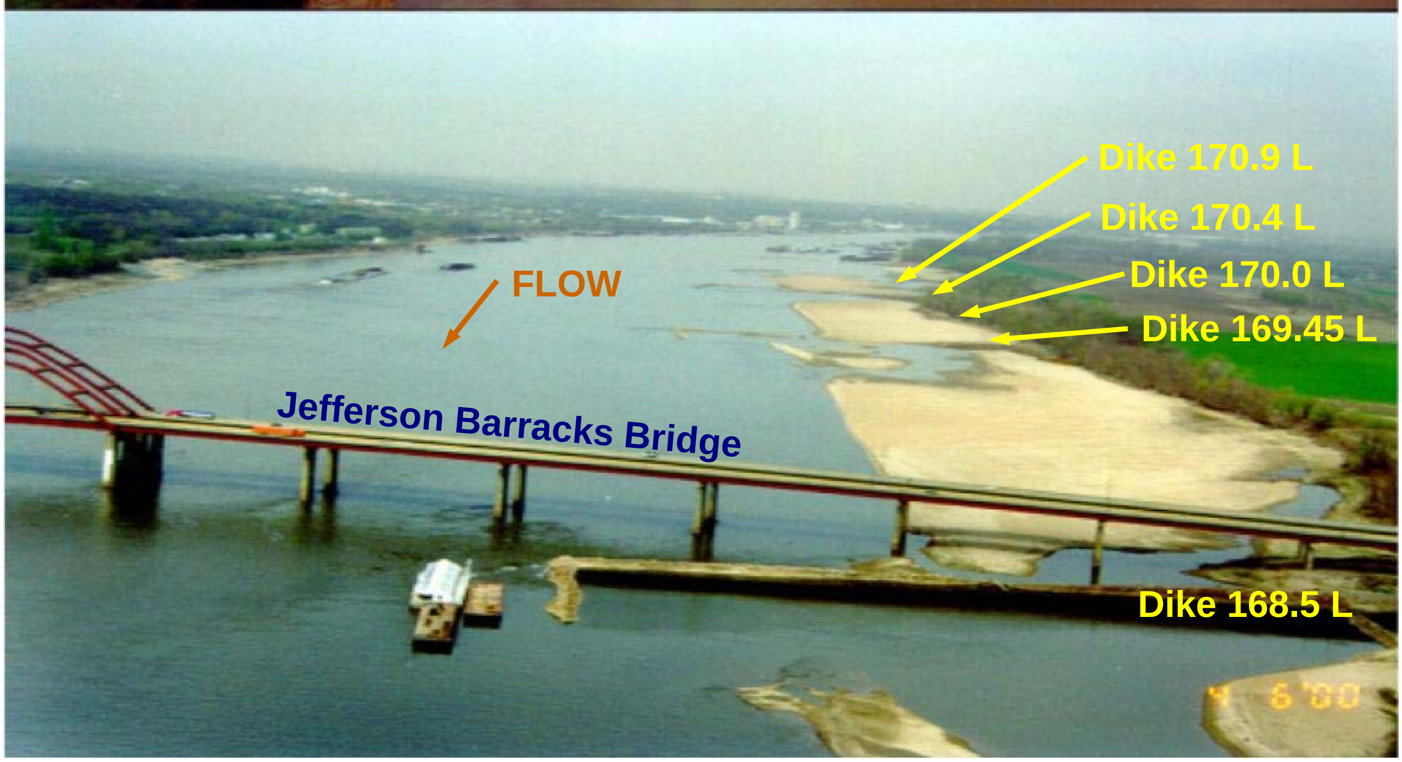
LOCATION AND VICINITY MAP OF THE STUDY REACH

DESIGN FILE: JB-VICINITY.PUB

Plot Date: 10/01

PLATE NO. 1





TOP PHOTO: :Looking Downstream

BOTTOM PHOTO: Looking Upstream

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ST. LOUIS, MISSOURI

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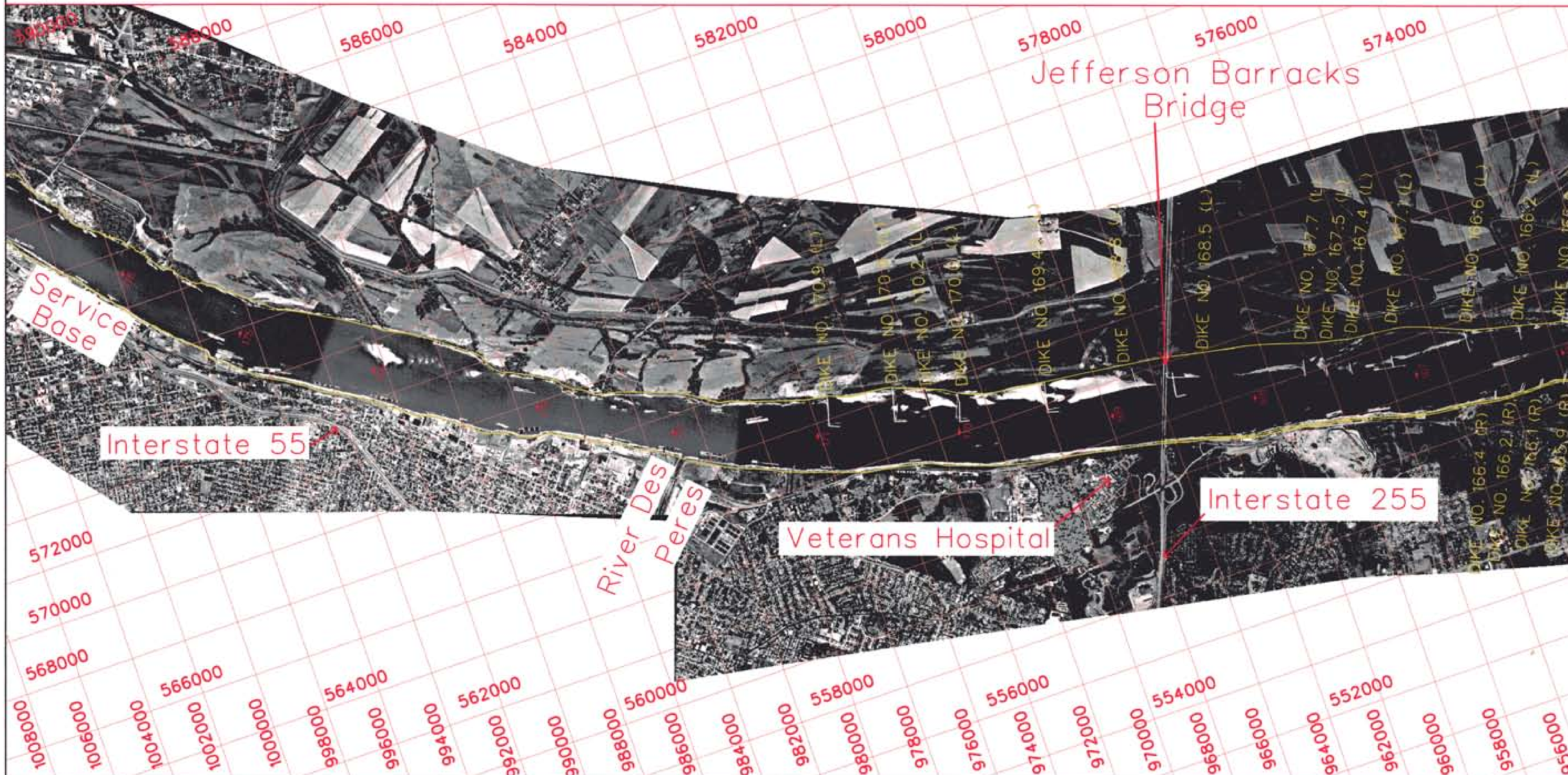
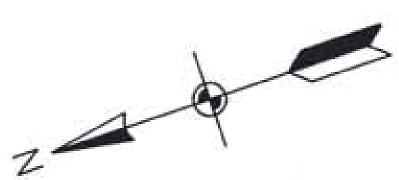
JEFFERSON BARRACKS MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 176.0 TO 166.0

JEFFERSON BARRACKS DIKE FIELD

DESIGN FILE: JB DIKES.PUB
PLOT DATE: 10/01
PLATE NO. **2**





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ST. LOUIS, MISSOURI

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CHECKED BY: R. DAVINROY

JEFFERSON BARRACKS MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 176.0 TO 166.0

CHARACTERISTICS OF THE STUDY REACH

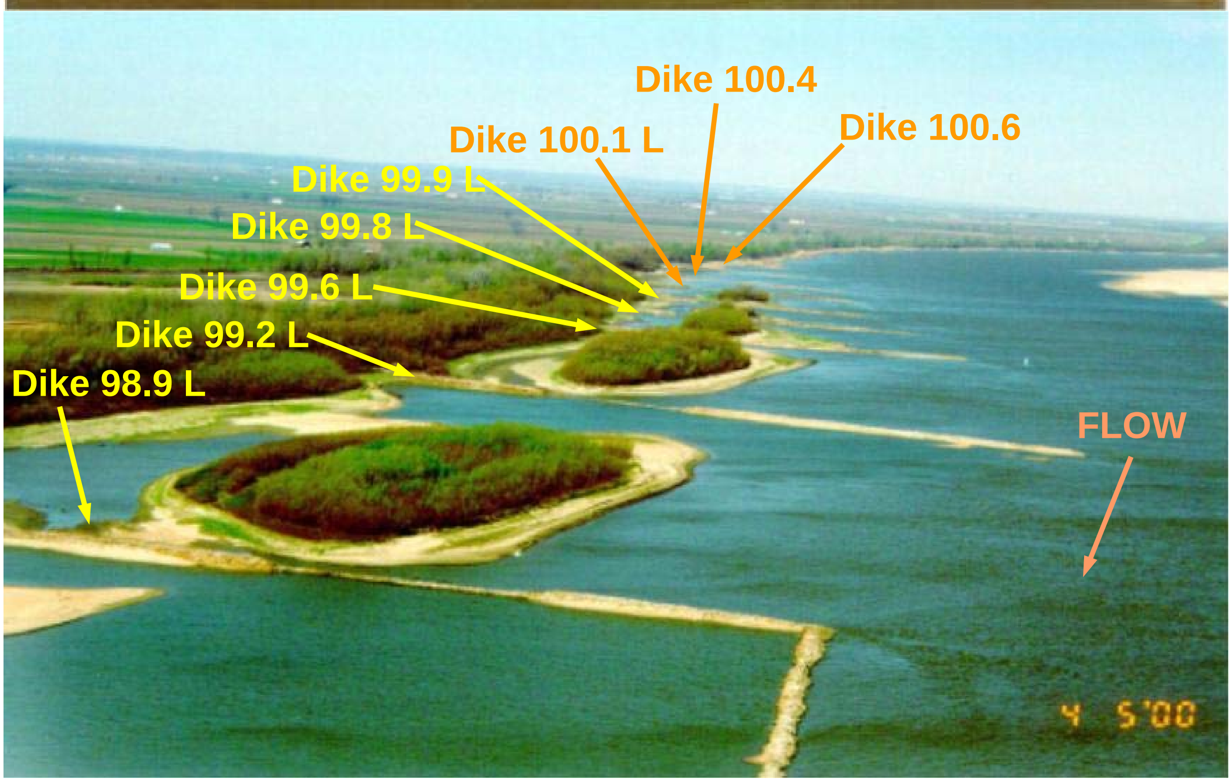
4000 3000 2000 1000 0 2000 4000

DESIGN FILE: CHARACTER.DGN

PLOT SCALE: 1" = 4000'

PLOT DATE: 10/01

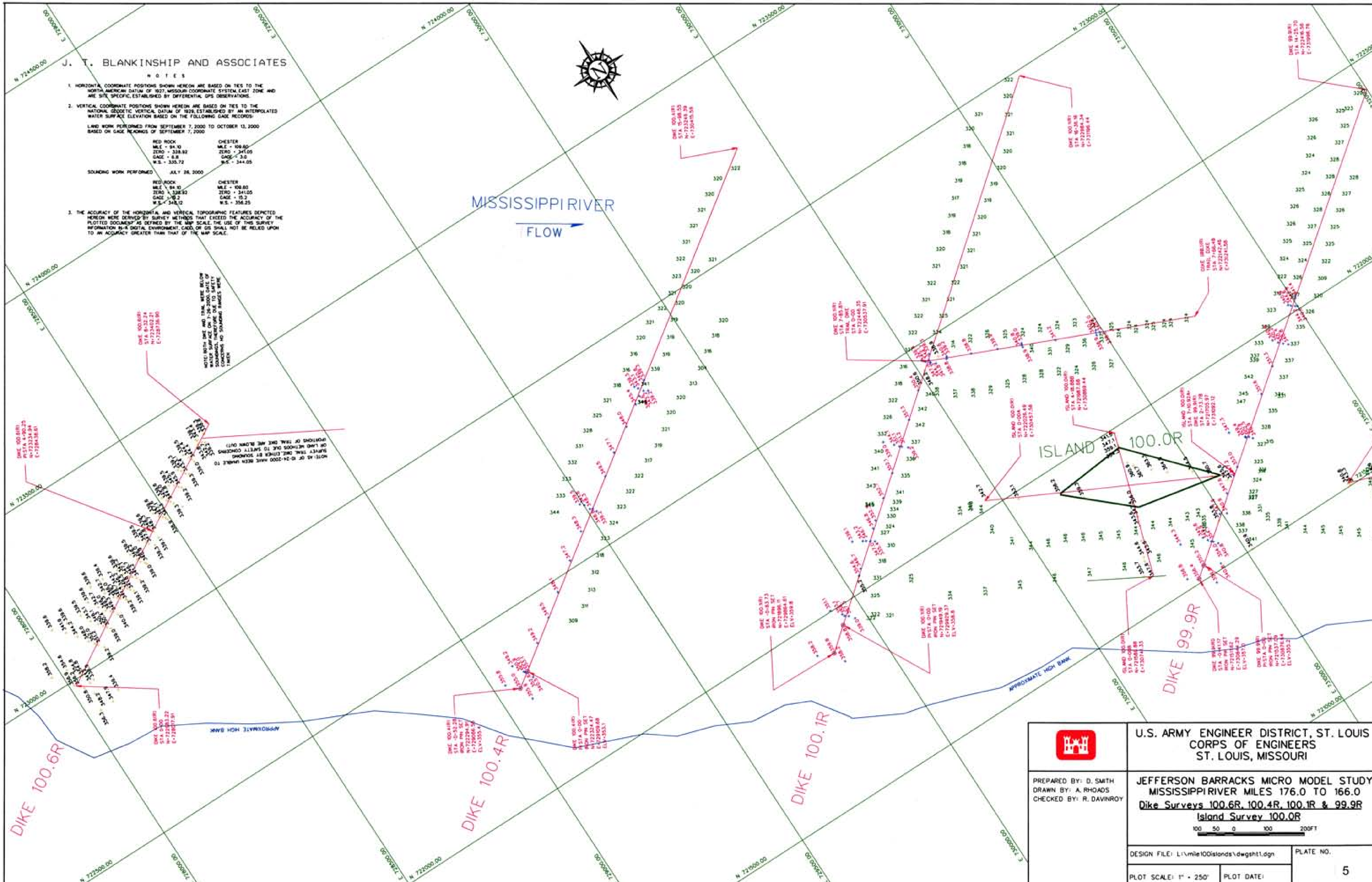
PLATE NO. 3



TOP PHOTO: Looking Downstream

BOTTOM PHOTO: Looking Upstream

	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS CORPS OF ENGINEERS ST. LOUIS, MO
PREPARED BY: D. SMITH DRAWN BY: A. RHOADS CHECKED BY: R. DAVINROY	JEFFERSON BARRACKS MICRO MODEL STUDY MISSISSIPPI RIVER MILES 176.0 TO 166.0 MILE 100 DIKE FIELD AND ISLANDS
	DESIGN FILE: MILE 100.PUB
	PLOT DATE: 10/01
	PLATE NO. 4



J. T. BLANKINSHIP AND ASSOCIATES

NOTES

1. HORIZONTAL COORDINATE POSITIONS SHOWN HEREON ARE BASED ON TIES TO THE NORTH AMERICAN DATUM OF 1927, MISSOURI COORDINATE SYSTEM, EAST ZONE AND ARE SITE SPECIFIC, ESTABLISHED BY DIFFERENTIAL GPS OBSERVATIONS.

2. VERTICAL COORDINATE POSITIONS SHOWN HEREON ARE BASED ON TIES TO THE NATIONAL GEODETIC VERTICAL DATUM OF 1929, ESTABLISHED BY AN INTERPOLATED WATER SURFACE ELEVATION BASED ON THE FOLLOWING GAGE RECORDS:

LAND WORK PERFORMED FROM SEPTEMBER 7, 2000 TO OCTOBER 13, 2000 BASED ON GAGE READINGS OF SEPTEMBER 7, 2000

RED ROCK	CHESTER
MILE = 94.10	MILE = 109.60
ZERO = 328.92	ZERO = 341.05
GAGE = 6.8	GAGE = 3.0
W.S. = 335.72	W.S. = 344.05

SOUNDING WORK PERFORMED JULY 26, 2000

RED ROCK	CHESTER
MILE = 94.10	MILE = 109.60
ZERO = 328.92	ZERO = 341.05
GAGE = 19.2	GAGE = 15.2
W.S. = 348.12	W.S. = 356.25

3. THE ACCURACY OF THE HORIZONTAL AND VERTICAL TOPOGRAPHIC FEATURES DEPICTED HEREON WERE DERIVED BY SURVEY METHODS THAT EXCEED THE ACCURACY OF THE PLOTTED DOCUMENT AS DEFINED BY THE MAP SCALE. THE USE OF THIS SURVEY INFORMATION IN A DIGITAL ENVIRONMENT, CADD OR GIS SHALL NOT BE RELIED UPON TO AN ACCURACY GREATER THAN THAT OF THE MAP SCALE.

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

PREPARED BY: D. SMITH
DRAWN BY: A. RHOADS
CHECKED BY: R. DAVINROY

JEFFERSON BARRACKS MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 176.0 TO 166.0
Dike Surveys 100.6R, 100.4R, 100.1R & 99.9R
Island Survey 100.0R

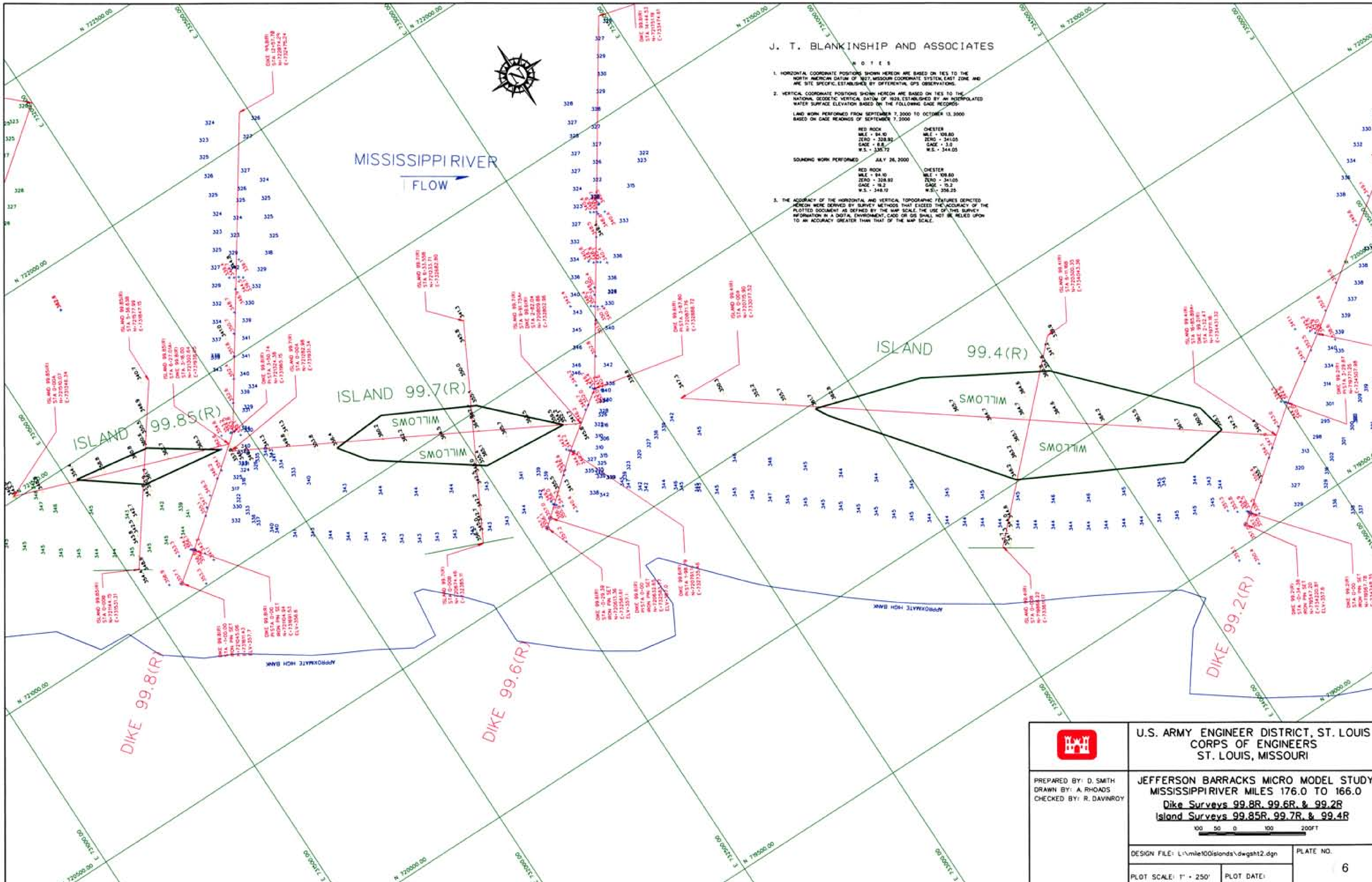
100 50 0 100 200FT

DESIGN FILE: L:\mile100islands\dwgsht1.dgn

PLOT SCALE: 1" = 250'

PLOT DATE:

PLATE NO. 5


MISSISSIPPI RIVER
FLOW
ISLAND 99.85(R)
ISLAND 99.7(R)
ISLAND 99.4(R)
WILLOWS
DIKE 99.8(R)
DIKE 99.6(R)
DIKE 99.2(R)
APPROXIMATE HIGH BANK
J. T. BLANKINSHIP AND ASSOCIATES
NOTES
1. HORIZONTAL COORDINATE POSITIONS SHOWN HEREON ARE BASED ON TIES TO THE NORTH AMERICAN DATUM OF 1927, MISSOURI COORDINATE SYSTEM, EAST ZONE AND ARE SITE SPECIFIC, ESTABLISHED BY DIFFERENTIAL GPS OBSERVATIONS.
2. VERTICAL COORDINATE POSITIONS SHOWN HEREON ARE BASED ON TIES TO THE NATIONAL GEODETIC VERTICAL DATUM OF 1929, ESTABLISHED BY AN INTERPOLATED WATER SURFACE ELEVATION BASED ON THE FOLLOWING GAGE RECORDS:
LAND WORK PERFORMED FROM SEPTEMBER 7, 2000 TO OCTOBER 13, 2000 BASED ON GAGE READINGS OF SEPTEMBER 7, 2000
RED ROCK MILE = 94.10 ZERO = 328.92 GAGE = 6.8 W.S. = 335.72
CHESTER MILE = 109.80 ZERO = 341.05 GAGE = 3.0 W.S. = 344.05
SOUNDING WORK PERFORMED JULY 26, 2000
RED ROCK MILE = 94.10 ZERO = 328.92 GAGE = 19.2 W.S. = 348.12
CHESTER MILE = 109.80 ZERO = 341.05 GAGE = 15.2 W.S. = 356.25
3. THE ACCURACY OF THE HORIZONTAL AND VERTICAL TOPOGRAPHIC FEATURES DEPICTED HEREON WERE DERIVED BY SURVEY METHODS THAT EXCEED THE ACCURACY OF THE PLOTTED DOCUMENT AS DEFINED BY THE MAP SCALE. THE USE OF THIS SURVEY INFORMATION IN A DIGITAL ENVIRONMENT, CADD OR GIS SHALL NOT BE RELIED UPON TO AN ACCURACY GREATER THAN THAT OF THE MAP SCALE.
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ST. LOUIS, MISSOURI
PREPARED BY: D. SMITH
DRAWN BY: A. RHOADS
CHECKED BY: R. DAVINROY
JEFFERSON BARRACKS MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 176.0 TO 166.0
Dike Surveys 99.8R, 99.6R, & 99.2R
Island Surveys 99.85R, 99.7R, & 99.4R
100 50 0 100 200FT
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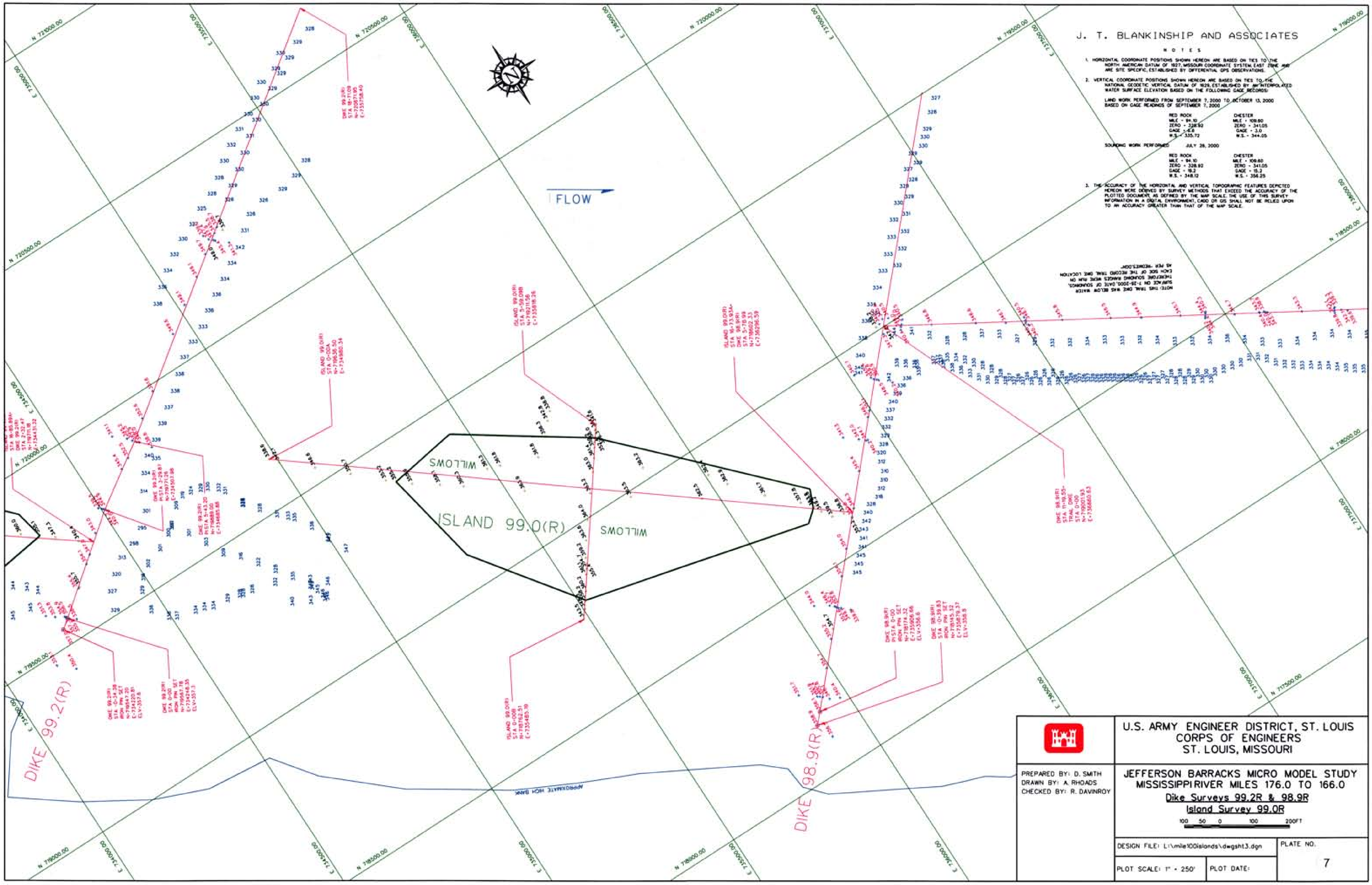
PLOT SCALE: 1" = 250'
PLOT DATE:
PLATE NO.
6



J. T. BLANKINSHIP AND ASSOCIATES

NOTES

1. HORIZONTAL COORDINATE POSITIONS SHOWN HEREON ARE BASED ON TIES TO THE NORTH AMERICAN DATUM OF 1927, MISSOURI COORDINATE SYSTEM, EAST ZONE AND ARE SITE SPECIFIC, ESTABLISHED BY DIFFERENTIAL GPS OBSERVATIONS.

2. VERTICAL COORDINATE POSITIONS SHOWN HEREON ARE BASED ON TIES TO THE NATIONAL GEODETIC VERTICAL DATUM OF 1929, ESTABLISHED BY AN INTERPOLATED WATER SURFACE ELEVATION BASED ON THE FOLLOWING GAGE RECORDS:

LAND WORK PERFORMED FROM SEPTEMBER 7, 2000 TO OCTOBER 13, 2000 BASED ON GAGE READINGS OF SEPTEMBER 7, 2000

RED ROCK	CHESTER
MILE = 94.10	MILE = 109.60
ZERO = 328.92	ZERO = 341.05
GAGE = 6.8	GAGE = 3.0
W.S. = 335.72	W.S. = 344.05

SOUNDING WORK PERFORMED JULY 28, 2000

RED ROCK	CHESTER
MILE = 94.10	MILE = 109.60
ZERO = 328.92	ZERO = 341.05
GAGE = 19.2	GAGE = 15.2
W.S. = 348.12	W.S. = 356.25

3. THE ACCURACY OF THE HORIZONTAL AND VERTICAL TOPOGRAPHIC FEATURES DEPICTED HEREON WERE DERIVED BY SURVEY METHODS THAT EXCEED THE ACCURACY OF THE PLOTTED DOCUMENT AS DEFINED BY THE MAP SCALE. THE USE OF THIS SURVEY INFORMATION IN A DIGITAL ENVIRONMENT, CADD OR GIS SHALL NOT BE RELIED UPON TO AN ACCURACY GREATER THAN THAT OF THE MAP SCALE.

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

PREPARED BY: D. SMITH
DRAWN BY: A. RHOADS
CHECKED BY: R. DAVINROY

JEFFERSON BARRACKS MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 176.0 TO 166.0
Dike Surveys 99.2R & 98.9R
Island Survey 99.0R

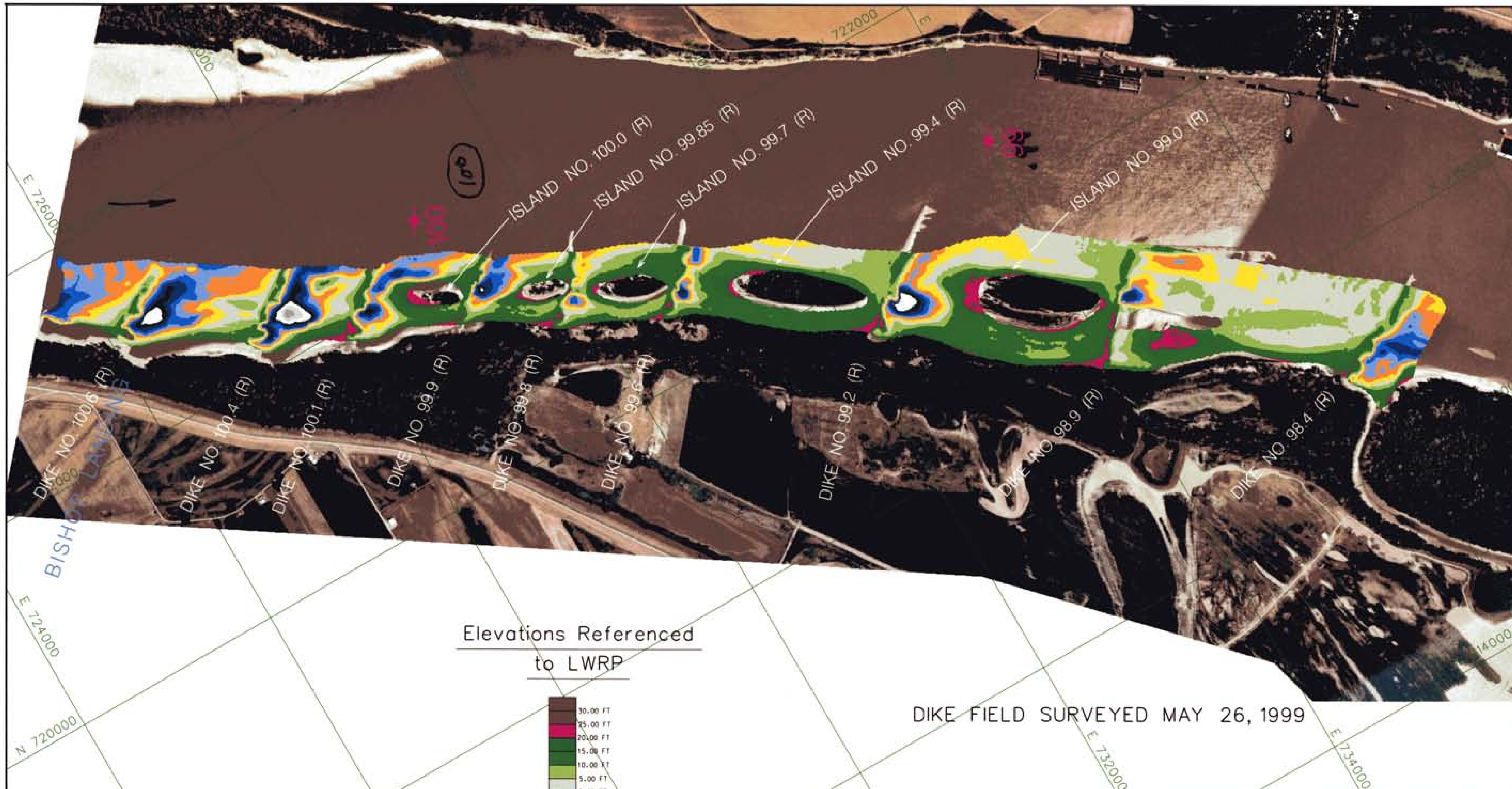
100 50 0 100 200FT

DESIGN FILE: L:\mile100islands\dwgsht3.dgn

PLOT SCALE: 1" = 250'

PLOT DATE:

PLATE NO. 7



U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
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PREPARED BY: D. SMITH
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CHECKED BY: R. DAVINROY

JEFFERSON BARRACKS BRIDGE
MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 176.0 TO 166.0

1999 SWEEP SURVEY - MILE 100 DIKE FIELD

1000 500 0 250 500 750 1000

DESIGN FILE: sweep99e2699.dgn

PLOT SCALE: 1" = 1000'

PLOT DATE: 10/01

PLATE NO. 8

	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS **CORPS OF ENGINEERS** **ST. LOUIS, MISSOURI**
PREPARED BY: D. SMITH DRAWN BY: A. RHOADS CHECKED BY: R. DAVINROY	JEFFERSON BARRACKS MICRO MODEL STUDY MISSISSIPPI RIVER MILES 176.0 TO 166.0 **JEFFERSON BARRACKS MICRO MODEL**
	DESIGN FILE: JB FLUME.PUB PLOT DATE: 10/01
	PLATE NO. **9**

Elevations Referenced to LWRP

Green	10 FT
Green	0 FT
Yellow	-10 FT
Blue	-20 FT
Black	-30 FT

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

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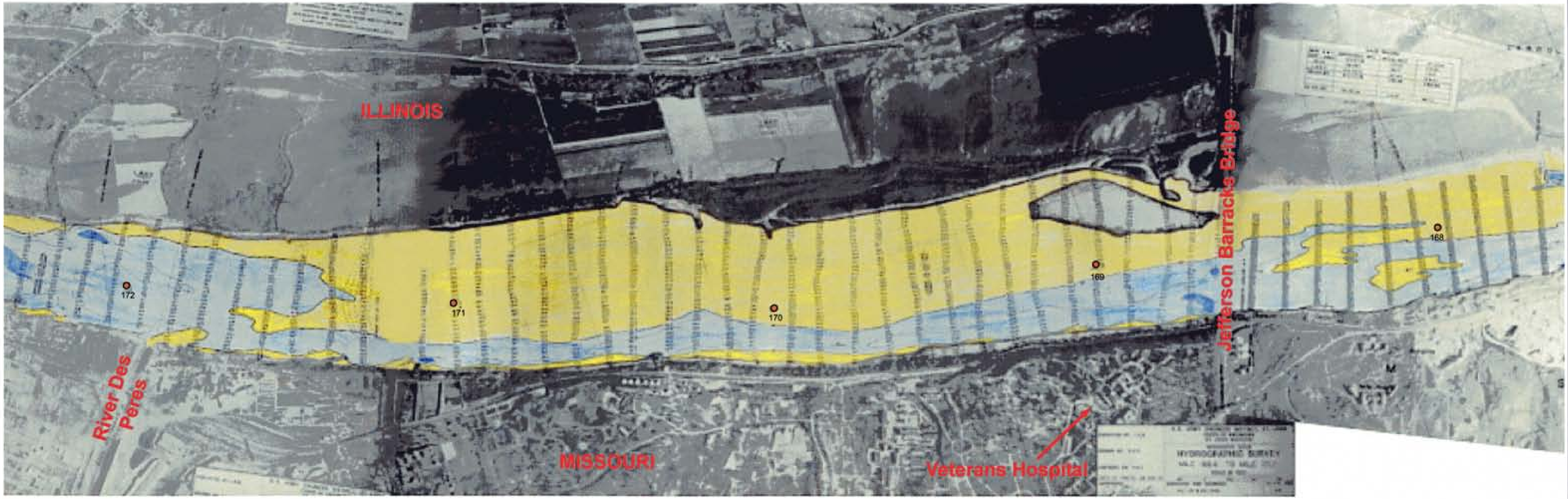
CHECKED BY: R. DAVINROY

JEFFERSON BARRACKS MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 176.0 TO 166.0

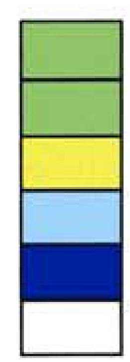
1959 PROTOTYPE SURVEY

1840 1380 920 460 0 920 1840

DESIGN FILE: 1959 PROTO.PUB
PLOT SCALE: 1" = 1840'
PLOT DATE: 10/01
PLATE NO. 10



Elevations Referenced to LWRP



N

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

PREPARED BY: D. SMITH
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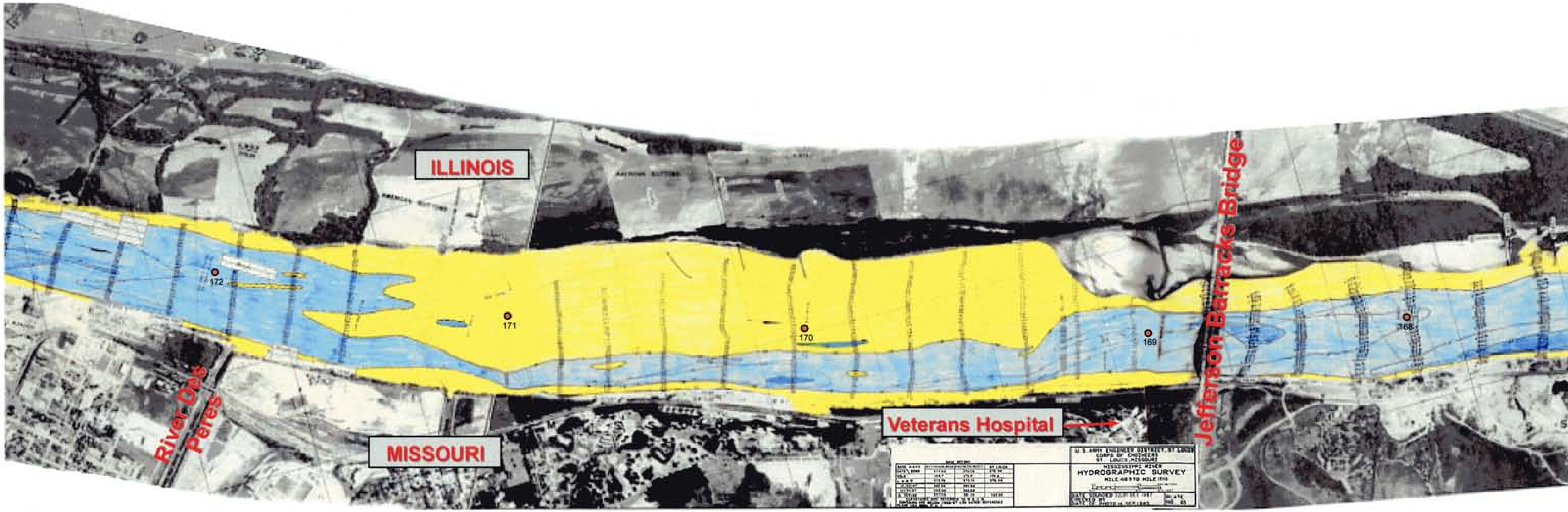
JEFFERSON BARRACKS MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 176.0 TO 166.0

<u>1969-71 PROTOTYPE SURVEY</u>

1568 1176 784 392 0 784 1568

DESIGN FILE: 1969-71 PROTO PUB
PLOT SCALE: 1" = 1568'
PLOT DATE: 10/01
PLATE NO. 11



N

Elevations Referenced to LWRP

10 FT
0 FT
-10 FT
-20 FT
-30 FT

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

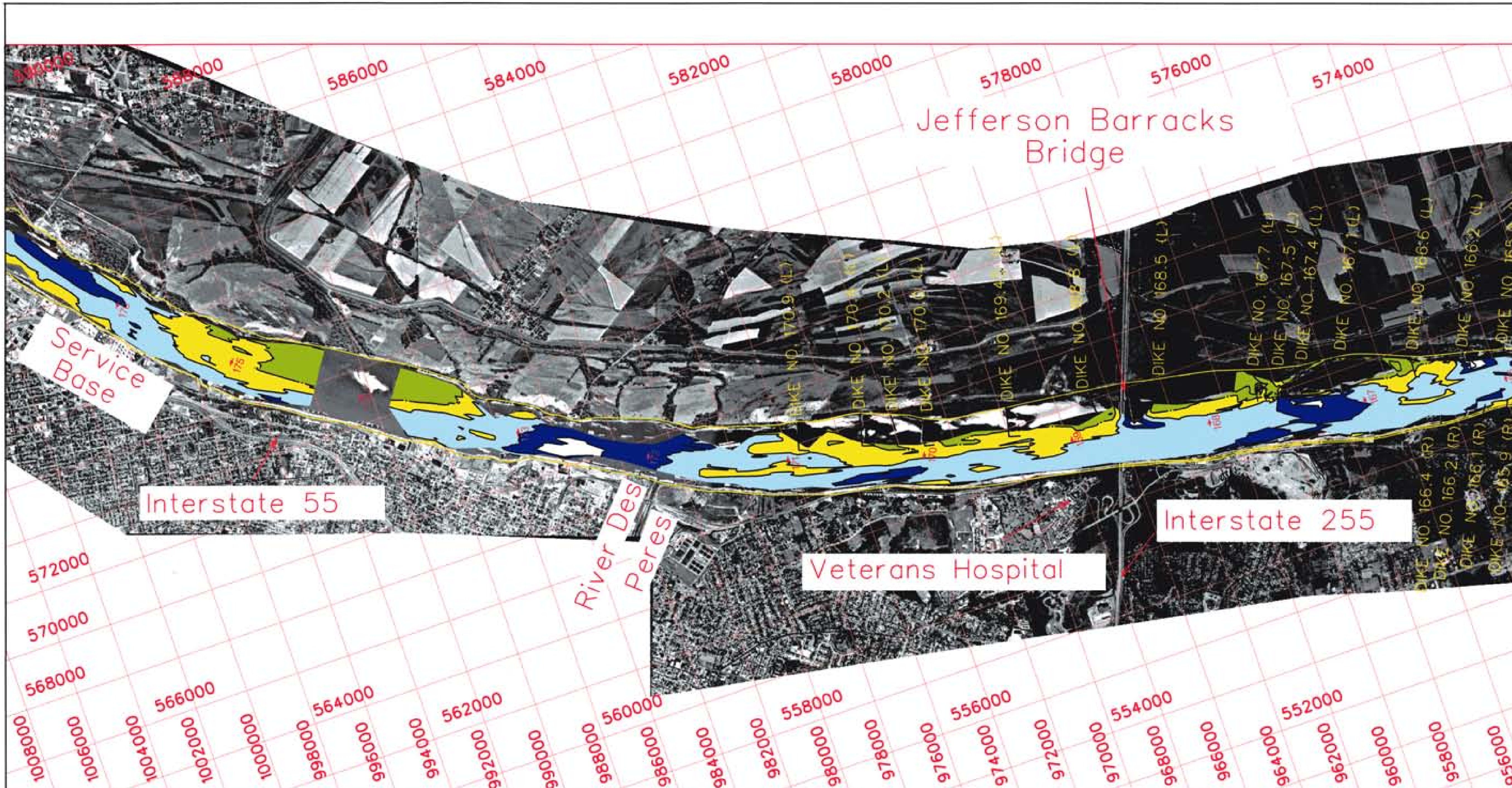
PREPARED BY: D. SMITH
DRAWN BY: A RHOADS
CHECKED BY: R. DAVINROY

JEFFERSON BARRACKS MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 176.0 TO 166.0

1986-87 PROTOTYPE SURVEY

1820 1365 910 455 0 910 1820

DESIGN FILE: 1986-87 PROTO.PUB
PLOT SCALE: 1" = 1820'
PLOT DATE: 10/01
PLATE NO. 12



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

PREPARED BY: D. SMITH
DRAWN BY: A. RHOADS
CHECKED BY: R. DAVINROY

JEFFERSON BARRACKS MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 176.0 TO 166.0

1993 PROTOTYPE SURVEY

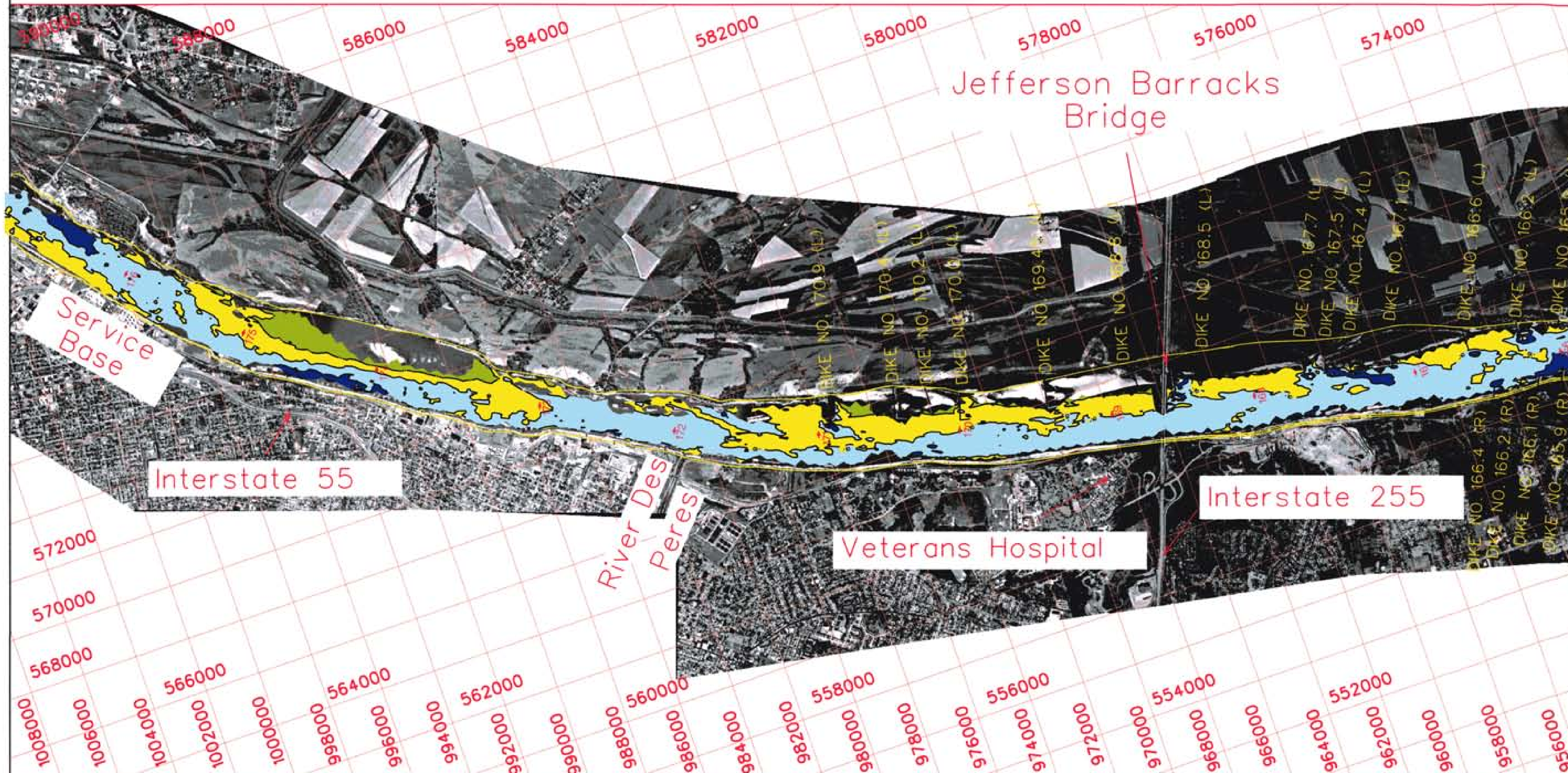
4000 3000 2000 1000 0 2000 4000

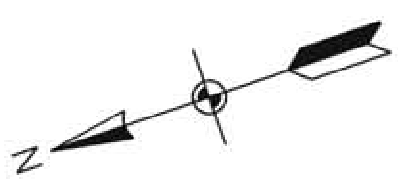
DESIGN FILE: 93SURV.DGN

PLOT SCALE: 1" = 4000'

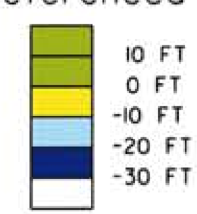
PLOT DATE: 10/01

PLATE NO. 13





Elevations Referenced to LWRP



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

PREPARED BY: D. SMITH
DRAWN BY: A. RHOADS
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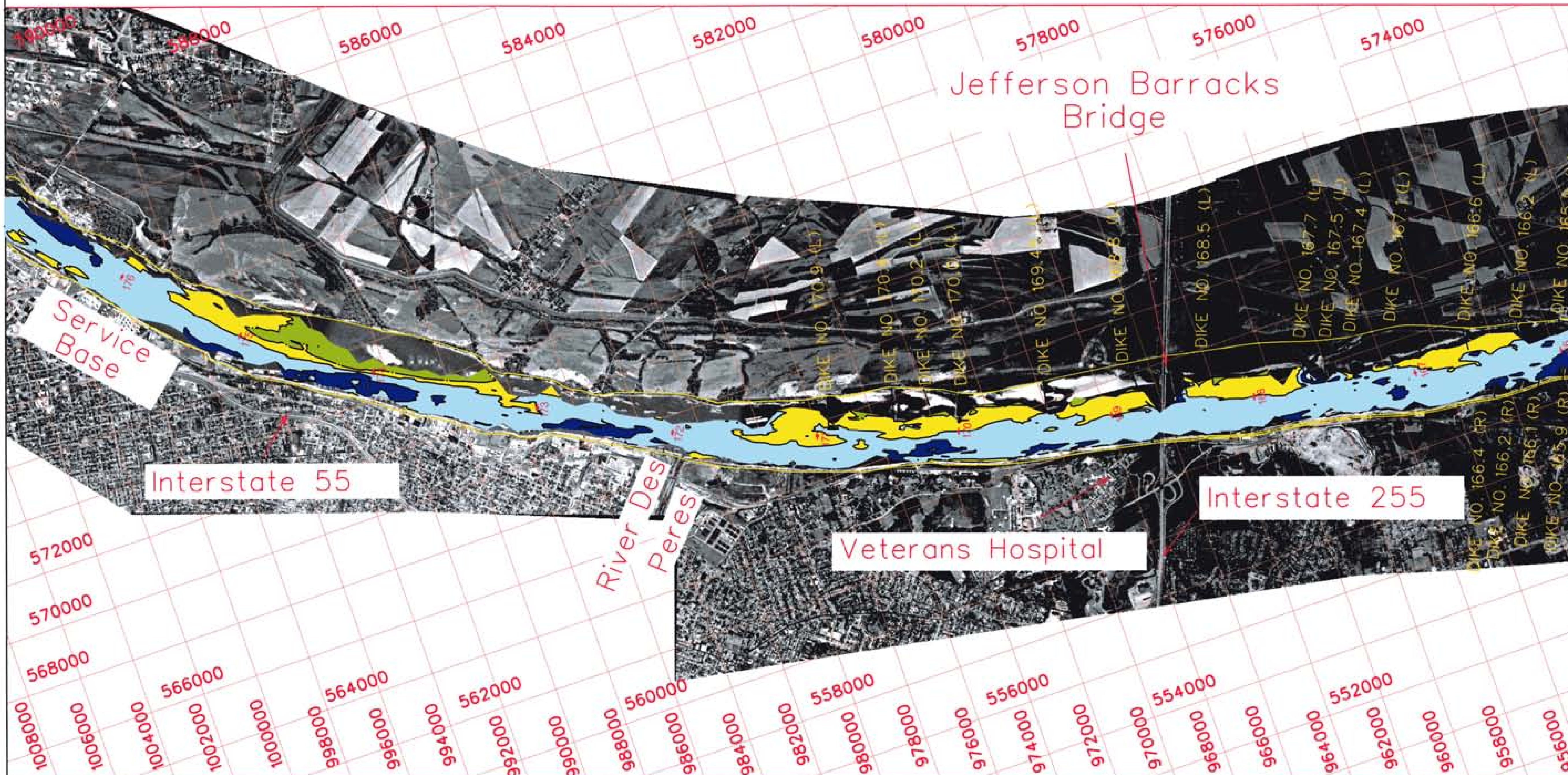
JEFFERSON BARRACKS MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 176.0 TO 166.0

1995 PROTOTYPE SURVEY

DESIGN FILE: 95SURV.DGN
PLOT SCALE: 1" = 4000'
PLOT DATE: 10/01
PLATE NO. 14



N

Elevations Referenced to LWRP

10 FT
0 FT
-10 FT
-20 FT
-30 FT

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

PREPARED BY: D. SMITH
DRAWN BY: A. RHOADS
CHECKED BY: R. DAVINROY

JEFFERSON BARRACKS MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 176.0 TO 166.0

1996 PROTOTYPE SURVEY

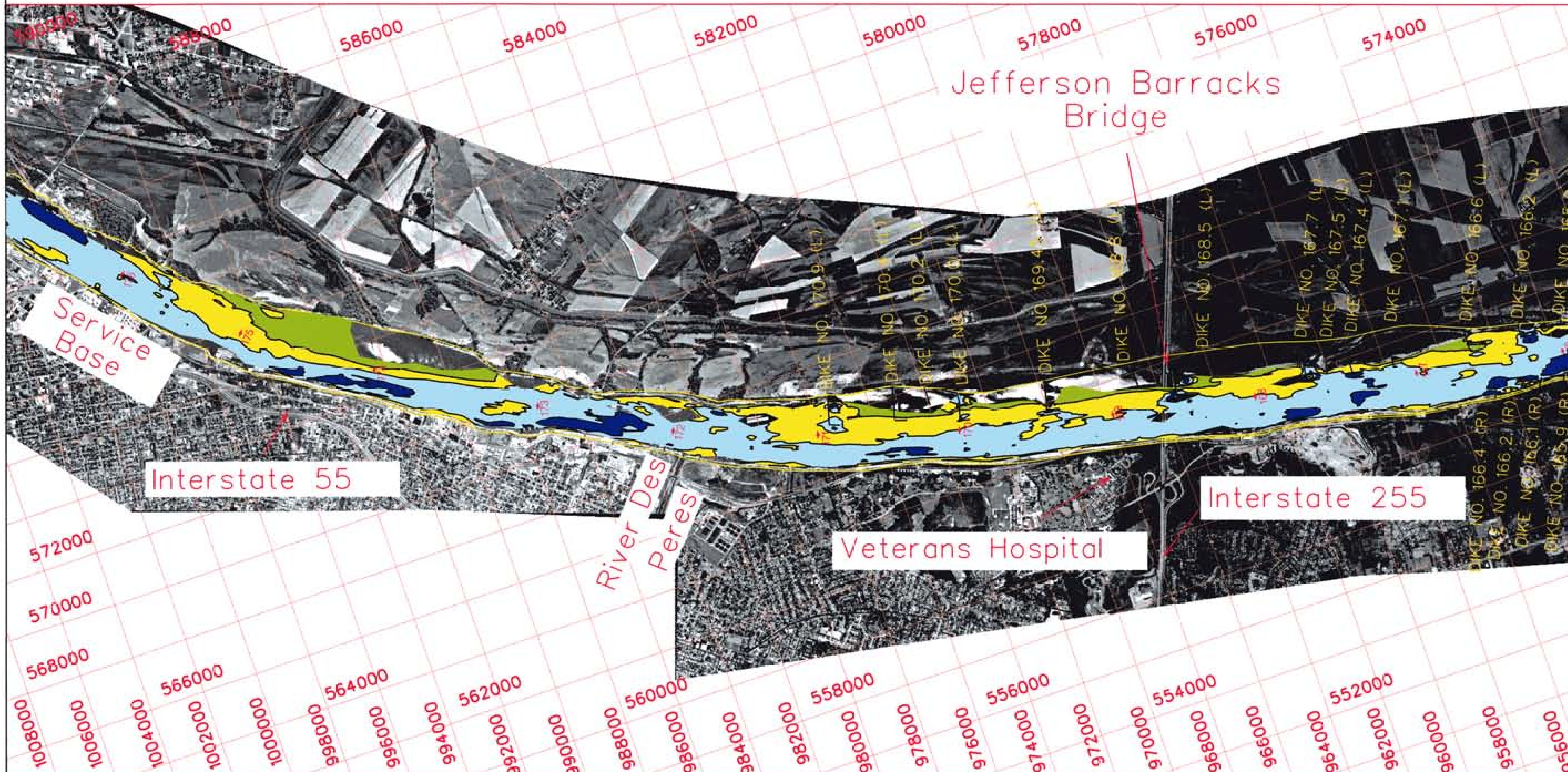
4000 3000 2000 1000 0 2000 4000

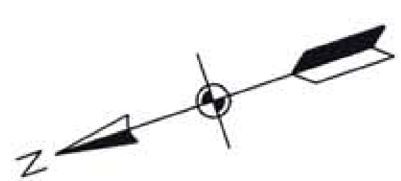
DESIGN FILE: 96SURV.DGN

PLOT SCALE: 1" = 4000'

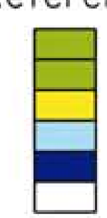
PLOT DATE: 10/01

PLATE NO.
15





Elevations Referenced to LWRP



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

PREPARED BY: D. SMITH
DRAWN BY: A. RHOADS
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JEFFERSON BARRACKS MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 176.0 TO 166.0

1998 PROTOTYPE SURVEY

4000 3000 2000 1000 0 2000 4000

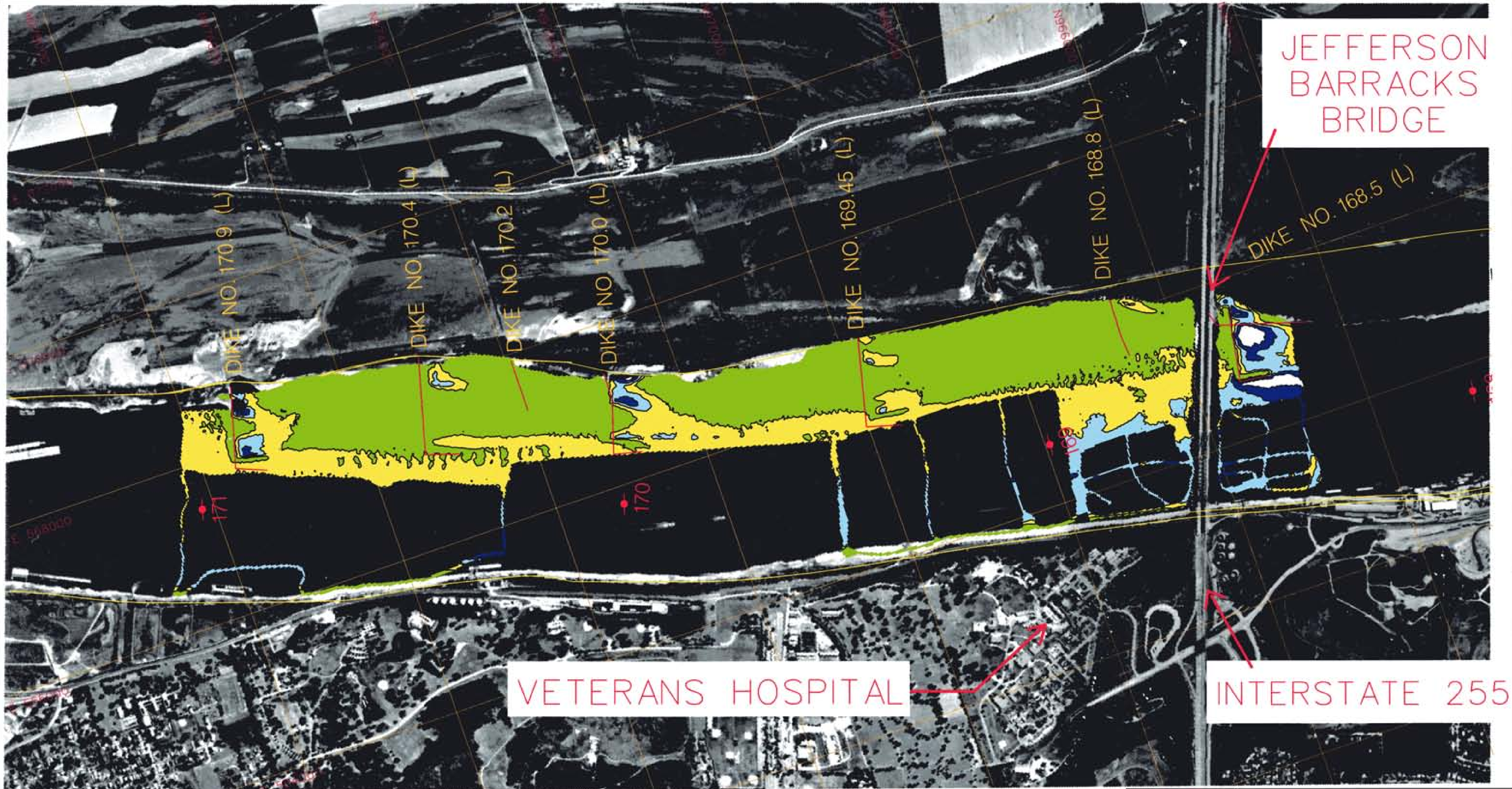
DESIGN FILE: 98SURV.DGN

PLOT SCALE: 1" = 4000'

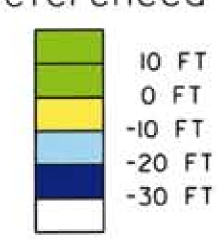
PLOT DATE: 10/01

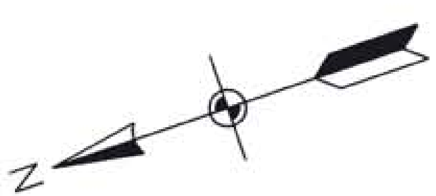
PLATE NO.

16



Elevations Referenced to LWRP





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

PREPARED BY: D. SMITH
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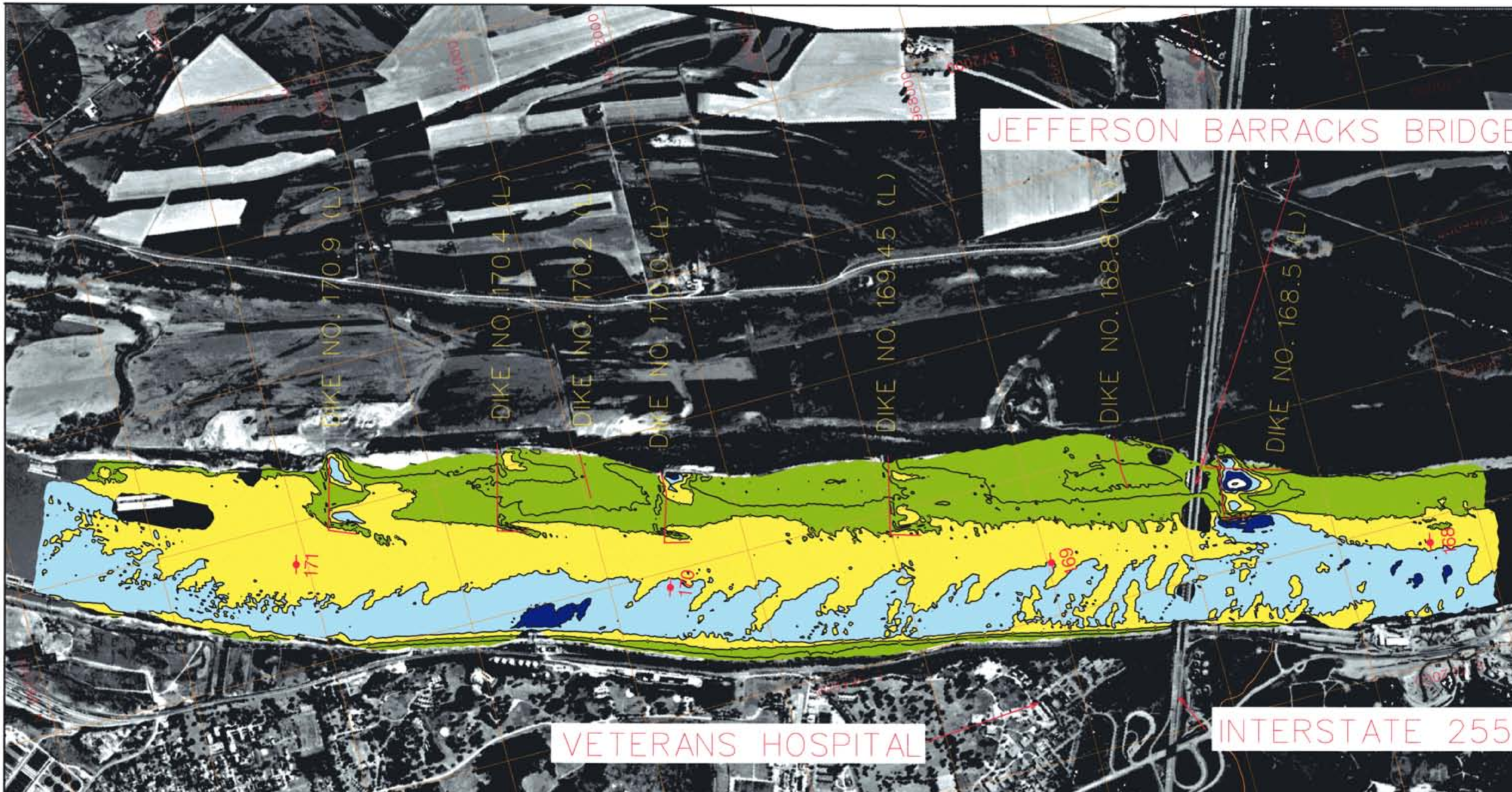
JEFFERSON BARRACKS MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 176.0 TO 166.0

1995 SWEEP SURVEY

DESIGN FILE: 169E95LW.DGN	PLATE NO. 17
PLOT SCALE: 1" = 1200'	PLOT DATE: 10/01



ELEVATIONS REFERENCED IN LWRP

EL.10
EL.0
EL.-10
EL.-20
EL.-30

N

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

PREPARED BY: D. SMITH
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JEFFERSON BARRACKS MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 176.0 TO 166.0

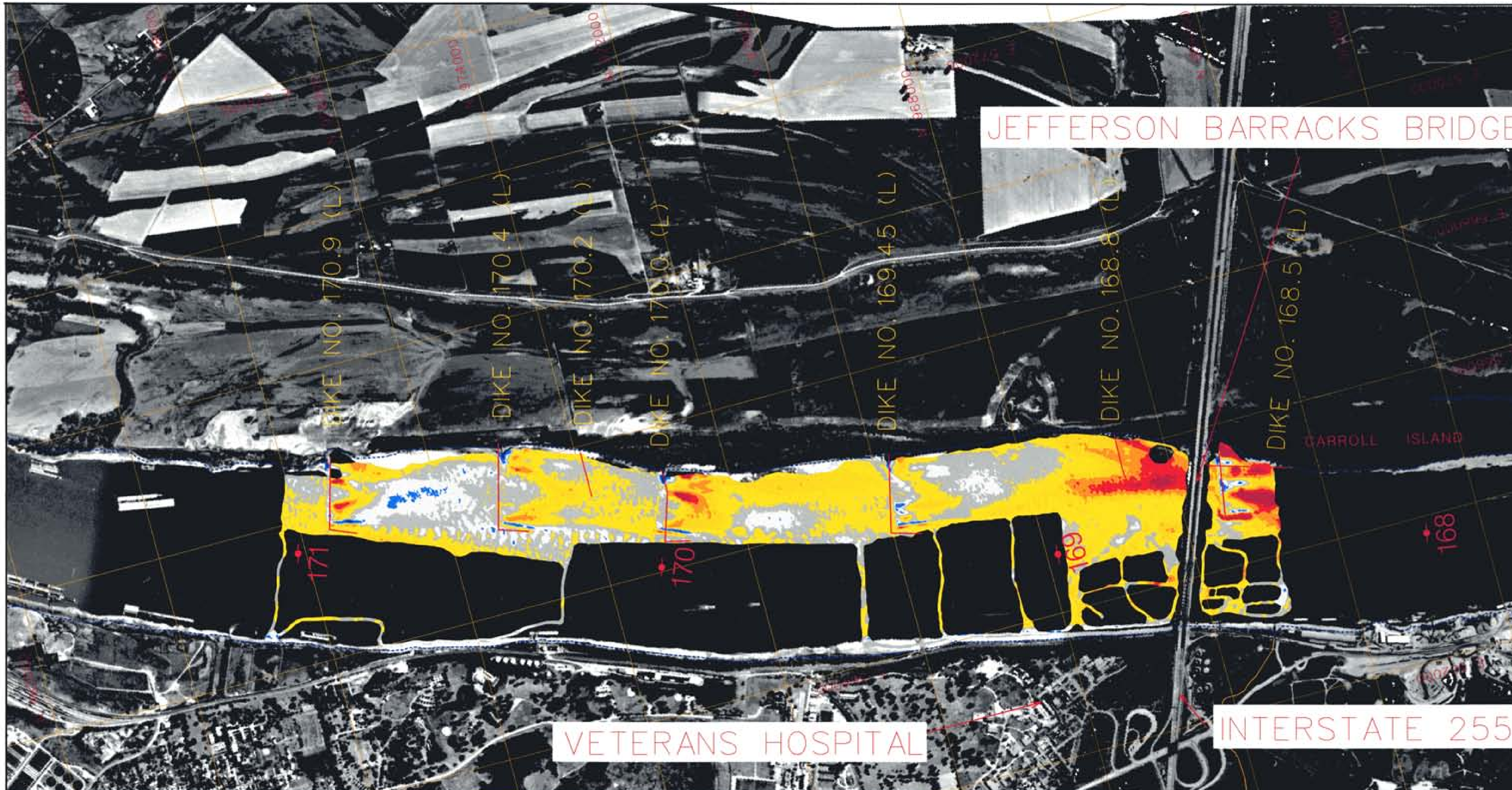
1999 SWEEP SURVEY

1400 1050 700 350 0 700 1400

DESIGN FILE: 169SWEEP99.DGN

PLOT SCALE: 1" = 1400'

PLATE NO. 18



Change in Elevation

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

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JEFFERSON BARRACKS MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 176.0 TO 166.0

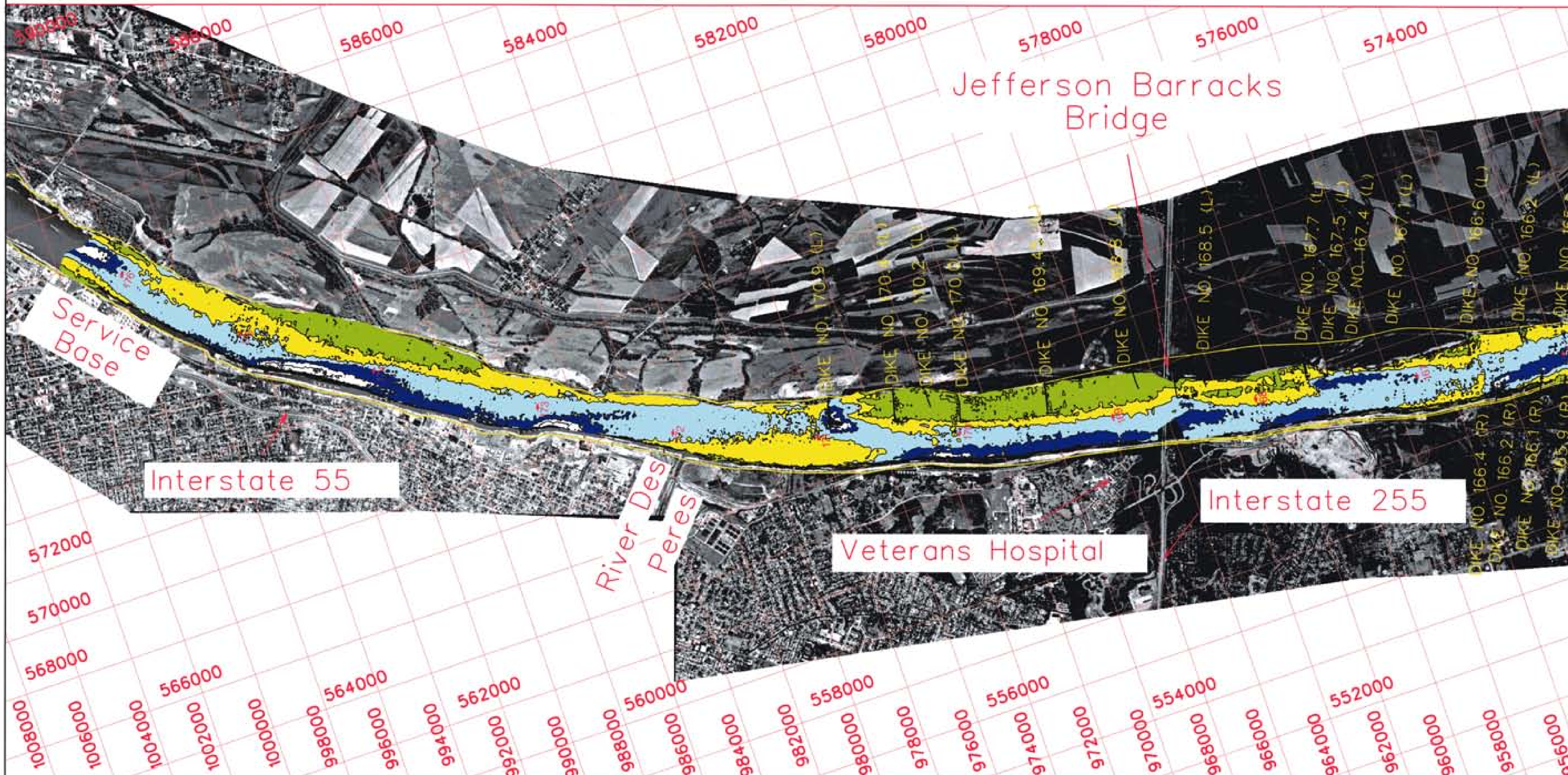
1995 - 1999 ISOPACH

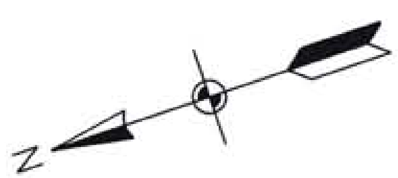
1400 1050 700 350 0 700 1400

DESIGN FILE: 95DIFF99.DGN

PLOT SCALE: 1" = 1400'

PLATE NO. 19





Elevations Referenced to LWRP

10 FT
0 FT
-10 FT
-20 FT
-30 FT

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

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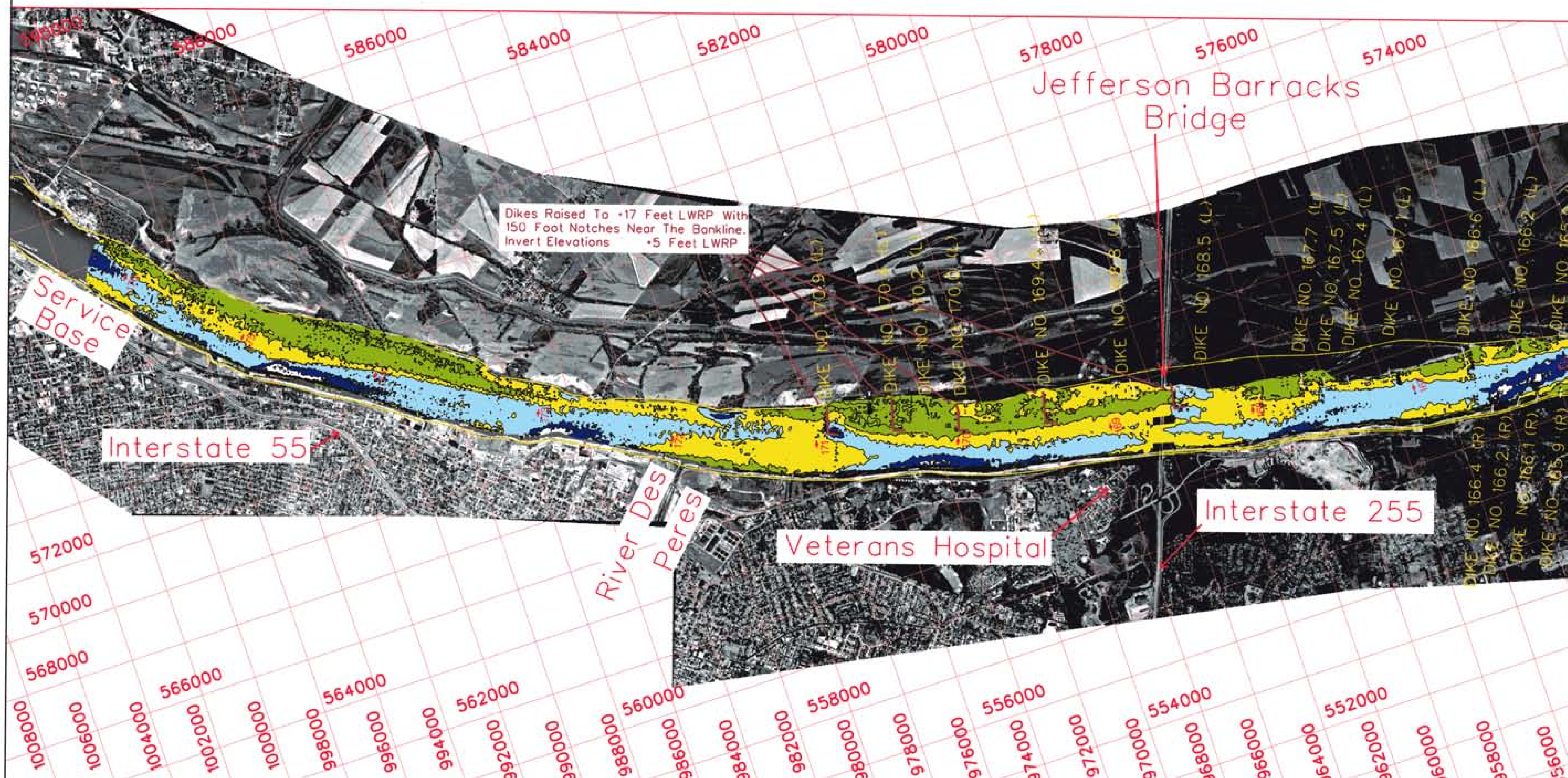
JEFFERSON BARRACKS MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 176.0 TO 166.0

BASE TEST

4000 3000 2000 1000 0 2000 4000

DESIGN FILE: 0104AR2.DGN
PLOT SCALE: 1" = 4000'
PLOT DATE: 10/01
PLATE NO. 20



Elevations Referenced to LWRP

	10 FT
	0 FT
	-10 FT
	-20 FT
	-30 FT

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
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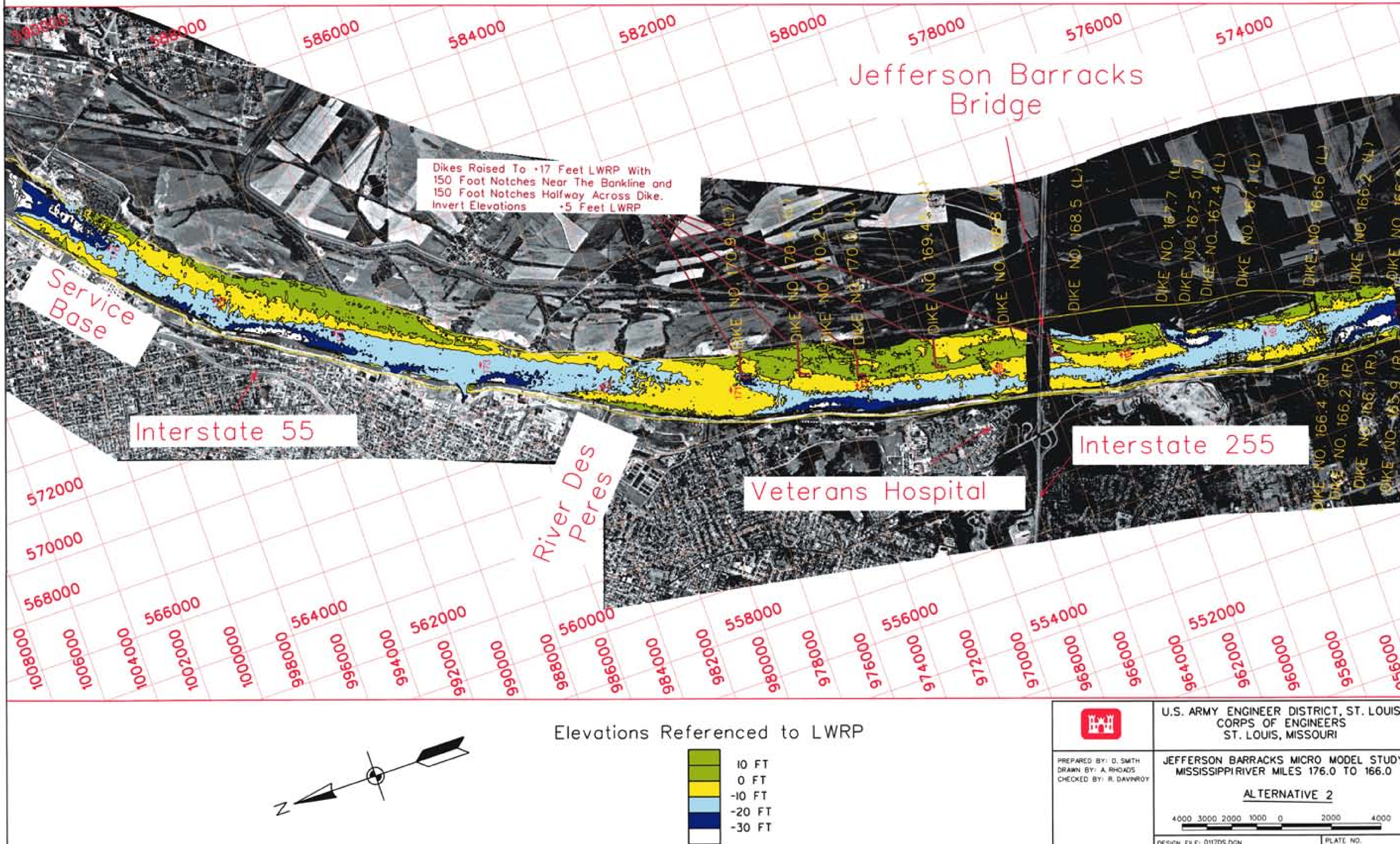
JEFFERSON BARRACKS MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 176.0 TO 166.0

ALTERNATIVE 1

4000 3000 2000 1000 0 2000 4000

DESIGN FILE: 0116DS.DGN
PLOT SCALE: 1" = 4000'
PLOT DATE: 10/01
PLATE NO. 21



U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
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JEFFERSON BARRACKS MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 176.0 TO 166.0

ALTERNATIVE 2

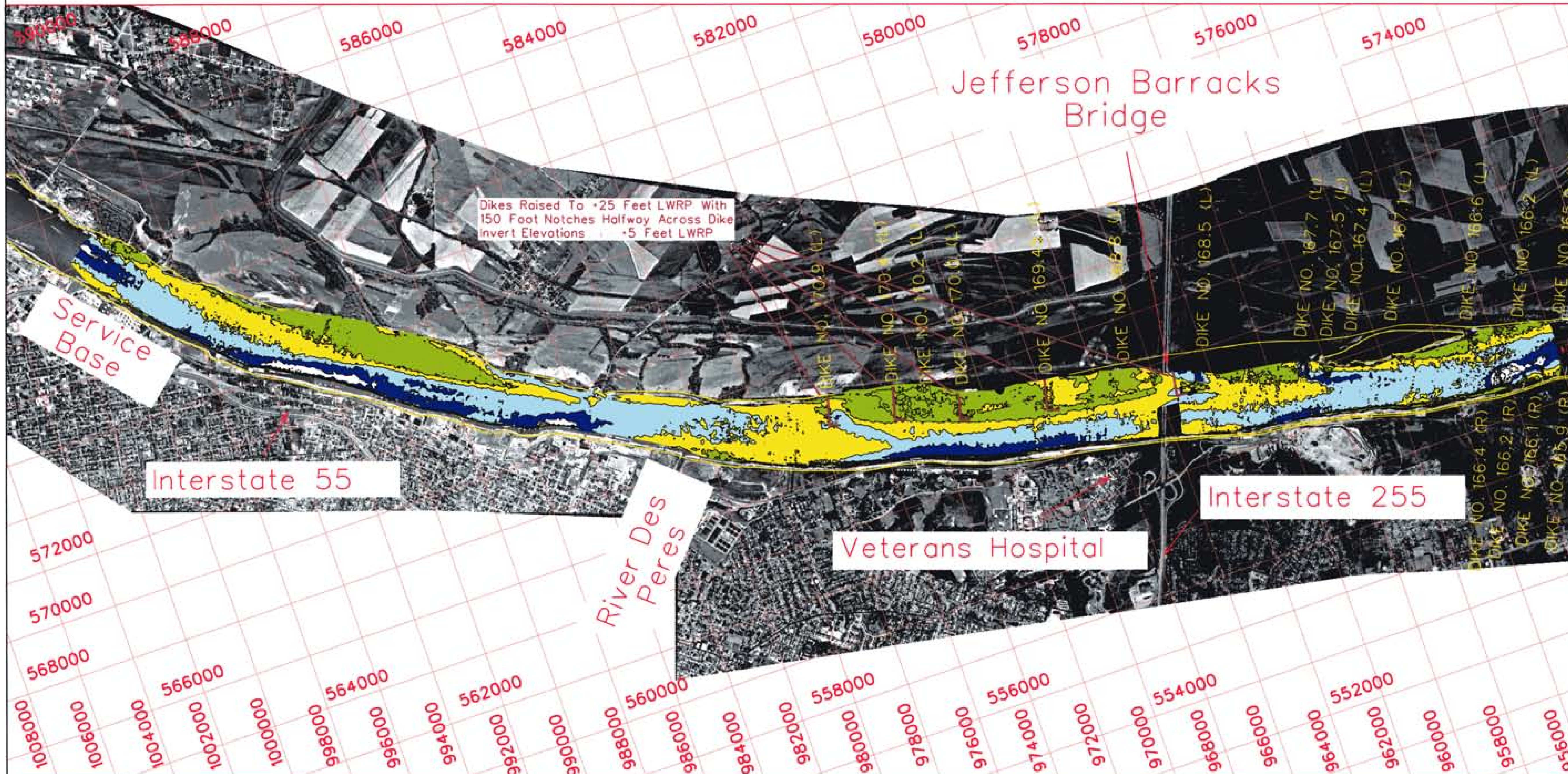
4000 3000 2000 1000 0 2000 4000

DESIGN FILE: 0117DS.DGN

PLOT SCALE: 1" = 4000'

PLOT DATE: 10/01

PLATE NO. 22



Elevations Referenced to LWRP

10 FT
0 FT
-10 FT
-20 FT
-30 FT

N

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

PREPARED BY: D. SMITH
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JEFFERSON BARRACKS MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 176.0 TO 166.0

ALTERNATIVE 3

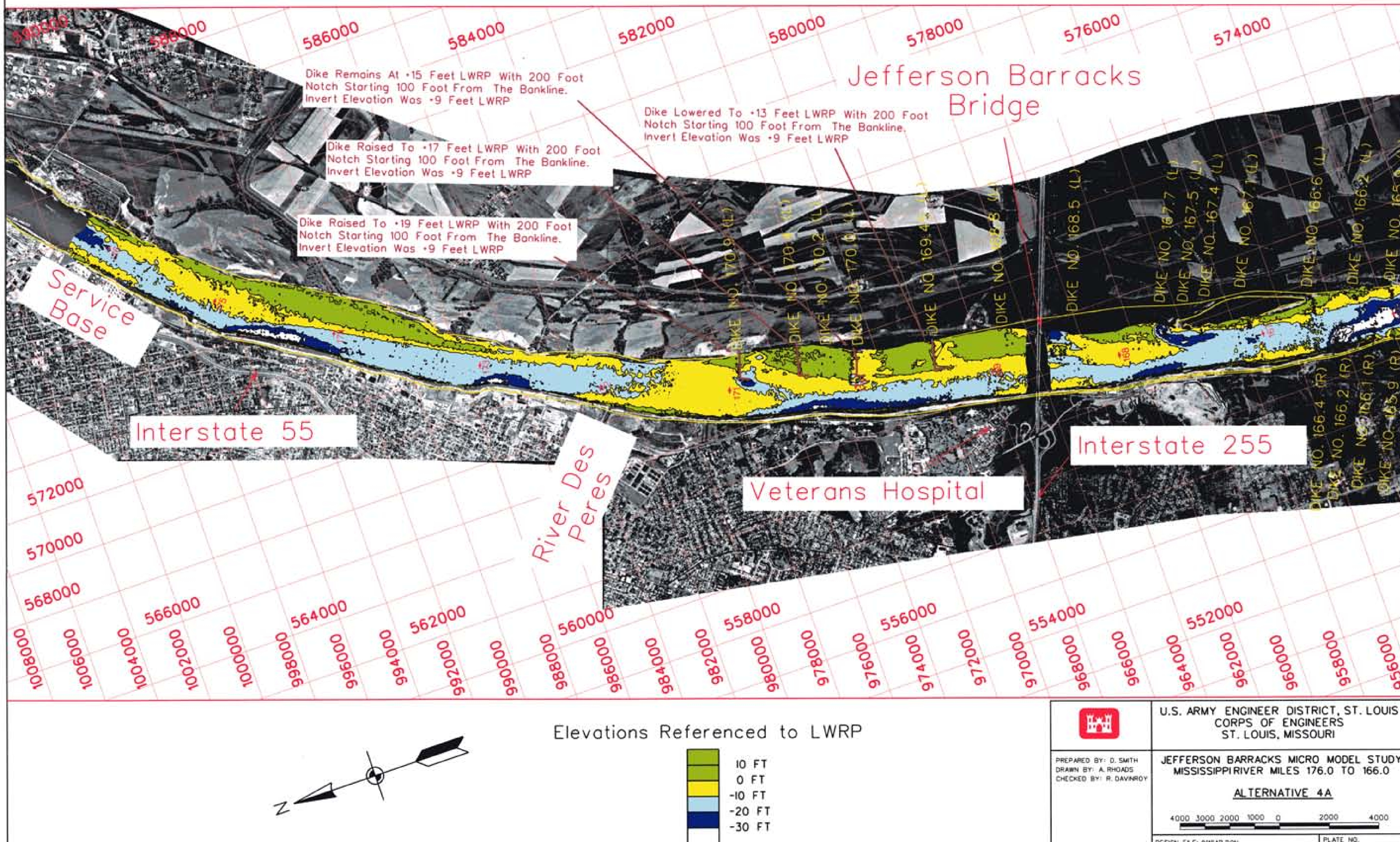
4000 3000 2000 1000 0 2000 4000

DESIGN FILE: 0117BC.DGN

PLOT SCALE: 1" = 4000'

PLOT DATE: 10/01

PLATE NO.
23



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

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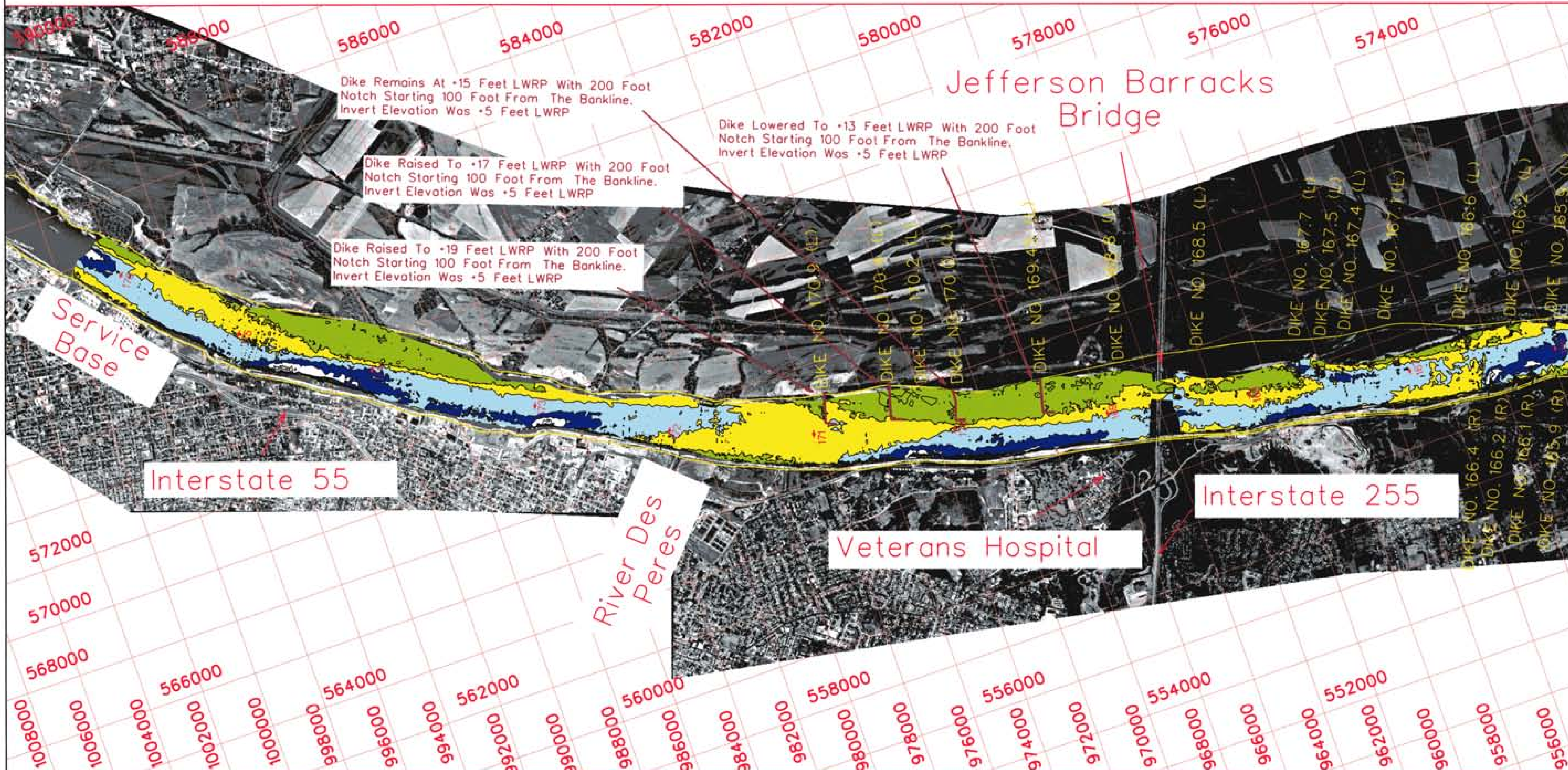
JEFFERSON BARRACKS MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 176.0 TO 166.0

ALTERNATIVE 4A

4000 3000 2000 1000 0 2000 4000

DESIGN FILE: 0119AR.DGN
PLOT SCALE: 1" = 4000'
PLOT DATE: 10/01
PLATE NO. 24



N

Elevations Referenced to LWRP

	10 FT
	0 FT
	-10 FT
	-20 FT
	-30 FT

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

PREPARED BY: D. SMITH
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JEFFERSON BARRACKS MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 176.0 TO 166.0

ALTERNATIVE 4B

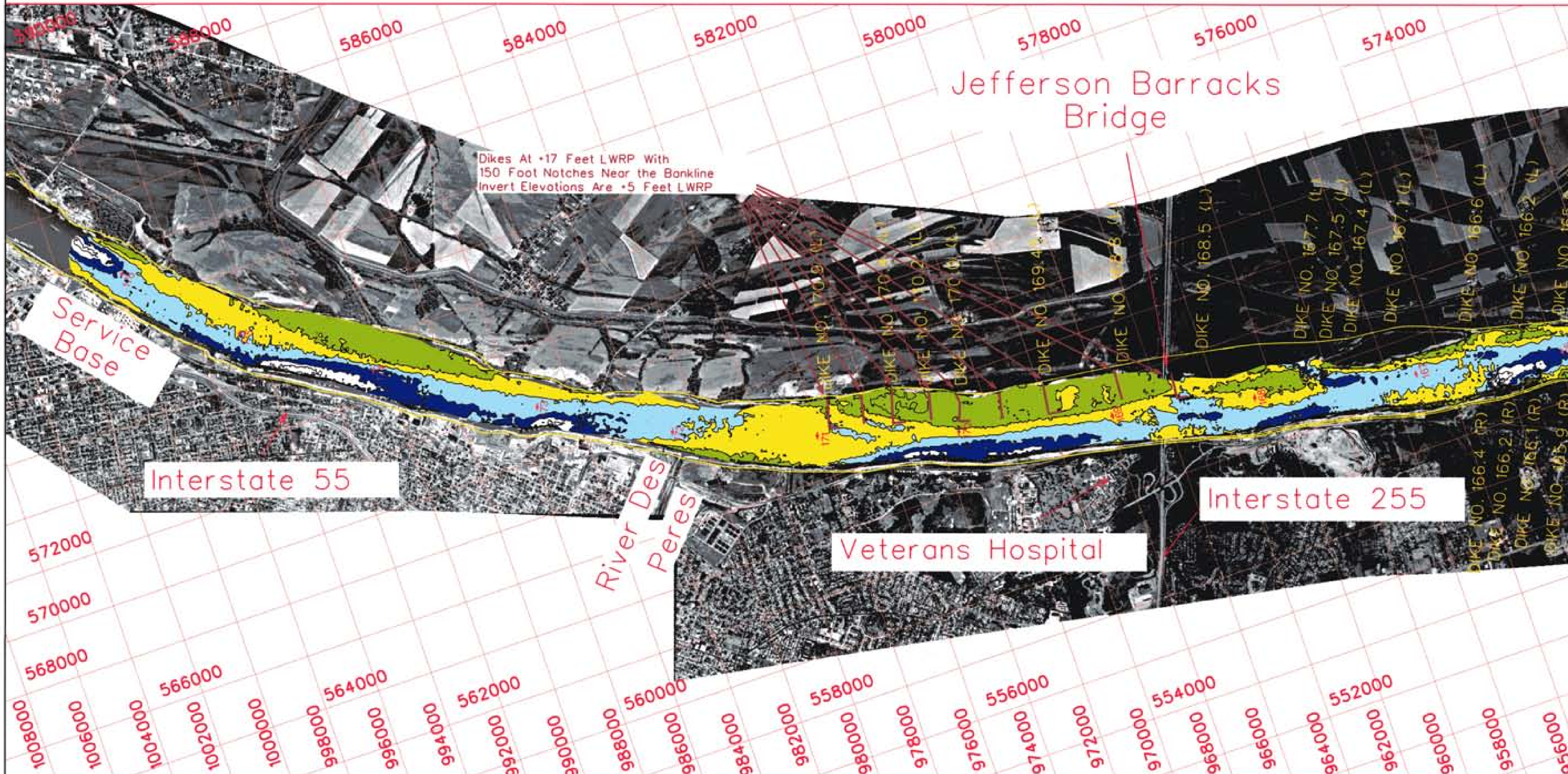
4000 3000 2000 1000 0 2000 4000

DESIGN FILE: 0119AR2.DGN

PLOT SCALE: 1" = 4000'

PLOT DATE: 10/01

PLATE NO.
25



Elevations Referenced to LWRP

10 FT
0 FT
-10 FT
-20 FT
-30 FT

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

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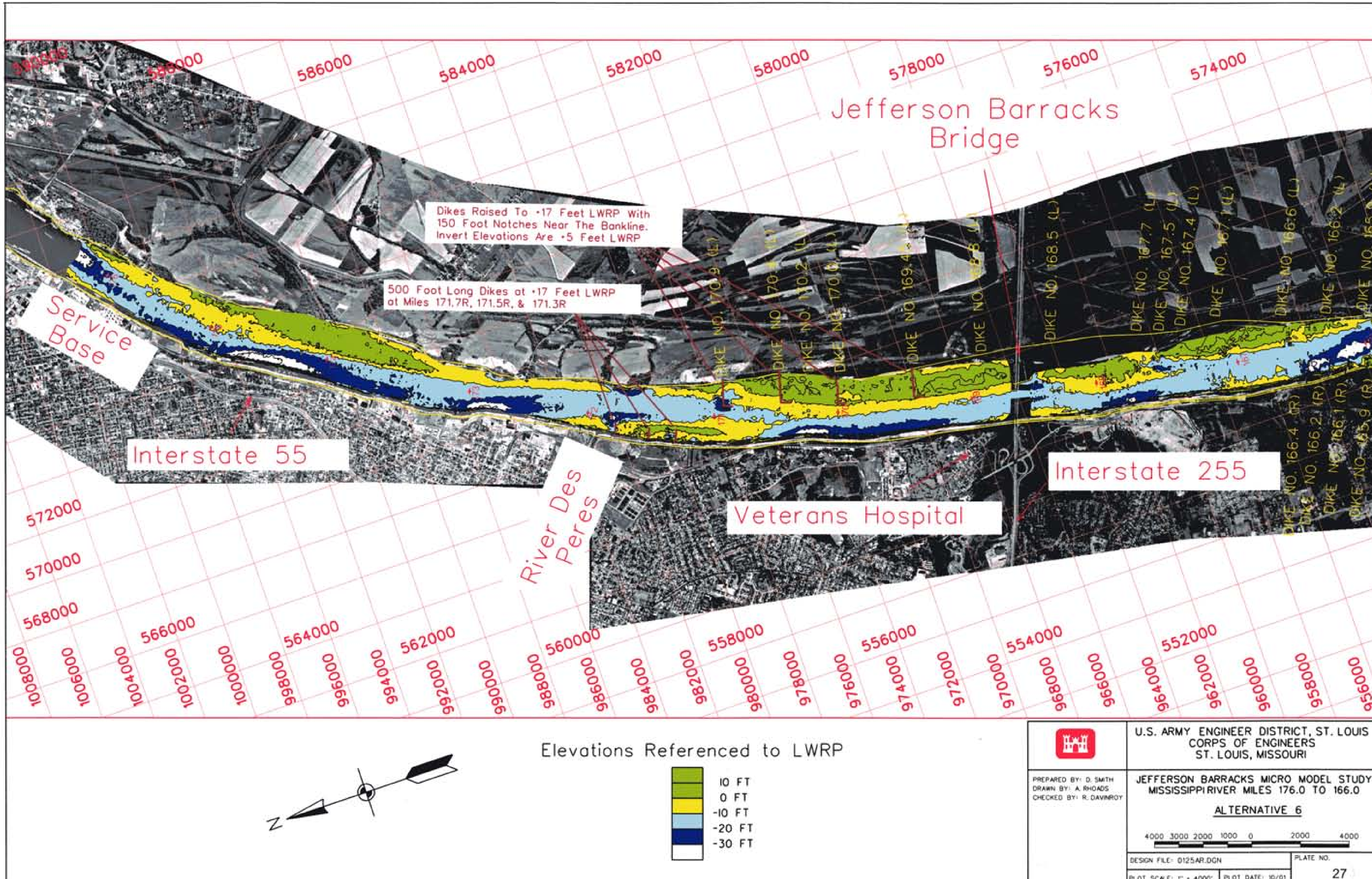
DRAWN BY: A. RHOADS
CHECKED BY: R. DAVINROY

JEFFERSON BARRACKS MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 176.0 TO 166.0

ALTERNATIVE 5

4000 3000 2000 1000 0 2000 4000

DESIGN FILE: 0122AR.DGN
PLOT SCALE: 1" = 4000'
PLOT DATE: 10/01
PLATE NO. 26



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

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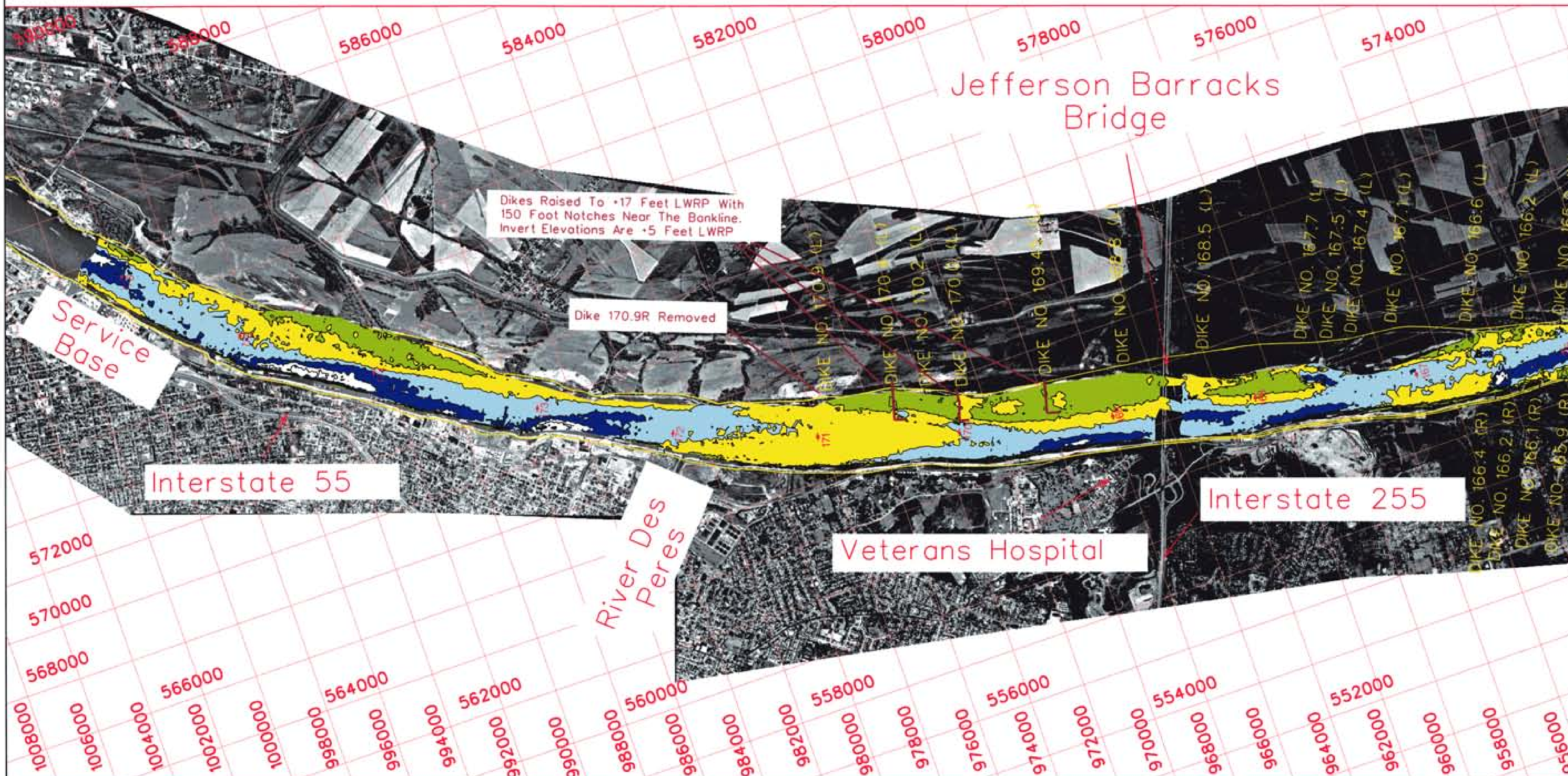
DRAWN BY: A. RHOADS
CHECKED BY: R. DAVINROY

JEFFERSON BARRACKS MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 176.0 TO 166.0

ALTERNATIVE 6

DESIGN FILE: 0125AR.DGN
PLOT SCALE: 1" = 4000'
PLOT DATE: 10/01

PLATE NO. 27



N

Elevations Referenced to LWRP

10 FT
0 FT
-10 FT
-20 FT
-30 FT

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

PREPARED BY: D. SMITH
DRAWN BY: A. RHOADS
CHECKED BY: R. DAVINROY

JEFFERSON BARRACKS MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 176.0 TO 166.0

ALTERNATIVE 7

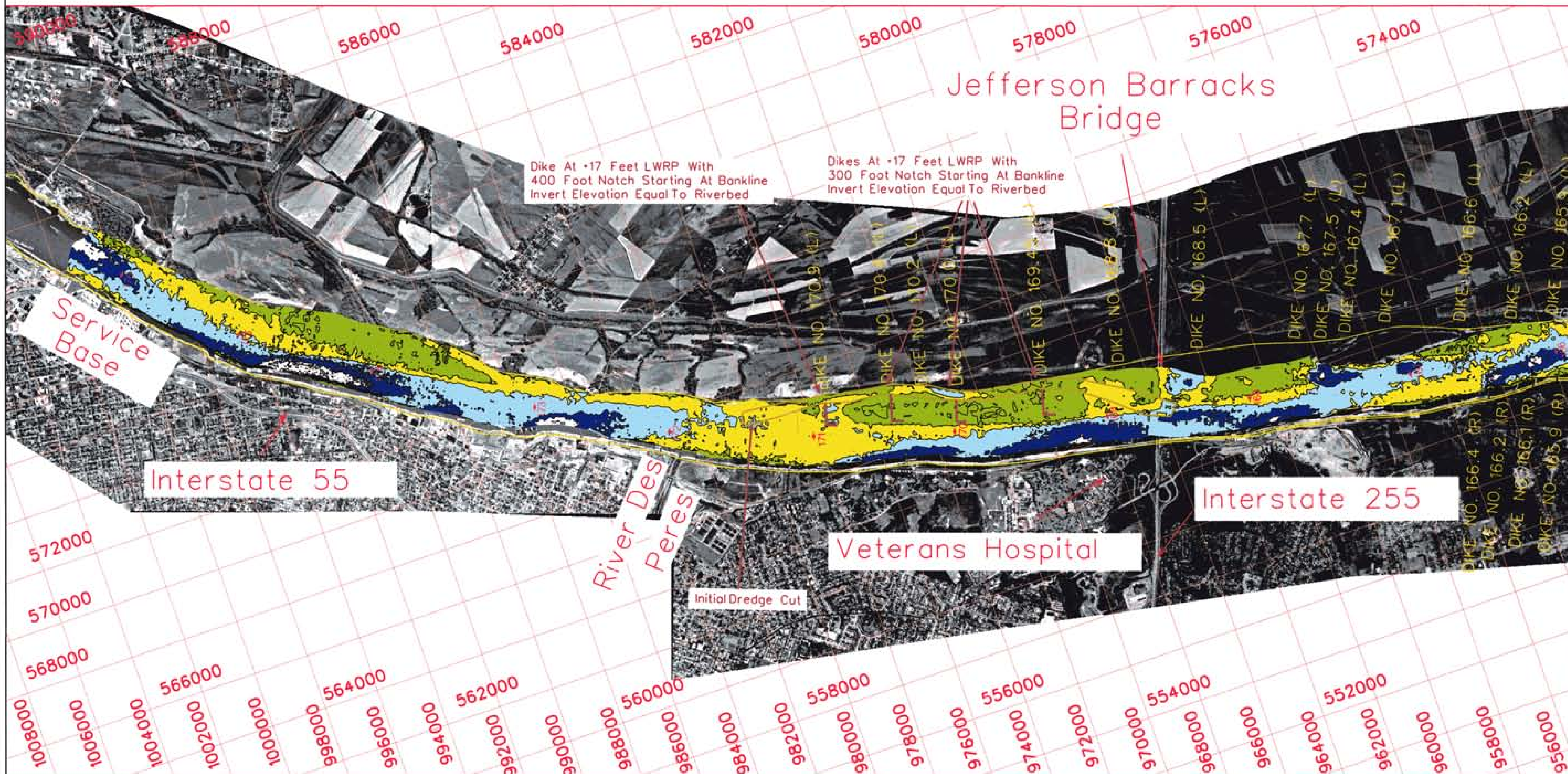
4000 3000 2000 1000 0 2000 4000

DESIGN FILE: 0125AR2.DGN

PLOT SCALE: 1" = 4000'

PLOT DATE: 10/01

PLATE NO.
28



Elevations Referenced to LWRP

10 FT
0 FT
-10 FT
-20 FT
-30 FT

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

PREPARED BY: D. SMITH
DRAWN BY: A. RHOADS
CHECKED BY: R. DAVINROY

JEFFERSON BARRACKS MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 176.0 TO 166.0

ALTERNATIVE 8

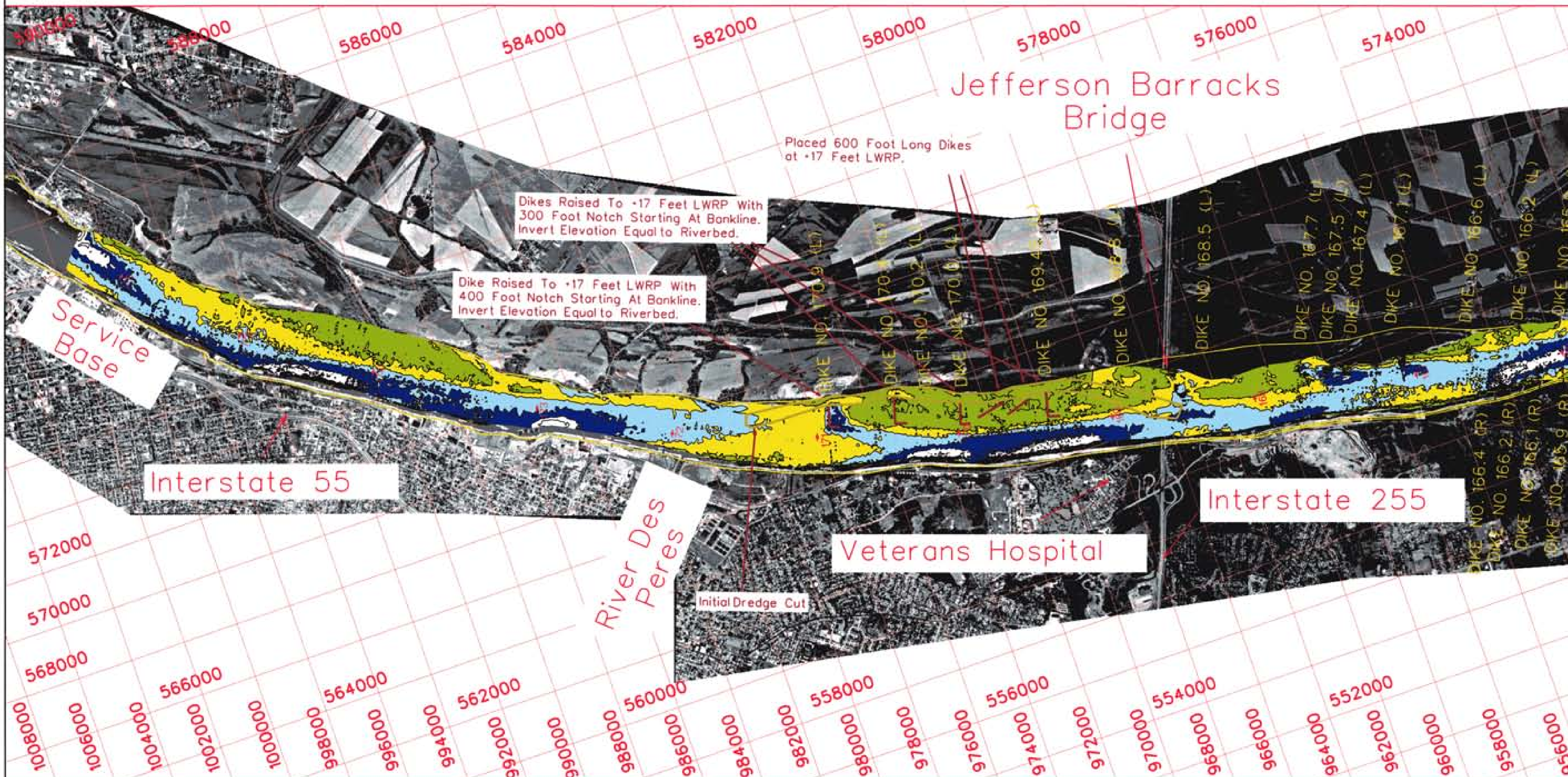
4000 3000 2000 1000 0 2000 4000

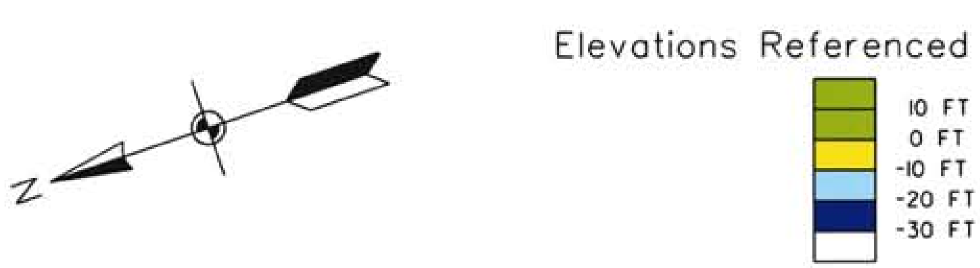
DESIGN FILE: 0130ds.dgn

PLOT SCALE: 1" = 4000'

PLOT DATE: 10/01

PLATE NO.
29





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

PREPARED BY: D. SMITH
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JEFFERSON BARRACKS MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 176.0 TO 166.0

ALTERNATIVE 9

4000 3000 2000 1000 0 2000 4000

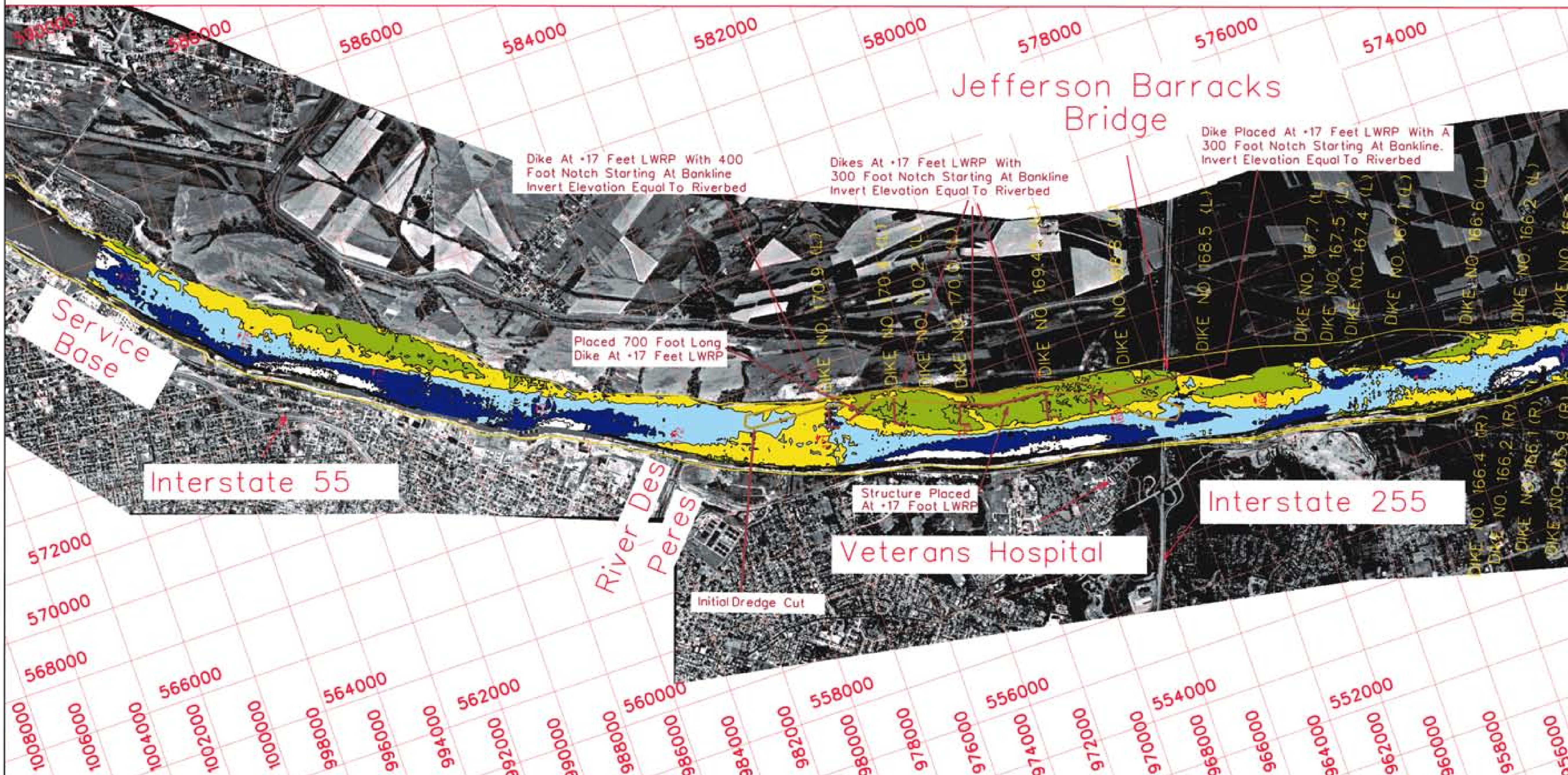
DESIGN FILE: 01310S.DGN

PLOT SCALE: 1" = 4000'

PLOT DATE: 10/01

PLATE NO.

30



Elevations Referenced to LWRP

10 FT
0 FT
-10 FT
-20 FT
-30 FT

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

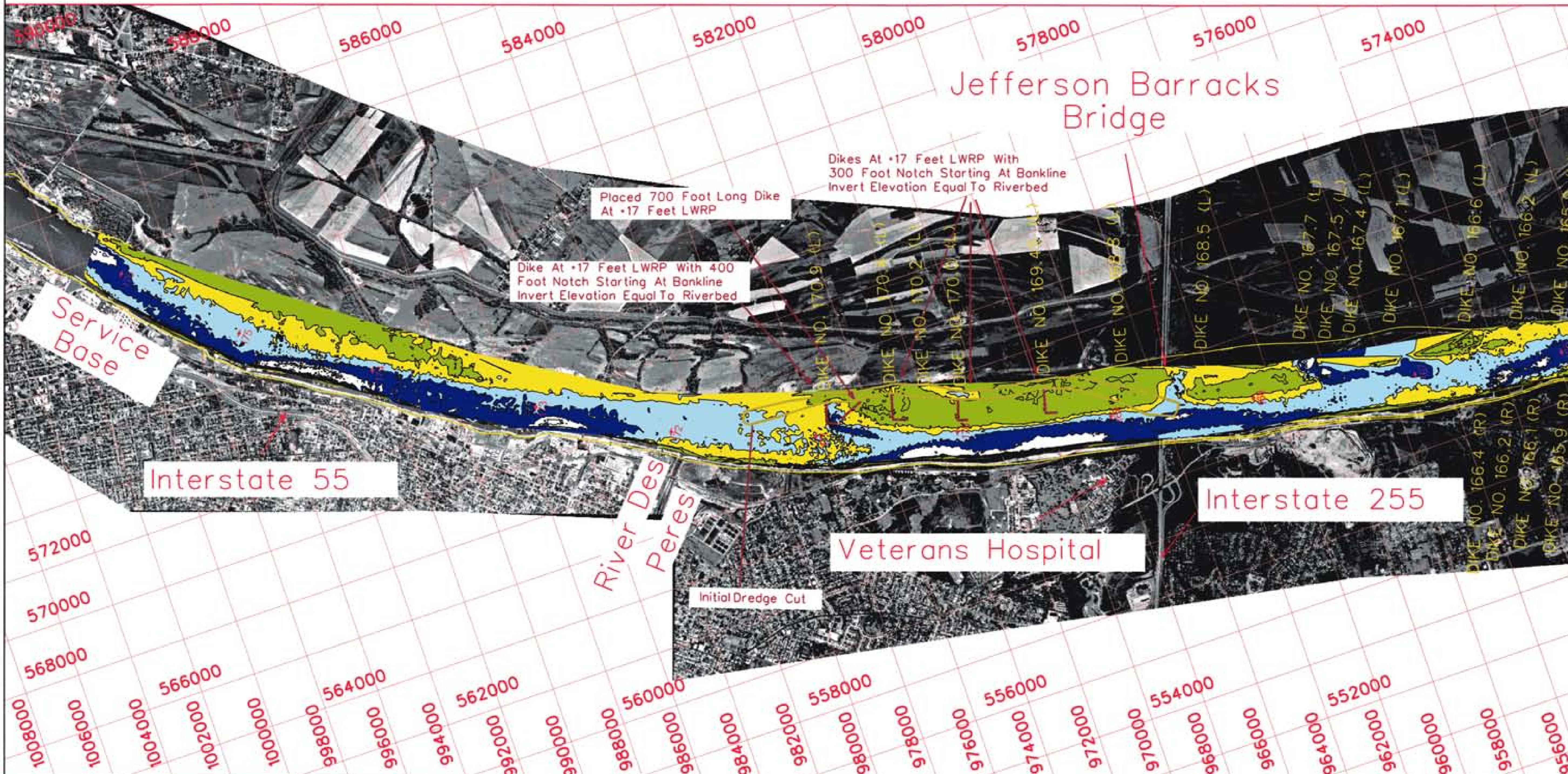
PREPARED BY: D. SMITH
DRAWN BY: A. RHOADS
CHECKED BY: R. DAVINROY

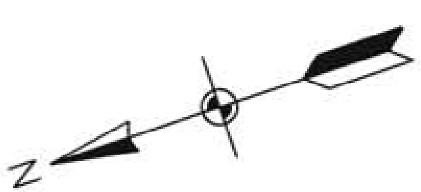
JEFFERSON BARRACKS MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 176.0 TO 166.0

ALTERNATIVE 10

4000 3000 2000 1000 0 2000 4000

DESIGN FILE: 0201DS.DGN
PLOT SCALE: 1" = 4000'
PLOT DATE: 10/01
PLATE NO.
31





Elevations Referenced to LWRP

10 FT
0 FT
-10 FT
-20 FT
-30 FT

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

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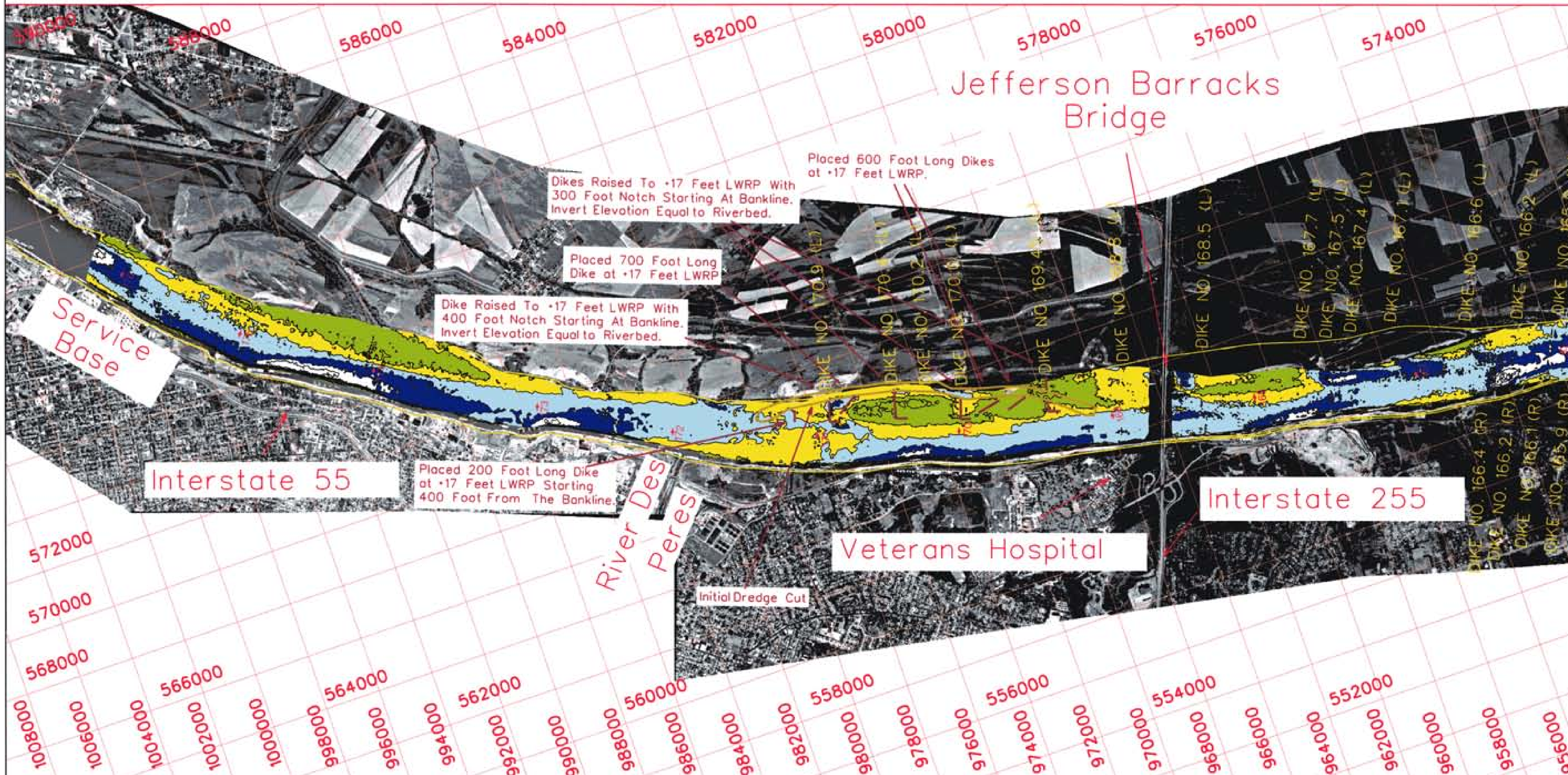
JEFFERSON BARRACKS MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 176.0 TO 166.0

ALTERNATIVE 11

4000 3000 2000 1000 0 2000 4000

DESIGN FILE: 0201DS2.DGN
PLOT SCALE: 1" = 4000'
PLOT DATE: 10/01
PLATE NO. 32



N

Elevations Referenced to LWRP

10 FT
0 FT
-10 FT
-20 FT
-30 FT

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

PREPARED BY: D. SMITH
DRAWN BY: A. RHOADS
CHECKED BY: R. DAVINROY

JEFFERSON BARRACKS MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 176.0 TO 166.0

ALTERNATIVE 12

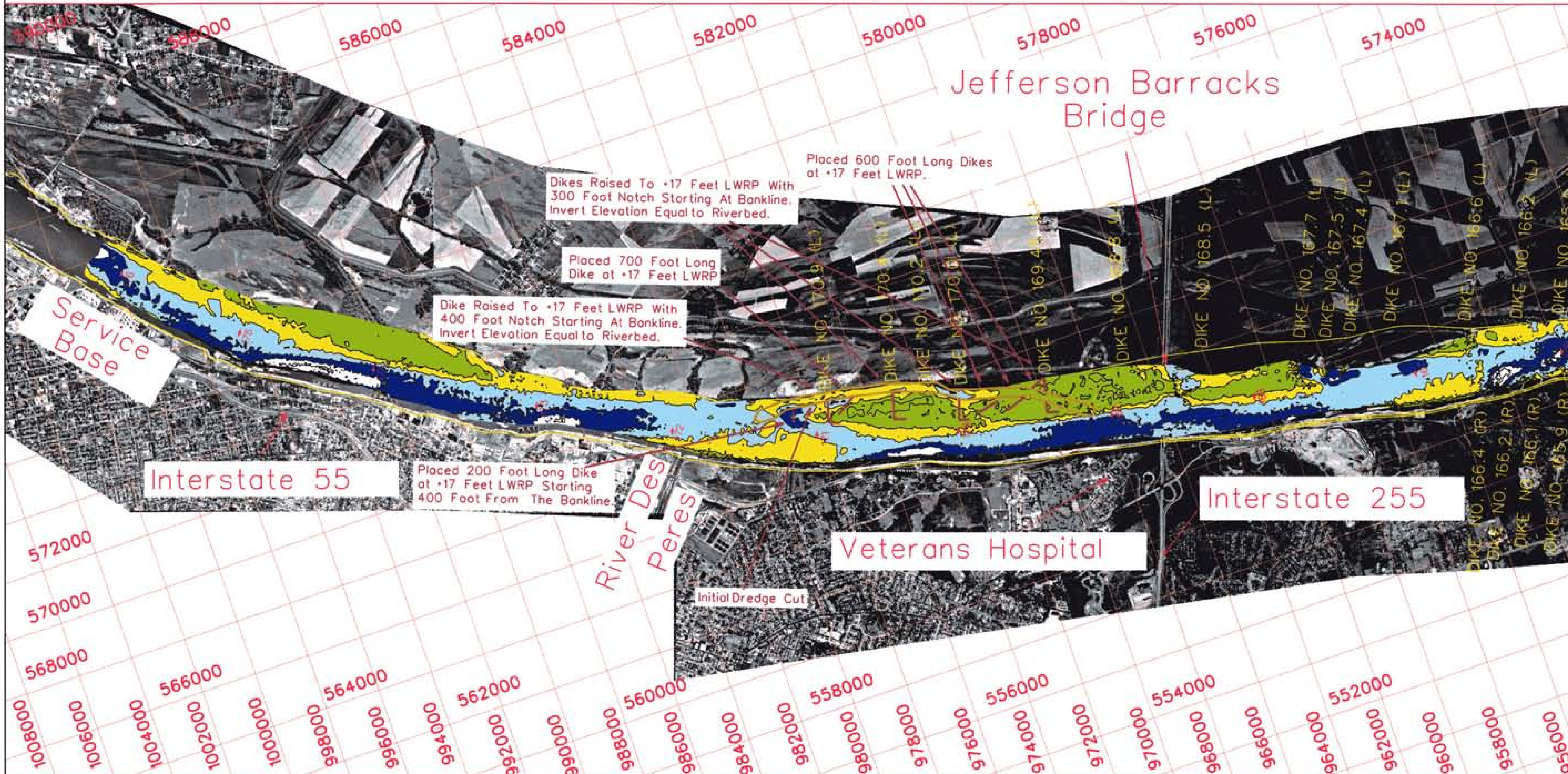
4000 3000 2000 1000 0 2000 4000

DESIGN FILE: 0207BC.DGN

PLOT SCALE: 1" = 4000'

PLOT DATE: 10/01

PLATE NO.
33



N

Elevations Referenced to LWRP

10 FT
0 FT
-10 FT
-20 FT
-30 FT

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

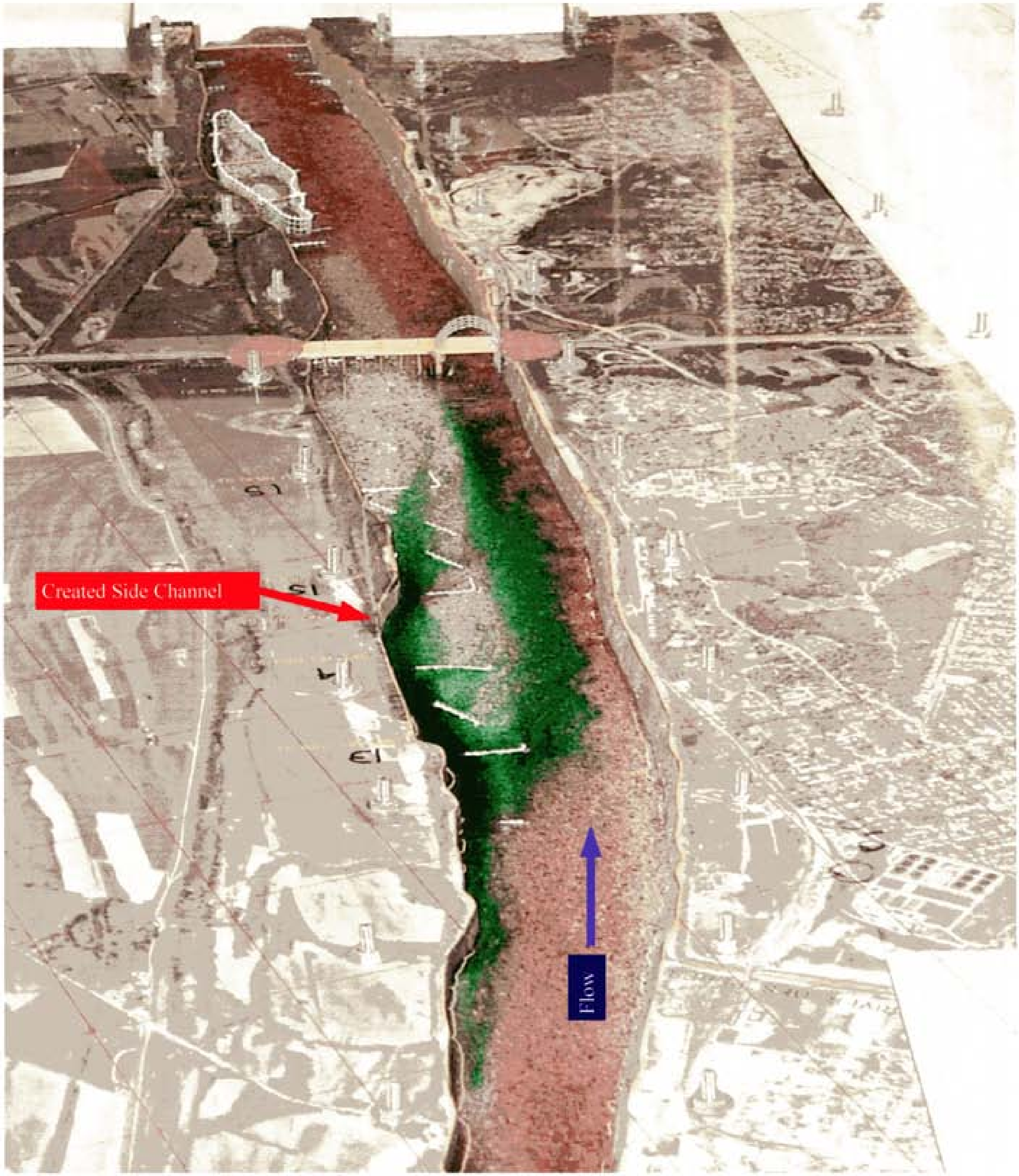
PREPARED BY: D. SMITH
DRAWN BY: A. RHOADS
CHECKED BY: R. DAVINROY

JEFFERSON BARRACKS MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 176.0 TO 166.0

ALTERNATIVE 13

4000 3000 2000 1000 0 2000 4000

DESIGN FILE: 021305.DGN
PLOT SCALE: 1" = 4000'
PLOT DATE: 10/01
PLATE NO.
34



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

PREPARED BY: D. SMITH
DRAWN BY: A. RHOADS
CHECKED BY: R. DAVINROY

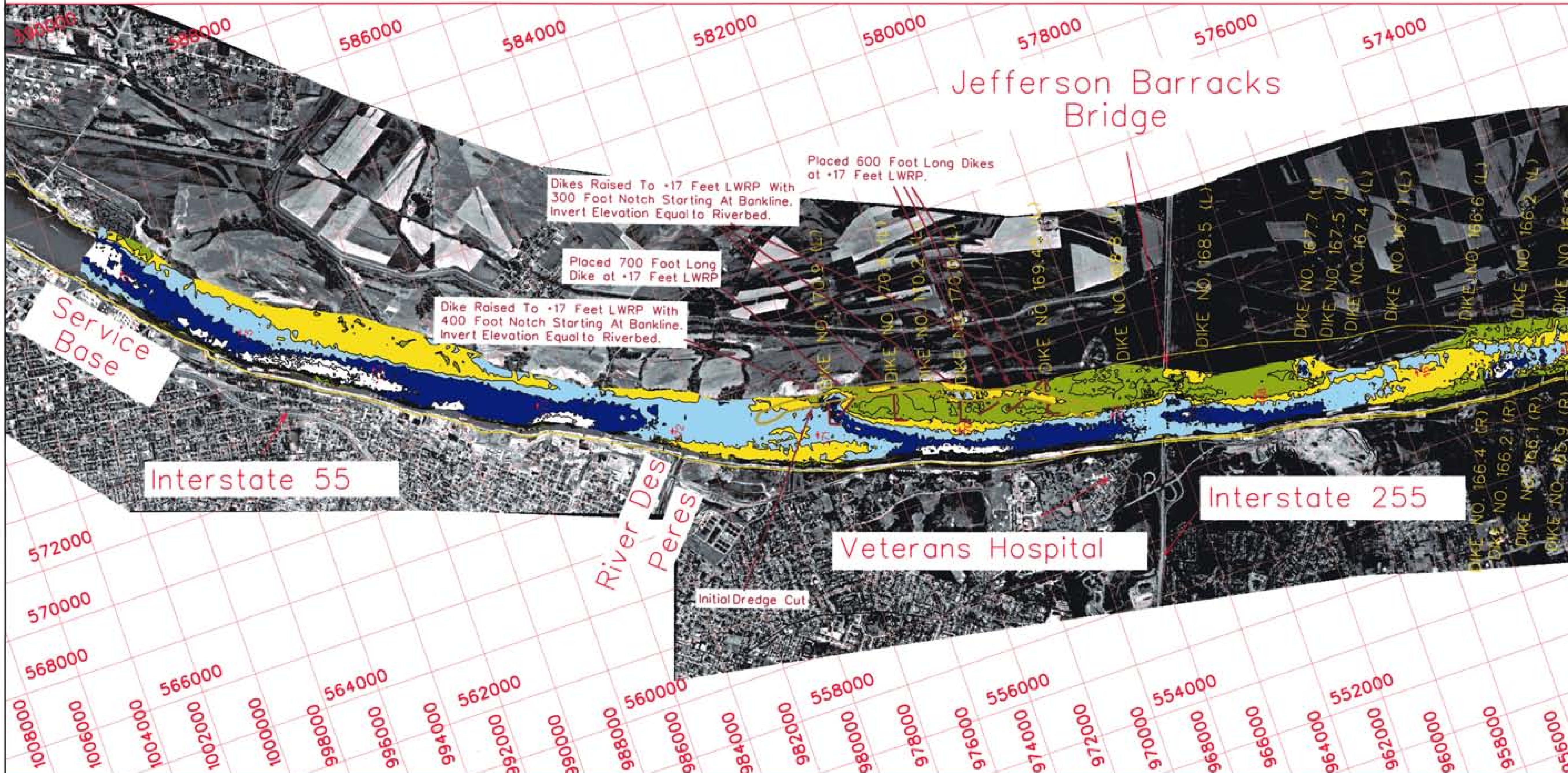
JEFFERSON BARRACKS MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 176.0 TO 166.0

FLOW VISUALIZATION FOR ALTERNATIVE 13

DESIGN FILE: JB DIKES.PUB

PLOT DATE: 10/01

PLATE NO.
35



Elevations Referenced to LWRP

10 FT
0 FT
-10 FT
-20 FT
-30 FT

N

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

PREPARED BY: D. SMITH
DRAWN BY: A. RHOADS
CHECKED BY: R. DAVINROY

JEFFERSON BARRACKS MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 176.0 TO 166.0

ALTERNATIVE 14

4000 3000 2000 1000 0 2000 4000

DESIGN FILE: 02220S.DGN
PLOT SCALE: 1" = 4000'
PLOT DATE: 10/01
PLATE NO.
36