TECHNICAL REPORT M50

FINAL REPORT—SEPTEMBER 2010

US Army Corps of Engineers
St. Louis District

LOCK AND DAM 25
HYDRAULIC SEDIMENT RESPONSE MODEL STUDY

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U.S. ARMY CORPS OF ENGINEERS
ST. LOUIS DISTRICT
HYDROLOGIC AND HYDRAULICS BRANCH
APPLIED RIVER ENGINEERING CENTER
FOOT OF ARSENAL STREET
ST. LOUIS, MISSOURI 63118

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ILLINOIS DEPARTMENT OF NATURAL RESOURCES
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RIVER INDUSTRY ACTION COMMITTEE (RIAC)
ARTCO
KIRBY CORPORATION
MARQUETTE TRANSPORTATION

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Lock and Dam 25 HSR MODEL
Mississippi River Miles 250.0-238.0

HYDRAULIC SEDIMENT RESPONSE MODEL INVESTIGATION

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INTRODUCTION

The U.S. Army Corps of Engineers, St. Louis District, conducted a sedimentation improvement study of the Lock and Dam 25 reach of the Mississippi River between River Miles (RM) 250.0 and 238.0 near Winfield, Missouri. This study was funded by a variety of programs, they were the American Recovery and Reinvestment Act and the U.S. Army Corps of Engineers, St. Louis District's Operation and Maintenance Funds. The main objectives of the study were to reduce or eliminate repetitive channel maintenance dredging and improve difficult alignment conditions experienced upstream of the Lock and Dam between RM 243.5 – 242.0.

The study was conducted between August, 2009 and September 30, 2010 using a hydraulic sediment response (HSR) model at the Applied River Engineering Center, St. Louis District in St. Louis, Missouri. The model study was performed by Mrs. Ashley Cox, Hydraulic Engineer, under direct supervision of Mr. Robert Davinroy, P.E., Chief of River Engineering Section for the St. Louis District. Other Corps of Engineers St. Louis District personnel included: Mr. Leonard Hopkins, P.E., Hydrologic and Hydraulic Branch Chief, Mr. Andrew Schimpf, P.E., Rivers Project Manager, Mr. Dave Gordon, P.E., Chief of Hydraulic Design Section, Mrs. June Jeffries, P.E., Project Manager, Mr. Lance Engle, Dredging Project Manager, Mr. Brian Johnson, Fishery Biologist, Mr. Donovan Henry, Ecologist, Mr. Jasen Brown, P.E., River Engineer, Mr. Ron Dieckmann, Hydraulic Engineer, Mr. Brian Markert, Environmental Management Program (EMP) Project Manager, Mr. Ken Allensworth, Lockmaster for LD 25, Mr. Eddie Brauer, P.E., River Engineer, and Ms. Emily Rivera, AREC Co-op. Personnel from other agencies involved in the study included: Mr. Matthew Mangan from the U.S. Fish and Wildlife Service, Mr. David Ostendorf and Mr. Jason Crites from the Missouri Department of Conservation, Mr. Bernard Heroff, Port Captain for ARTCo, Mr. Shannon Hughes from RIAC and Kirby Corp, and Mr. David Goin, from Marquette Transportation.

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BACKGROUND

1. Problem Description

A. Upstream Approach to Lock and Dam 25

Navigation conditions for downbound tow traffic in the upstream approach to Lock and Dam 25 are difficult. Between Mile 243.0 and Mile 241.5 barge tows must cross from near the Left Descending Bank (LDB) to the Right Descending Bank (RDB) while avoiding a large sandbar in order to properly align themselves with the upstream guardwall at the lock. Because the Mississippi River is approximately 3,600 foot in width at Mile 243.0 (just 1.5 miles upstream of the lock), this crossing requires barge tow pilots to make steep turns in a slow approach to the lock. This situation results in reduced navigation efficiency and presents safety concerns for the navigation industry.

B. Repetitive Dredging between Mile 242.5 and Mile 243.3

Dredging in the Mississippi River is commonly used to provide required navigation depth, width, alignment, or a combination of all three. In the case of the upstream approach to Lock and Dam 25, repetitive channel maintenance dredging is required for navigation alignment. Without dredging, the sandbar located along the RDB between Mile 242.5 and Mile 243.3 would grow in size resulting in an unacceptable navigation approach to the lock. On average, dredging in this area has been required every two to three years from 1985-2006. During that time frame, an average annual amount of 54,390 cubic yards were dredged at a cost of $74,800. The dredging has increased since then and has been required every year since 2007 through 2010. Since 2007, the average annual volume dredged was 397,360 cubic yards at a cost of $671,000.

2. Study Purpose and Goals

The purpose of this study was to develop remedial measures to improve navigation conditions upstream of Lock and Dam 25.

The goals of this study were to:

i. Investigate and provide analysis on the existing flow mechanics causing the dredging and navigation alignment problems.

ii. Evaluate a variety of remedial measures in the HSR model with the objective of identifying the most positive, economical, and environmentally friendly plan to alleviate the need for repetitive channel maintenance dredging while improving channel alignment in the upstream approach to Lock and Dam 25. In order to determine the best alternative, three criteria should be used to evaluate each alternative.

   a. The alternative has to sufficiently reduce or completely eliminate the large volume of sediment between RM 243.5-242.0 and improve the navigation channel alignment for approaching vessels.
   b. The alternative should not negatively impact the outdraft at Lock 25.
   c. The alternative should be evaluated regarding the LDB near Batchtown, the split flow near RM 242.5-241.6, and the depositional area below Batchtown and upstream of the overflow dike. Any changes to the Batchtown Complex should be noted.

iii. Communicate to other engineers, lockmasters, river industry personnel, and environmental agency personnel the results of the HSR model tests and the plans for improvements.

3. Study Reach

The study comprised a twelve mile stretch of the Upper Mississippi River, between RM 250.0 – 238.0 near Winfield, Missouri. The study reach was located between Lincoln County in Missouri and Calhoun County in Illinois. Plate 1 is a location and vicinity map of the study reach. Within the reach there were a variety of features.

On the Left Descending Bank (LDB) from RM 246.0-242.5 is an important biological habitat called the Batchtown Habitat Rehabilitation and Enhancement Project and is managed under the Upper Mississippi River Environmental Management Program (UMRSEMP). Within Turner Island Chute, Batchtown has the 40’s and 70’s channels that allow flow from the Mississippi River in to the complex or stoplogs can can be shut to keep water out. Turner Island Chute is located near RM 245.8-244.6. The Batchtown Chevrons (three J hooks located at RM 245.7, 245.5 and 245.4) were constructed in December 2009. These structures will not affect the model study results. The Batchtown Complex and Turner Island Chute are important environmental features of this reach of river and should not be negatively affected by any solutions to the dredging and alignment issues.

Presently Lock and Dam 25 only has a 600 ft lock. The Navigation and Ecosystem Sustainability Program (NESP) is developing plans to construct a 1,200 foot lock adjacent to the existing lock. The proposed 1,200 foot lock will be constructed in the tailwater of Lock and Dam 25. The results of the HSR study should be provided to the NESP project design team to incorporate in the future lock extension study.

Sandy Chute is located on the land side of the Right Descending Bank (RDB) levee near RM 243.0-241.3. The chute connects with the Mississippi River downstream of Lock and Dam 25 near RM 241.3. Since Lock and Dam 25 does not control Sandy Chute, it represents a big hazard for losing the pool if the levee is compromised.

What used to be a vegetated island near RM 242.8-241.6 on the LDB side of the navigation channel was graded so that the island acts as a control structure and splits the flow. The trees were cut down and the stumps remain on the graded island and can be seen at maximum drawdown. The flow is directed toward the LDB below the Batchtown Complex and directed toward the navigation channel and lock chamber. A mussel survey conducted near the degraded island in 2009 found there was no longer an active mussel bed at that location. Dredge spoils are now disposed of on and near the degraded island, instead of on the RDB sand bar near RM 243.3-242.3.

4. Study Reach Channel Characteristics and General Trends

A. Bathymetry

Hydrographic surveys of the Mississippi River, in the HSR Model extents, are shown on Plates 7-15. The plates show Range Line surveys from 1997 to 2007 and a multi-beam survey from 2009.

The following bathymetric trends have remained relatively constant from 1997 to 2007 after comparison of the above mentioned hydrographic surveys:

Table 1 : Study Reach Bathymetry Trends

River Miles	Description
245.5 – 244.0	The thalweg was located on the right descending bank (RDB) with depths between -30 ft and -50 ft LWRP.
244.0 – 243.5	A crossing was observed between RM 244.0 – 243.5.
243.5 – 242.5	The main energy of the river and thalweg were located on the left descending bank (LDB). Near RM 243.0 a bar was located along the RDB, and separated from the bank by a narrow channel along the revetment. Repetitive channel dredging has occurred between RM 243.5 and 242.3 near the point of the bar in order to maintain the navigation channel. The dredge disposal was placed on the bank side of the RDB bar because an active mussel bed was thought to have existed near the degraded island near RM 242.6. However, a survey in the fall of 2009 showed no mussel bed existed and the dredge material was disposed of on the LDB degraded island near RM 242.6.
242.5 – 241.5	A three way flow split was observed near RM 242.6. A degraded island acted as a control structure and split the high energy flow near the LDB. Part of the flow crossed back over from the LDB to the RDB around RM 242.5. The area in front of the lock has been deep enough to require no dredging.

B. Velocity

ADCP (Acoustic Doppler Current Profile) surveys of the Mississippi River, in the HSR Model extents, are shown on Plates 16-17. ADCP collects the velocity magnitude and direction of the water. The plates show velocity surveys from 2005 to 2008.

Table 2 : Study Reach Velocity Trends

River Miles	Description
243.5 – 242.5	The main energy of the river and higher velocities were located near the LDB. There was a flow split near RM 243 resulting in decreased velocities in the main navigation channel.
242.5 – 241.5	Main channel velocities were relatively constant from RM 242.5 through 242. The magnitudes increased near RM 241.8, in front of the dam, due to split flows coming back together.
241.5-241.0	There were lower velocities near the downstream guide wall for the lock. There were higher velocities near the auxiliary chamber and middle of the channel from RM 241.5 to 241.0.

C. Site Visit Data Collection

The multi-beam bathymetry collected in October 2009, Plate 15, raised questions pertaining to some areas of the river. It was thought that the areas of interest were a result of previous river plan forms or structures, so historical files and photographs were researched. Prior to 1936 (pre - Lock and Dam 26) aerial photographs were geo-referenced into ArcGIS to compare old islands, bank lines, and revetment to the existing conditions. It was determined that near RM 243.0 the narrow line of deposition (or old structure) in the multi-beam survey was historical revetment left in the river from a previous bank failure.

The islands, or depositional bars, were further investigated with surface bed samples. The narrow line of deposition and the large sand bar on the RDB near RM

243.0 was found to be a mixture of clay and mud. The area from RM 243.5-242.5 was recently dredged, and the spoils were placed on top of the depositional bar around RM 242.5 so the sample taken indicated sand. That sample may not be an accurate representation of the bar. Some samples were also taken in the depositional area on the LDB downstream of the Batchtown Complex and near the overflow dike. All the samples had a mixture of clay and some silt. Pictures from the site visit can be seen on Plates 2-4 and the bed sample locations as well as the 2009 mussel survey grid can be seen on Plate 5.

D. Analysis on Existing Flow Mechanics

After thoroughly investigating the model reach, it was apparent that the flow exiting the bend at RM 245.0 was directed towards the LDB and the Batchtown Complex. Because most of the energy was directed towards the LDB, the sediment was deposited near RM 243.0 over the existing RDB bar and into the navigation channel.

Until 2008, the dredge spoils were placed on the RDB bar at RM 243.0 which most likely increased the growth of the bar. As a result of the existing planform of the river and previous dredge disposals, the alignment and depth of the navigation channel was a problem that needed to be addressed. The dredge spoils from 2008 were placed over the degraded island, with the thought that the RDB bar would grow at a much slower rate than it was when dredge spoils were placed on top of the bar. However, the navigation channel and alignment have worsened in 2010 and will most likely have to be dredged during the fall dredging season. It’s possible that the placement of dredge spoils was only a minor contributing factor to the growth of the RDB bar.

HSR MODEL DESCRIPTION

A picture of the Lock and Dam 25 Hydraulic Sediment Response (HSR) model is shown on Plate 6. An aerial photo of the extents of the HSR model is shown on Plate 17A.

1. Scales and Bed Materials

The model employed a horizontal scale of 1 inch = 800 feet, or 1:9600, and a vertical scale of 1 inch = 45 feet, or 1:540, for a 17.78 to 1 distortion ratio of linear scales. This distortion supplied the necessary forces required for the simulation of sediment transport conditions similar to those observed in the prototype. The bed material was granular plastic urea, Type II, with a specific gravity of 1.40.

2. Appurtenances

The HSR model planform insert was constructed according to the 2006 high-resolution aerial photography of the study reach. The insert was then mounted in a standard HSR model flume. The riverbanks of the model were routed into dense polystyrene foam and modified during calibration with clay and galvanized steel mesh. Rotational jacks located within the hydraulic flume controlled the slope of the model. The measured slope of the insert and flume was approximately 0.04 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 control the flow of water and sediment into the model. Discharge was monitored by a magnetic flow meter interfaced with the customized computer software. Resultant bed configurations were measured and recorded with a three dimensional laser scanner. The magnitude and direction of the velocities of the water in the model were measured and recorded with a Laser Doppler Velocimeter (LDV).

HSR MODEL TESTS

1. Model Calibration

The calibration of the model involved the adjustment of water discharge, sediment volume, model slope, bed material, 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. One important parameter to note was that in calibration, screen was used on the model riverbed to maintain the integrity of the point bar near Turners Island and RM 245. Because the screen was needed for calibration, the screen had to remain in the model throughout the rest of the study (ie during alternative testing).

A. HSR Model Operation

In all model tests, steady state flow was simulated in the 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 1.42 gallons per minute for all design alternatives tested. An important factor during the modeling process was 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 bank full stage.

2. Base Test

A. Bathymetry

Calibration was achieved after numerous favorable bathymetric comparisons of the prototype surveys were made to several surveys of the model. The resultant bathymetry served as the bathymetry base test for the model and is shown on Plate 18.

Results of the HSR model base test bathymetry and a comparison to the 1999 through 2008 prototype surveys indicated the following trends:

From RM 245.5 to 244.0, the model and the prototype surveys showed the thalweg on the RDB. The prototype surveys had slightly more depth than the model base test survey. The point bar was slightly larger in the model than in the prototype.

In the model, the crossing was observed from RM 244.0-243.3 which reduced the depositional area on the LDB near RM 244.0-243.8. In the prototype, the crossing was observed from RM 244.0-243.0, after it formed a slightly smaller sand bar than the model. The prototype crossing was deeper than in the model. The sand bar developed at RM 243.9 in the model and extended to RM 242.3. In the prototype, the sand bar typically formed further downstream at RM 243.4; thus the prototype had more depth on the RDB from RM 243.9 -242.3 than the model. In some prototype surveys, a small, narrow gut was observed between the RDB and the depositional area; in other prototype surveys, the gut was not observed.

The model and the prototype had a split flow near RM 243.0. In both surveys, the flow split around the degraded island that was located from RM 242.5-241.7. In the model, there was deposition in the navigation channel from RM 243.0-242.4. This deposition was not seen in the prototype due to the repetitive dredging.

Between RM 243.0-242.3, the thalweg crossed from the LDB to the RDB in both the prototype and model. Below the Batchtown complex and upstream of the overflow structure, a sand bar formed in the model and was observed in prototype surveys. At the downstream end of the degraded island there was no longer a flow split. As a result of the concentrated flow, there was deep water both upstream and downstream of the lock and dam in the prototype and model.

B. Velocity (LDV)

Once favorable bathymetric trends were observed in the model, Laser Doppler Velocimeter (LDV) profiles were collected from the model to compare with ADCP data collected on the river. After comparisons of the prototype ADCP were made to several LDV surveys of the model and the trends were similar, the model was considered calibrated. The resultant LDV velocities served as the velocity base test for the model and is shown on Plate 19.

The profile for the LDV was determined based upon the previously collected prototype transects. Results of the HSR model base test velocities and a comparison to the 2005 and 2007 prototype ADCP surveys indicated the following trends:

From RM 243.0 to 242.3, the model and the prototype both showed higher velocities existed in the main navigation channel. The prototype velocities curved around and followed along the form of the existing RDB sand bar slightly more than the model velocity base test survey.

In both the model and the prototype, once the flow deflected off the RDB L-dike at RM 242.1, the velocities direction changed and were nearly parallel to the RDB from RM 242.1 to 241.6. Just upstream and around the lock, in both the model and the prototype, the velocities changed direction, from parallel along the RDB, to angled away from the bank and towards the dam and LDB. This change in the direction of the velocity has been dangerous for tows near the lock and is called outdraft. Some alternatives that bathymetrically showed reduction in deposition and improved the channel alignment were monitored with the LDV to document if the alternative had positive or negative results on the outdraft.

3. Design Alternative Tests

The testing process consisted of installing alternative structure configurations in the model followed by a bathymetric and velocimetric analyses of the results. The goal was to alter the model bathymetry and velocity distribution in a manner intended to alleviate channel dredging, improve alignment, and either reduce or not worsen the outdraft in front of the lock. Evaluation of each alternative was accomplished through a qualitative comparison to the model base test bathymetry and model base test velocity (LDV) data. When an alternative reduced the deposition and improved the channel alignment, then the LDV was run to determine the effects on outdraft. The effects on outdraft were analyzed by looking at the magnitude and direction of the velocity just upstream of the lock in the alternative test compared to the magnitude and direction of velocity just upstream of the lock in the base test.

Alternative 1:

Type of Structure	River Mile	LDB or RDB	Dimensions (Feet)	Structure Top Elevation (ft in MSL)
Raise Existing Dike	243.8	RDB	NA	436
Raise Existing Dike	243.5	RDB	NA	436
Raise Existing Dike	242.9	RDB	NA	436
Raise Existing Dike	242.8	RDB	NA	436

Results: *Bathymetry (Plate 20)*

Reduced Sediment Deposition between RM 243.5-242.0	Additional Comments
No	

Alternative 2:

Type of Structure	River Mile	LDB or RDB	Dimensions (Feet)	Structure Top Elevation (ft in MSL)
Raise Existing Dike	243.9	LDB	NA	436
Raise Existing Dike	243.7	LDB	NA	436

Results: *Bathymetry (Plate 21)*

Reduced Sediment Deposition between RM 243.5-242.0	Additional Comments
No	The reduction in deposition was not significant enough to be considered a recommendation. It also reduced the split flow near the LDB in the vicinity of RM 242.8, which could negatively affect the Batchtown Complex (ie, cut off the downstream flow into the complex).

Alternative 3:

Type of Structure	River Mile	LDB or RDB	Dimensions (Feet)	Structure Top Elevation (ft in MSL)
Raise Existing Dike	243.9	LDB	NA	436
Raise Existing Dike	243.8	RDB	NA	436
Raise Existing Dike	243.7	LDB	NA	436
Raise Existing Dike	243.5	RDB	NA	436
Raise Existing Dike	242.9	RDB	NA	436
Raise Existing Dike	242.8	RDB	NA	436

Results: *Bathymetry (Plate 22)*

Reduced Sediment Deposition between RM 243.5-242.0	Additional Comments
Yes	The reduction in deposition was not significant enough to be considered a recommendation.

Alternative 4:

Type of Structure	River Mile	LDB or RDB	Dimensions (Feet)	Structure Top Elevation (ft in MSL)
Raise Existing Dike	243.9	LDB	NA	436
Raise Existing Dike	243.7	RDB	NA	436
Raise Existing Dike	243.8	LDB	NA	436
Raise Existing Dike	243.5	RDB	NA	436

Results: *Bathymetry (Plate 23)*

Reduced Sediment Deposition between RM 243.5-242.0	Additional Comments
Yes	Although there was a slight reduction in deposition near RM 243, deposition increased near the L dike at RM 242.

Alternative 5:

Type of Structure	River Mile	LDB or RDB	Dimensions (Feet)	Structure Top Elevation (ft in MSL)
Construct Chevron	243.7	LDB	400 x 400	436
Construct Chevron	243.5	LDB	300 x 300	436
Construct Chevron	243.0	LDB	300 x 300	436

Results: *Bathymetry (Plate 24), Velocity Upstream (Plate 25), and Velocity Downstream (Plate 26) Analysis*

Reduced Sediment Deposition between RM 243.5-242.0	Positive Impact or No Change in Outdraft	Additional Comments
Yes	Yes	The navigation channel was deepened with an average depth of about -10 to -15 ft LWRP. A better, more straight alignment was created and the outdraft was reduced. The chevrons split the high velocities, forcing the high flows to remove deposition in the main channel.

Alternative 6:

Type of Structure	River Mile	LDB or RDB	Dimensions (Feet)	Structure Top Elevation (ft in MSL)
Construct Chevron	243.7	LDB	300 x 300	436
Construct Chevron	243.5	LDB	300 x 300	436
Construct Chevron	243.0	LDB	300 x 300	436

Results: *Bathymetry (Plate 27) and Velocity (Plate 28) Analysis*

Reduced Sediment Deposition between RM 243.5-242.0	Positive Impact or No Change in Outdraft	Additional Comments
Yes	Yes	Although the navigation channel was deepened with an average depth of -10 to -15 ft, there was still some sediment build up near the chevron in the channel at RM 243.5. A better more straight alignment was created and the out draft was reduced. It also reduced the split flow near the LDB in the vicinity of RM 242.8.

Alternative 7:

Type of Structure	River Mile	LDB or RDB	Dimensions (Feet)	Structure Top Elevation (ft in MSL)
Construct Chevron	243.5	LDB	500 x 500 (RDB leg = 800)	436

Results: *Bathymetry (Plate 29)*

Reduced Sediment Deposition between RM 243.5-242.0	Additional Comments
Yes	The navigation channel was deepened, but there was still a large volume of sediment near RM 243 in the main navigation channel.

Alternative 8:

Type of Structure	River Mile	LDB or RDB	Dimensions (Feet)	Structure Top Elevation (ft in MSL)
Construct Rootless Trail Dike	243.65	LDB	125 ft Gap From Bank 1,200 ft Dike 1,200 ft Trail Dike	436

Results: *Bathymetry (Plate 30) and Velocity (Plate 31) Analysis*

Reduced Sediment Deposition between RM 243.5-242.0	Positive Impact or No Change in Outdraft	Additional Comments
Yes	No Change	The navigation channel was deepened, but there was still some sediment build up near RM 243.5 in the main navigation channel. It also reduced the split flow near the LDB in the vicinity of RM 242.8. These results could lead to too much sedimentation at the downstream end of Batchtown, cutting off flow to the complex.

Alternative 9:

Type of Structure	River Mile	LDB or RDB	Dimensions (Feet)	Structure Top Elevation (ft in MSL)
Construct Chevron	243.7	LDB	400 x 400	436
Construct Chevron	243.4	LDB	300 x 300	436
Construct Chevron	242.6	LDB	300 x 300	436

Results: *Bathymetry (Plate 32)*

Reduced Sediment Deposition between RM 243.5-242.0	Additional Comments
Yes	The navigation channel was deepened here, but there was still a large volume of sediment near RM 243 in the main navigation channel.

Alternative 10:

Type of Structure	River Mile	LDB or RDB	Dimensions (Feet)	Structure Top Elevation (ft in MSL)
Construct Chevron	243.7	LDB	400 x 400	436
Construct Chevron	243.5	RDB	300 x 300	436
Construct Chevron	243.4	LDB	300 x 300	436
Construct Chevron	242.6	LDB	300 x 300	436

Results: *Bathymetry (Plate 33)*

Reduced Sediment Deposition between RM 243.5-242.0	Additional Comments
Yes	The navigation channel was deepened, but there was still a large volume of sediment from RM 243.5-242.5.

Alternative 11:

Type of Structure	River Mile	LDB or RDB	Dimensions (Feet)	Structure Top Elevation (ft in MSL)
Construct Chevron	243.7	LDB	400 x 400	436
Construct Chevron	243.5	RDB	300 x 300	436
Construct Chevron	243.4	LDB	300 x 300	436
Construct Chevron	243.0	LDB	300 x 300	436
Construct Chevron	242.8	LDB	300 x 300	436

Results: *Bathymetry (Plate 34)*

Reduced Sediment Deposition between RM 243.5-242.0	Additional Comments
Yes	The navigation channel was deepened, but there was still a large volume of sediment from RM 243.5-242.8.

Alternative 12:

Type of Structure	River Mile	LDB or RDB	Dimensions (Feet)	Structure Top Elevation (ft in MSL)
Construct Chevron	243.7	LDB	400 x 400	436
Construct Chevron	243.5	RDB	300 x 300	436
Construct Chevron	243.4	LDB	300 x 300	436
Construct Chevron	243.1	LDB	300 x 300	436
Construct Chevron	242.8	LDB	300 x 300	436

Results: *Bathymetry (Plate 35), Velocity Upstream (Plate 36), and Velocity Downstream (Plate 37) Analysis*

Reduced Sediment Deposition between RM 243.5-242.0	Positive Impact or No Change in Outdraft	Additional Comments
Yes	Yes	The navigation channel was deepened. The alignment was slightly better than the base test, but not as straight as the Alternative 5 alignment. The first chevron splits the flow exiting the bend at RM 244.0. Higher velocities were observed in the main channel and allowed slower velocities to deflect toward the LDB side. With the first chevron located at RM 243.7, navigation tows would have more time to adjust coming downstream out of the bend to the new alignment. The flow in the main channel remained relatively straight or parallel to the RDB bank.

Alternative 13:

Type of Structure	River Mile	LDB or RDB	Dimensions (Feet)	Structure Top Elevation (ft in MSL)
Construct Chevron	244.3	LDB	400 x 400	436
Construct Chevron	243.8	LDB	400 x 400	436
Construct Chevron	243.5	RDB	300 x 300	436
Construct Chevron	243.4	LDB	300 x 300	436
Construct Chevron	243.1	LDB	300 x 300	436
Construct Chevron	242.8	LDB	300 x 300	436

Results: *Bathymetry (Plate 38), Velocity Upstream (Plate 39), and Velocity Downstream (Plate 40) Analysis*

Reduced Sediment Deposition between RM 243.5-242.0	Positive Impact or No Change in Outdraft	Additional Comments
Yes	Yes	Compared to other alternatives, this alternative caused the navigation channel to be the deepest. The alignment was better than the base test. Once the flow came out of the bend, the first chevron split the flow just like Alt. 12, however it occurred further upstream, because the first chevron was located at RM 244.3. When compared to Alt. 12, the location of the first chevron could increase the difficulty for large tows exiting the bend. Tows would need to come out of the bend and adjust their tow immediately to navigate the new alignment. The flow in the main channel remained relatively straight or parallel to the RDB bank.

Alternative 14:

Type of Structure	River Mile	LDB or RDB	Dimensions (Feet)	Structure Top Elevation (ft in MSL)
Rootless Dike -550 ft from LDB	244.0	LDB	800	436
Rootless Dike -400 ft from LDB	243.7	LDB	900	436
Rootless Dike -330 ft from LDB	243.5	LDB	900	436
Rootless Dike -1,300 ft from LDB	243.1	LDB	900	436

Results: *Bathymetry (Plate 41), Velocity Upstream (Plate 42), and Velocity Downstream (Plate 43) Analysis*

Reduced Sediment Deposition between RM 243.5-242.0	Positive Impact or No Change in Outdraft	Additional Comments
Yes	No Change	The navigation channel was deepened. The velocities upstream acted very similar to Alt. 12, but more flow was observed in the main channel in Alt. 14. The velocities were parallel to the RDB. However, the downstream velocities showed that flows deflected off the RDB near RM 242.3 and Dike 242.1R, which caused the outdraft to worsen.

Alternative 15:

Type of Structure	River Mile	LDB or RDB	Dimensions (Feet)	Structure Top Elevation (ft in MSL)
Chevron	244.4	LDB	400 x 400	436
Chevron	244.0	LDB	300 x 300	436
Chevron	243.7	LDB	400 x 400	436
Rootless Dike -815 ft from LDB	243.4	LDB	1,000	436
Rootless Dike -1,700 ft from LDB	242.9	LDB	800	436

Results: *Bathymetry (Plate 44) Analysis*

Reduced Sediment Deposition between RM 243.5-242.0	Additional Comments
Yes	The navigation channel was deepened, but there still was some sediment build up near RM 243.5-242.5. There was also a build up of sediment near the LDB of the degraded island, reducing the flow near the LDB in the vicinity of RM 242.0.

Alternative 16:

Type of Structure	River Mile	LDB or RDB	Dimensions (Feet)	Structure Top Elevation (ft in MSL)
Weir	244.8	RDB	615	414.7
Weir	244.6	RDB	510	414.7
Weir	244.5	RDB	690	414.7
Weir	244.4	RDB	600	414.7
Weir	244.3	RDB	795	414.7
Weir	244.2	RDB	845	414.7
Weir	244.0	RDB	870	414.7

Results: *Bathymetry (Plate 45)*

Reduced Sediment Deposition between RM 243.5-242.0	Additional Comments
Yes	Although the weirs more evenly distributed the energy which straightened the alignment and deepened the channel, there was still some deposition from RM 243-242.5. It also reduced the flow near the LDB in the vicinity of RM 243.0.

Note: Typically when weirs are placed in a bendway, velocities in the bend are distributed across a wider navigable channel resulting in some scouring of the point bar on the inside of the bend. During the calibration process of the model, screen was used on the model river bed to maintain the integrity of the point bar near Turners Island and RM 245. As a result, the screen had to remain in the model during alternative testing. This screen did not allow the weirs to scour the point bar underneath the screen. The test results may have been impacted by the use of screen on this point bar.

Alternative 17:

Type of Structure	River Mile	LDB or RDB	Dimensions (Feet)	Structure Top Elevation (ft in MSL)
Weir	244.8	RDB	615	414.7
Weir	244.6	RDB	510	414.7
Weir	244.5	RDB	690	414.7
Weir	244.4	RDB	600	414.7
Weir	244.3	RDB	795	414.7
Weir	244.2	RDB	845	414.7
Weir	244.0	RDB	870	414.7
Chevron	243.2	LDB	300 x 300	436
Chevron	242.85	LDB	300 x 300	436

Results: *Bathymetry Analysis (Plate 46)*

Reduced Sediment Deposition between RM 243.5-242.0	Additional Comments
Yes	This alternative combined the weirs from Alternative 16 and two chevrons downstream, however the two chevrons did not remove all the sediment build up near RM 243-242.5. It also reduced the flow near the LDB in the vicinity of RM 243.0.

Note: Typically when weirs are placed in a bendway, velocities in the bend are distributed across a wider navigable channel resulting in some scouring of the point bar on the inside of the bend. During the calibration process of the model, screen was used on the model river bed to maintain the integrity of the point bar near Turners Island and RM 245. As a result, the screen had to remain in the model during alternative testing. This screen did not allow the weirs to scour the point bar underneath the screen. The test results may have been impacted by the use of screen on this point bar.

Alternative 18:

Type of Structure	River Mile	LDB or RDB	Dimensions (Feet)	Structure Top Elevation (ft in MSL)
Weir	244.8	RDB	615	414.7
Weir	244.6	RDB	510	414.7
Weir	244.5	RDB	690	414.7
Weir	244.4	RDB	600	414.7
Weir	244.3	RDB	795	414.7
Weir	244.2	RDB	845	414.7
Weir	244.0	RDB	870	414.7
Chevron	243.5	LDB	300 x 300	436
Chevron	243.0	LDB	300 x 300	436
Chevron	242.8	LDB	300 x 300	436

Results: *Bathymetry (Plate 47), Velocity Upstream (Plate 48), and Velocity Downstream (Plate 49) Analysis*

Reduced Sediment Deposition between RM 243.5-242.0	Positive Impact or No Change in Outdraft	Additional Comments
Yes	Yes	This alternative combined weirs and three chevrons downstream and removed most of the sediment build up near RM 243-242.5. The alignment did not improve as compared to the existing alignment. It also reduced the flow near the LDB in the vicinity of RM 243.0.

Note: Typically when weirs are placed in a bendway, velocities in the bend are distributed across a wider navigable channel resulting in some scouring of the point bar on the inside of the bend. During the calibration process of the model, screen was used on the model river bed to maintain the integrity of the point bar near Turners Island and RM 245. As a result, the screen had to remain in the model during alternative testing. This screen did not allow the weirs to scour the point bar underneath the screen. The test results may have been impacted by the use of screen on this point bar.

Alternative 19:

Type of Structure	River Mile	LDB or RDB	Area in Square Feet	Remove Bank to Elevation (ft in MSL)
Adjust RDB Island Bank Line	244.5-244.3	RDB*	72,600	412

* Of navigation channel

Results: *Bathymetry (Plate 50) Analysis*

Reduced Sediment Deposition between RM 243.5-242.0	Additional Comments
No	The thalweg and energy of the river remained closer to the RDB of the island creating a slightly straighter alignment at RM 244.5. However, there was not enough energy to reduce the aggredation of sediment in the navigation channel.

Alternative 20:

Type of Structure	River Mile	LDB or RDB	Dimensions (Feet)	Remove Bank to Elevation (ft in MSL)
Adjust RDB Island Bank Line	244.5-244.3	RDB*	72,600 (approx. area in sq. ft)	412
Construct Chevron	243.7	LDB	400 x 400	436
Construct Chevron	243.5	RDB	300 x 300	436
Construct Chevron	243.4	LDB	300 x 300	436
Construct Chevron	243.1	LDB	300 x 300	436
Construct Chevron	242.8	LDB	300 x 300	436

***** Of navigation channel

Results: *Bathymetry (Plate 51) Analysis, Velocity Upstream (Plate 52), and Velocity Downstream (Plate 53) Analysis*

Reduced Sediment Deposition between RM 243.5-242.0	Positive Impact or No Change in Outdraft	Additional Comments
Yes	No Change	The navigation channel was deepened. The thalweg and energy of the river remained closer to the RDB of the island creating a straighter alignment. The first chevron splits the flow exiting the bend at RM 244.0. Higher velocities were observed in the main channel and allowed slower velocities to deflect toward the LDB side. With the first chevron located at RM 243.7 and the bank adjusted on the island, navigation tows would have more time to adjust coming downstream out of the bend to the new alignment. The flow in the main channel remained relatively straight or parallel to the RDB bank.

CONCLUSIONS

1. Evaluation and Summary of the Model Tests (Condition Analyses Combined)

Alternatives	Reduced Sediment Deposition between RM 243.5-242.0	Positive Impact or No Change in Out draft	Structures Located in Present Navigation Channel	Alternative would Require Dredging	Positive Overall Impact on Study Reach
Alternative 1	No	*	No	No	No
Alternative 2	No	*	No	No	No
Alternative 3	Yes	*	No	No	No
Alternative 4	Yes	*	No	No	No
Alternative 5	Yes	Yes	Yes	No	Yes
Alternative 6	Yes	Yes	Yes	No	No
Alternative 7	Yes	*	Yes	No	No
Alternative 8	Yes	No Change	No	No	No
Alternative 9	Yes	*	No	No	No
Alternative 10	Yes	*	No	No	No
Alternative 11	Yes	*	No	No	No
Alternative 12	Yes	Yes	Yes	Yes	Yes
Alternative 13	Yes	Yes	Yes	Yes	Yes
Alternative 14	Yes	No	Yes	Yes	Yes
Alternative 15	Yes	*	Yes	Yes	No
Alternative 16	Yes	*	Yes	No	No
Alternative 17	Yes	*	Yes	No	No
Alternative 18	Yes	Yes	Yes	No	No
Alternative 19	No	*	No	No	No
Alternative 20	Yes	No Change	Yes	Yes	Yes

* No LDV tests were run to assess impacts to outdraft, due to bathymetry results

In order to determine the best alternative, certain criteria, based on the study purpose and goals, were used to evaluate each alternative. The first and most important consideration was that the alternative had to sufficiently reduce or completely eliminate the large volume of sediment between RM 243.5-242.0 while improving the navigation channel alignment for approaching vessels. The second condition was that the alternative would not negatively impact the outdraft at Lock 25. Lastly, the alternative was evaluated regarding the LDB near Batchtown, the split flow near RM 242.5-241.6, and the depositional area below Batchtown and upstream of the overflow dike. If any alternative caused scour or deposition near the Batchtown complex it was noted. The ideal alternative would have been able to meet all three conditions, however, no alternative tested successfully met all three conditions. There were several alternatives that met two of the three conditions. Although some alternatives did meet most of the criterion and were considered successful in reducing the deposition, they were not recommended. This was due to either the velocities exiting the bend were directed at the lead structure and could cause difficulty for downbound tows or the cost of construction for an alternative, that had comparable results to the preferred alternative, would have been significantly higher. Alternatives that met most of the criterion but were not chosen were alternatives 5, 13, 14, and 20.

2. Recommendations

Alternative 12, Plates 35-37, was recommended as the most desirable alternative because of its observed ability to significantly reduce the deposition between RM 243.5-242.0. This alternative could significantly reduce repetitive maintenance dredging and create a better alignment than the existing conditions. According to the LDV results, the outdraft was not impacted by the chevrons, and the existing flow split around the degraded island was maintained. Overall, this alternative greatly enhanced the navigation safety for downbound tows, provided a self maintaining channel, and sustained the existing environmental features of the reach.

The recommended design included the following:

- RM 243.7L: Construct new 400x400 ft chevron
  - Structure top elevation = 436 ft (MSL)

- RM 243.5R: Remove any remnants of existing structure to present river bed elevation or 415 ft (MSL)

- RM 243.5R: Construct new 300x300 ft chevron
  - Structure top elevation = 436 ft (MSL)

- RM 243.3L: Construct new 300x300 ft chevron
  - Structure top elevation = 436 ft (MSL)

- RM 243.1L: Construct new 300x300 ft chevron
  - Structure top elevation = 436 ft (MSL)

- RM 242.9R and 242.8R: Remove any remnants of existing structures to present river bed elevation or 420 ft (MSL)

- RM 242.8L: Construct new 300x300 ft chevron
  - Structure top elevation = 436 ft (MSL)

- RM 243.6L: It is suggested that approximately 1,000 ft on the LDB be revetted

The new structures, bathymetry, and alignment were tested in the Lock 25 2-Dimensional Adaptive Hydraulics (ADH) model. This model has been used to aid in the design of the new 1,200 foot lock planned at Lock 25. Since the recommended structures would significantly change the channel alignment and bathymetry patterns, the model was used to evaluate the impacts on alignment and outdraft at the approach to the existing lock. The model could also be used to evaluate impacts to the design of the new lock such as approaches, outdraft, and porting in the upper guardwall. Additional flow visualization was conducted on the HSR model to verify the LDV results. Because both the 2-D ADH model and the flow visualization confirmed the HSR model results, additional testing using the fixed bed physical model at ERDC was not necessary. These evaluations were coordinated with the NESP Lock 25 Design Team. The findings from these additional studies can be found in the Appendix C.

There was additional concern regarding the funding of the construction of the project. A phased construction approach was tested in the HSR model and was determined that there would not be any negative or detrimental effects to the lock approach. The findings from the phased construction study can be found in the Appendix D.

3. Interpretation of Model Test Results

In the interpretation and evaluation of the model test results, it should be remembered that these results are 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 Mississippi 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 HSR modeling or the Applied River Engineering Center, please contact Robert Davinroy, P.E., Ashley Cox, or Dave Gordon, P.E. at:

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http://www.mvs.usace.army.mil/arec/index.html

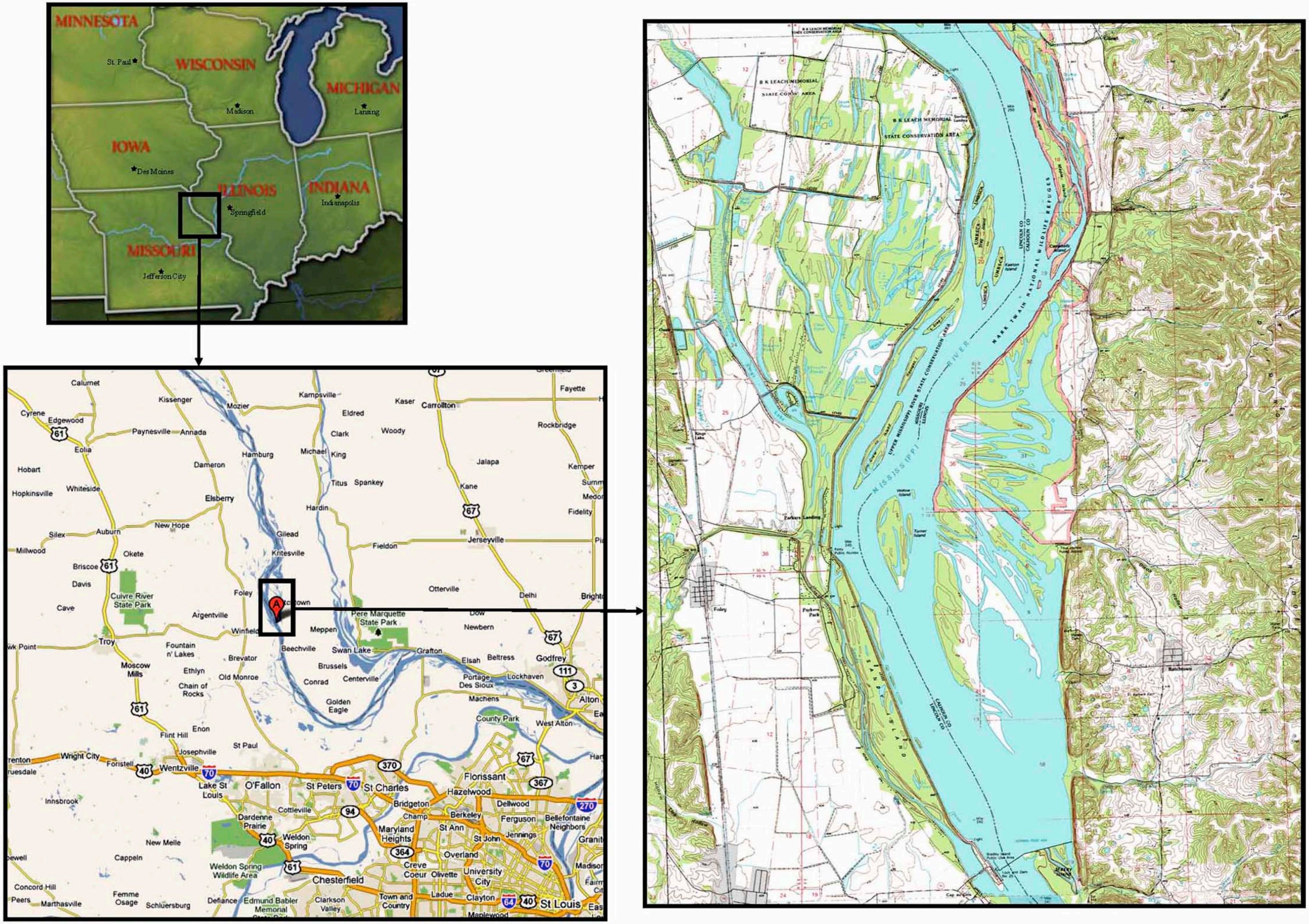
APPENDIX A

1. Plate: Location and Vicinity Map of the Study Reach
2. Plate: Field Photographs
3. Plate: Field Photographs
4. Plate: Field Photographs
5. Plate: Bed Sample Locations
6. Plate: Picture of LD 25 HSR Model
7. Plate: 1997 Hydrographic Survey
8. Plate: 1999 Hydrographic Survey
9. Plate: 2004 Hydrographic Survey
10. Plate: 2005 Hydrographic Survey
11. Plate: 2007 Hydrographic Survey
12. Plate: 2009 Pre-Dredge Survey
13. Plate: 2009 Pre-Dredge Survey
14. Plate: 2009 Post-Dredge Survey
15. Plate: 2009 Multi-Beam Hydrographic Survey
16. Plate: ADCP: April 2005
17. Plate: ADCP: April 2007

17A. Plate: Oblique Aerial Photographs

18. Plate: Base Test: Bathymetry - 1:22,500
19. Plate: Base Test: LDV - 1:22,500
20. Plate: Alternative 1: Bathymetry - 1:22,500
21. Plate: Alternative 2: Bathymetry - 1:22,500
22. Plate: Alternative 3: Bathymetry - 1:22,500
23. Plate: Alternative 4: Bathymetry - 1:22,500
24. Plate: Alternative 5: Bathymetry - 1:22,500
25. Plate: Alternative 5: LDV (Upstream) – 1:22,500
26. Plate: Alternative 5: LDV (Downstream) – 1:22,500
27. Plate: Alternative 6: Bathymetry – 1:22,500
28. Plate: Alternative 6: LDV – 1:22,500
29. Plate: Alternative 7: Bathymetry - 1:22,500
30. Plate: Alternative 8: Bathymetry - 1:22,500

31. Plate: Alternative 8: LDV – 1:22,500
32. Plate: Alternative 9: Bathymetry - 1:22,500
33. Plate: Alternative 10: Bathymetry - 1:22,500
34. Plate: Alternative 11: Bathymetry - 1:22,500
35. Plate: Alternative 12: Bathymetry - 1:22,500
36. Plate: Alternative 12: LDV (Upstream) - 1:22,500
37. Plate: Alternative 12: LDV (Downstream) – 1:22,500
38. Plate: Alternative 13: Bathymetry – 1:22,500
39. Plate: Alternative 13: LDV (Upstream) – 1:22,500
40. Plate: Alternative 13: LDV (Downstream) – 1:22,500
41. Plate: Alternative 14: Bathymetry – 1:22,500
42. Plate: Alternative 14: LDV (Upstream) – 1:22,500
43. Plate: Alternative 14: LDV (Downstream) – 1:22,500
44. Plate: Alternative 15: Bathymetry - 1:22,500
45. Plate: Alternative 16: Bathymetry - 1:22,500
46. Plate: Alternative 17: Bathymetry - 1:22,500
47. Plate: Alternative 18: Bathymetry – 1:22,500
48. Plate: Alternative 18: LDV (Upstream) – 1:22,500
49. Plate: Alternative 18: LDV (Downstream) – 1:22,500
50. Plate: Alternative 19: Bathymetry - 1:22,500
51. Plate: Alternative 20: Bathymetry – 1:22,500
52. Plate: Alternative 20: LDV (Upstream) – 1:22,500
53. Plate: Alternative 20: LDV (Downstream) – 1:22,500



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	FILE NAME: LD25/PLATES		PLOT DATE: 08/19/2008

LOCATION AND VICINITY MAP

PLATE NUMBER 1

Barge headed downstream around RM 244

Looking upstream at Turner Island (on left) and small island on LDB side of Turner Island

Batchtown's southern sluice gate

Batchtown's new rock berm under construction at southern reach of complex

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	FILE NAME: LD25/PLATES	PLOT DATE: 09/16/2009

Lock and Dam 25
Date Photographed: September 16, 2009

PLATE NUMBER
2

New Gate construction at southern end of Batchtown Complex

Looking downstream at Turner Island Chute (Batchtown is on the left)

Rock being placed by sills at L&D 25 to prevent scour

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Lock and Dam 25
Date Photographed: September 16, 2009

PLATE NUMBER
3

New J Hook (Batchtown chevrons) construction at RM 245.5 in Turner Island Chute

Looking upstream through Turner Island Chute (two J hooks partially completed)

Looking upstream through Turner Island Chute (two J hooks completed)

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Lock and Dam 25
Date Photographed: Dec. 15, 2009

PLATE NUMBER
4

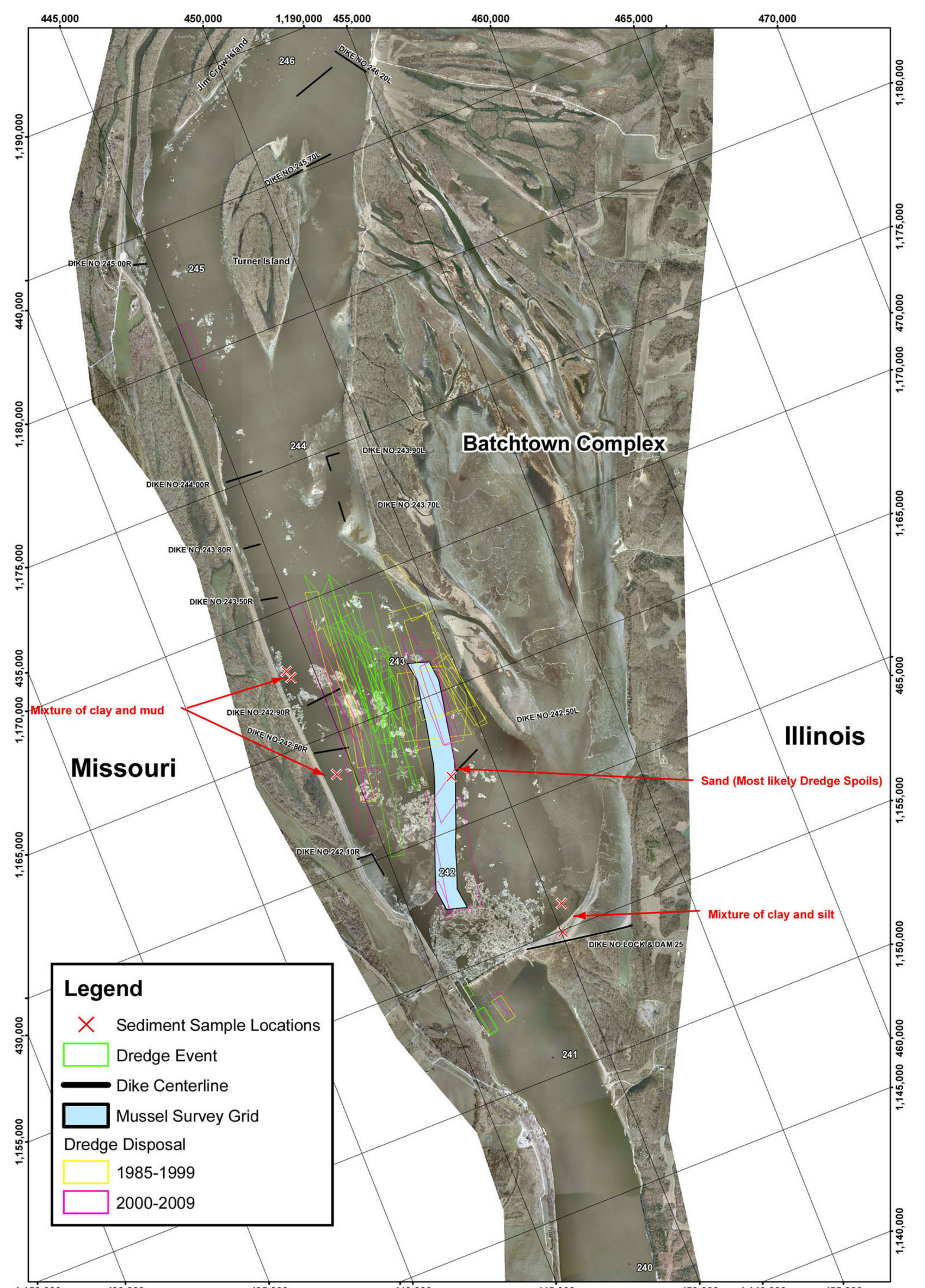

PLATE NUMBER 5

0 650 1,300 2,600 3,900
Feet

Bed Sample Locations
2006 AERIAL PHOTOGRAPH

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Upper Mississippi River Basin
St. Louis District
Lock and Dam 25
HSR Model

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PLATE NUMBER 6

Lock and Dam 25
HSR Model
Date Photographed: November 9, 2009

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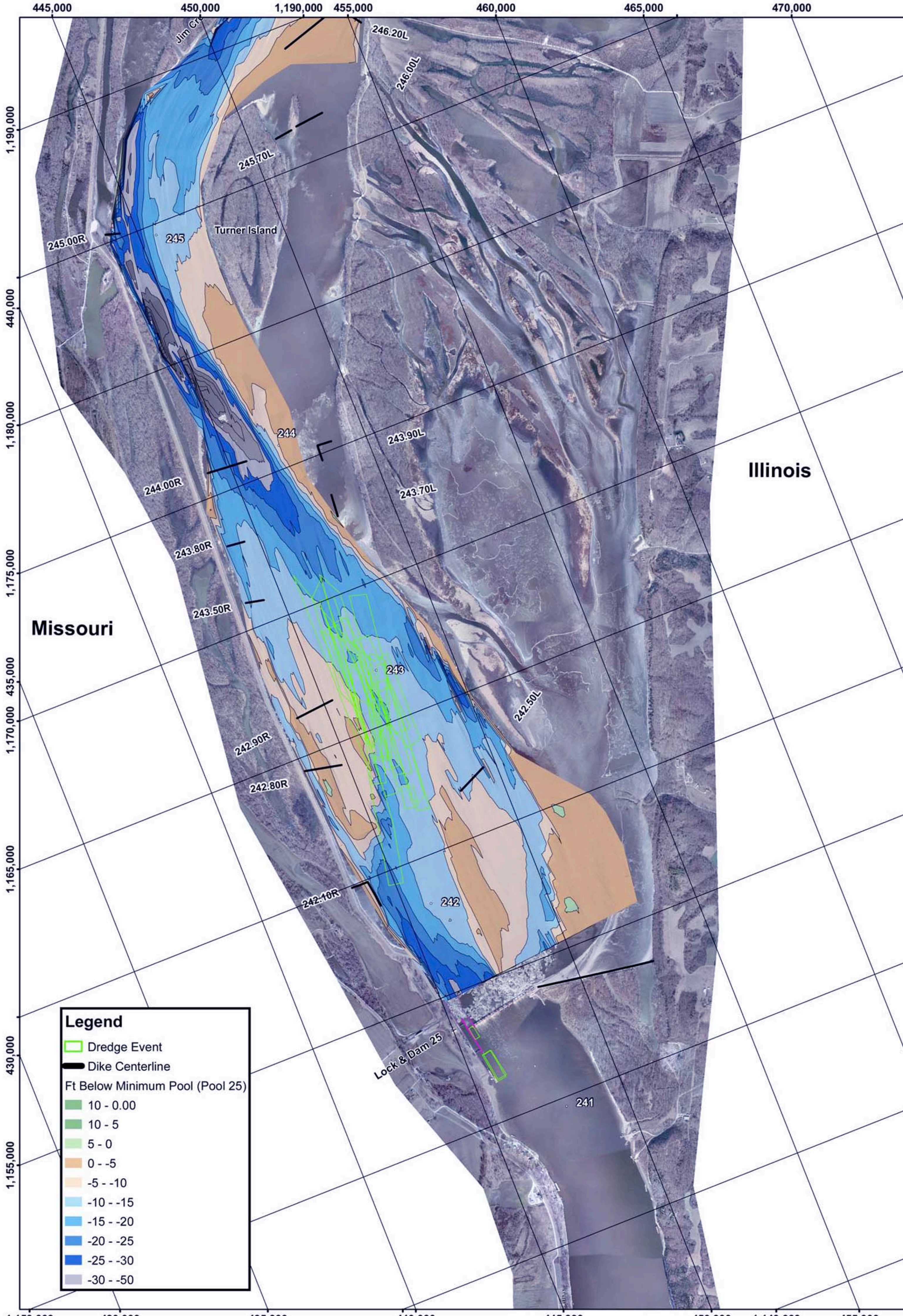

PLATE NUMBER 7

0 600 1,200 2,400 3,600
Feet

1997 Hydrographic Survey
2006 AERIAL PHOTOGRAPH

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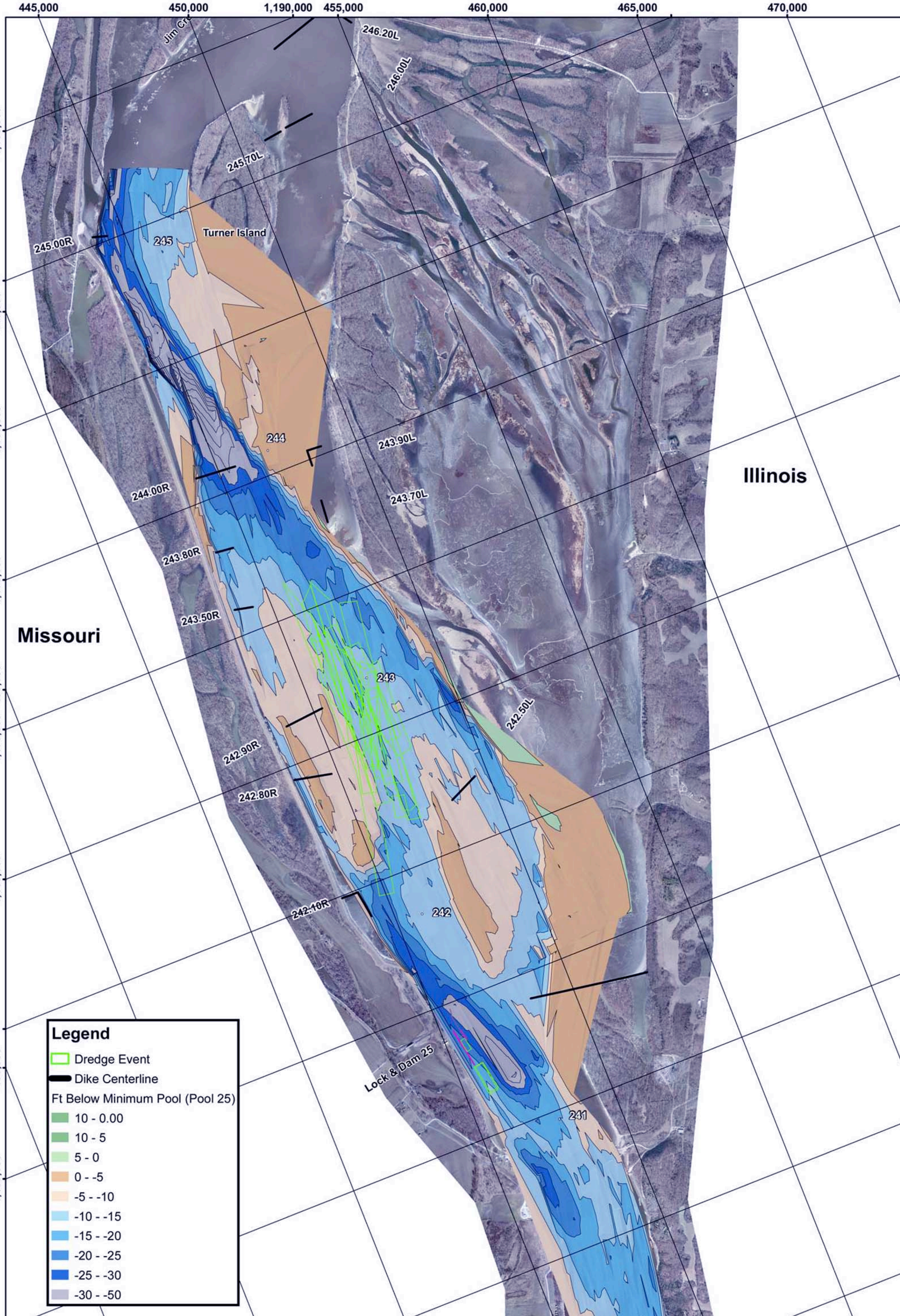

PLATE NUMBER 8

0 600 1,200 2,400 3,600
Feet

1999 Hydrographic Survey
2006 AERIAL PHOTOGRAPH

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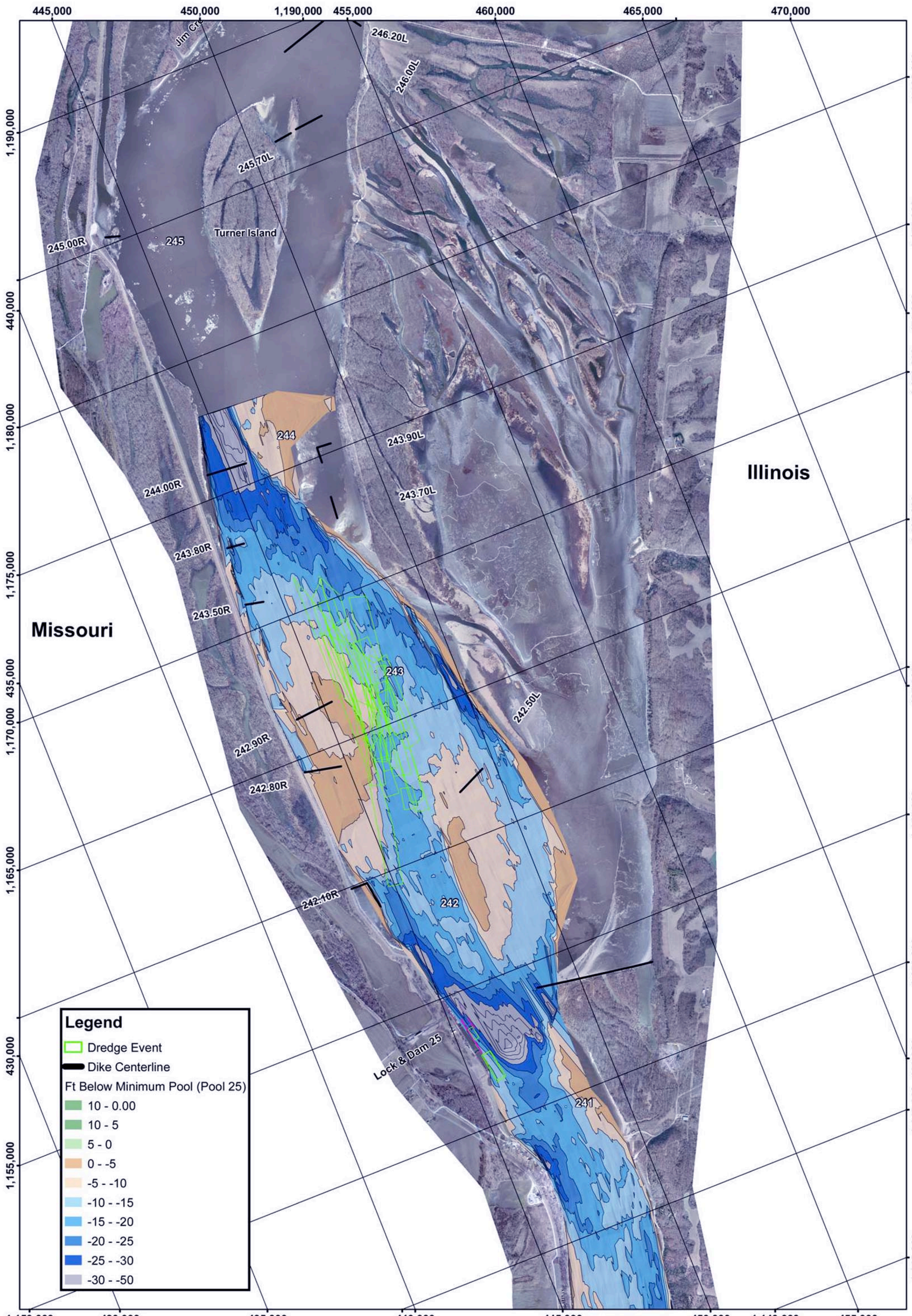

PLATE NUMBER 9

2004 Hydrographic Survey

2006 AERIAL PHOTOGRAPH

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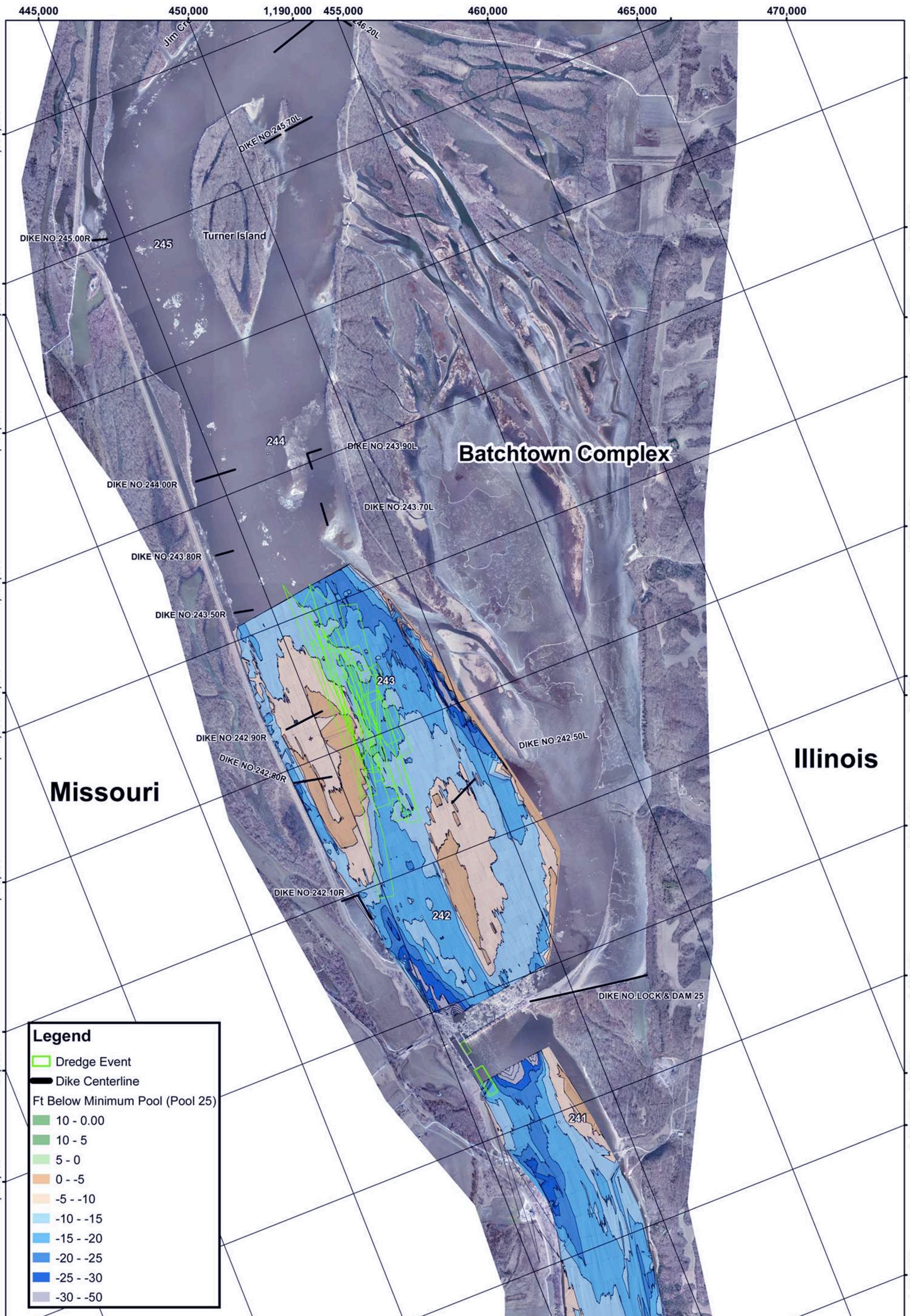

PLATE NUMBER 10

0 600 1,200 2,400 3,600
Feet

2005 Hydrographic Survey

2006 AERIAL PHOTOGRAPH

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Upper Mississippi River Basin
St. Louis District
Lock and Dam 25
HSR Model

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SUBMITTED: A COX		APPROVED: R DAVINROY, P.E.
FILE NAME: . . . LD25/Plates		PLOT DATE: 04/12/2010

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US Army Corps of Engineers
St. Louis District

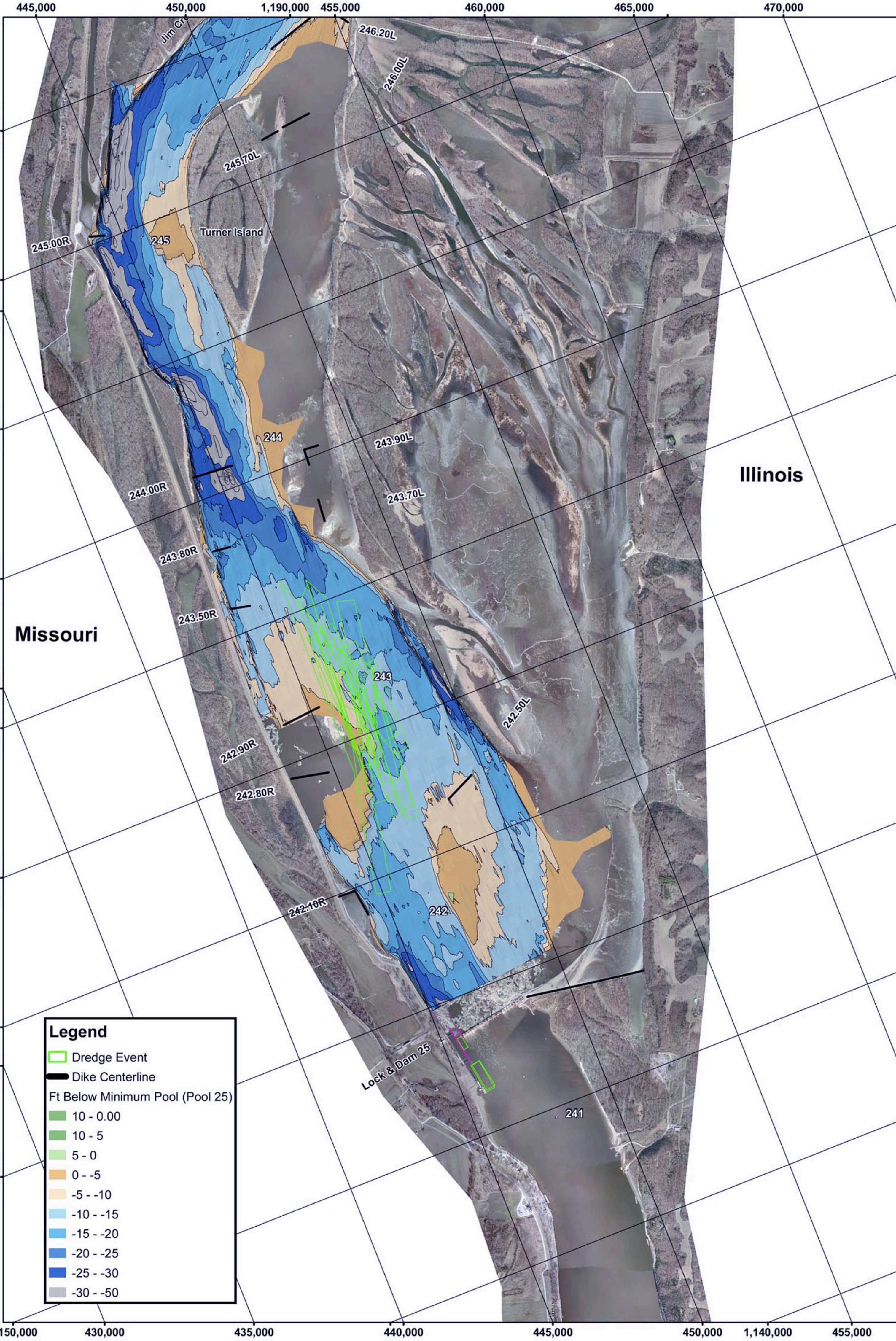

PLATE NUMBER 11

0 600 1,200 2,400 3,600
Feet

2007 Hydrographic Survey
2006 AERIAL PHOTOGRAPH

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

Upper Mississippi River Basin
St. Louis District
Lock and Dam 25
HSR Model

DESIGNED BY:		SURVEY DATE:
A COX		2007
DRAWN BY: A COX	REVIEWED BY: J BROWN, P.E.	CHECKED BY: E BRAUER, P.E.
SUBMITTED: A COX		APPROVED: R DAVINROY, P.E.
FILE NAME: . . . LD25/Plates		PLOT DATE: 04/12/2010

N
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APPLIED RIVER ENGINEERING CENTER

US Army Corps of Engineers
St. Louis District

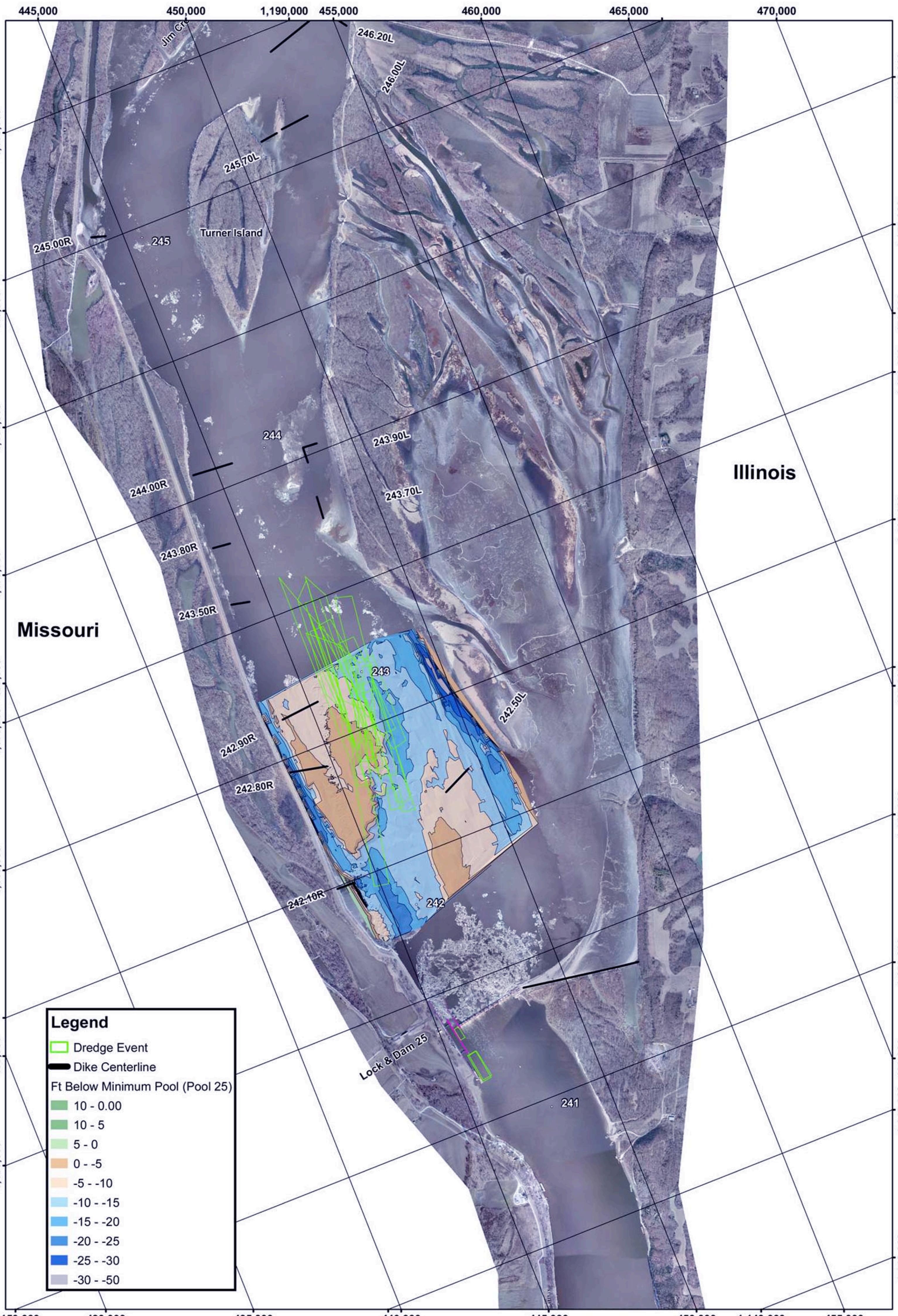

PLATE NUMBER 12

0 600 1,200 2,400 3,600
Feet

2009 Pre-Dredge Survey

2006 AERIAL PHOTOGRAPH

U.S. ARMY ENGINEER DIVISION CORPS OF ENGINEERS ST. LOUIS, MISSOURI	DESIGNED BY: A COX		SURVEY DATE: 04/29/2009
	DRAWN BY: A COX	REVIEWED BY: J BROWN, P.E.	CHECKED BY: E BRAUER, P.E.
Upper Mississippi River Basin St. Louis District Lock and Dam 25 HSR Model	SUBMITTED: A COX		APPROVED: R DAVINROY, P.E.
	FILE NAME: . . . LD25/Plates		PLOT DATE: 04/12/2010

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APPLIED RIVER ENGINEERING CENTER

US Army Corps of Engineers
St. Louis District

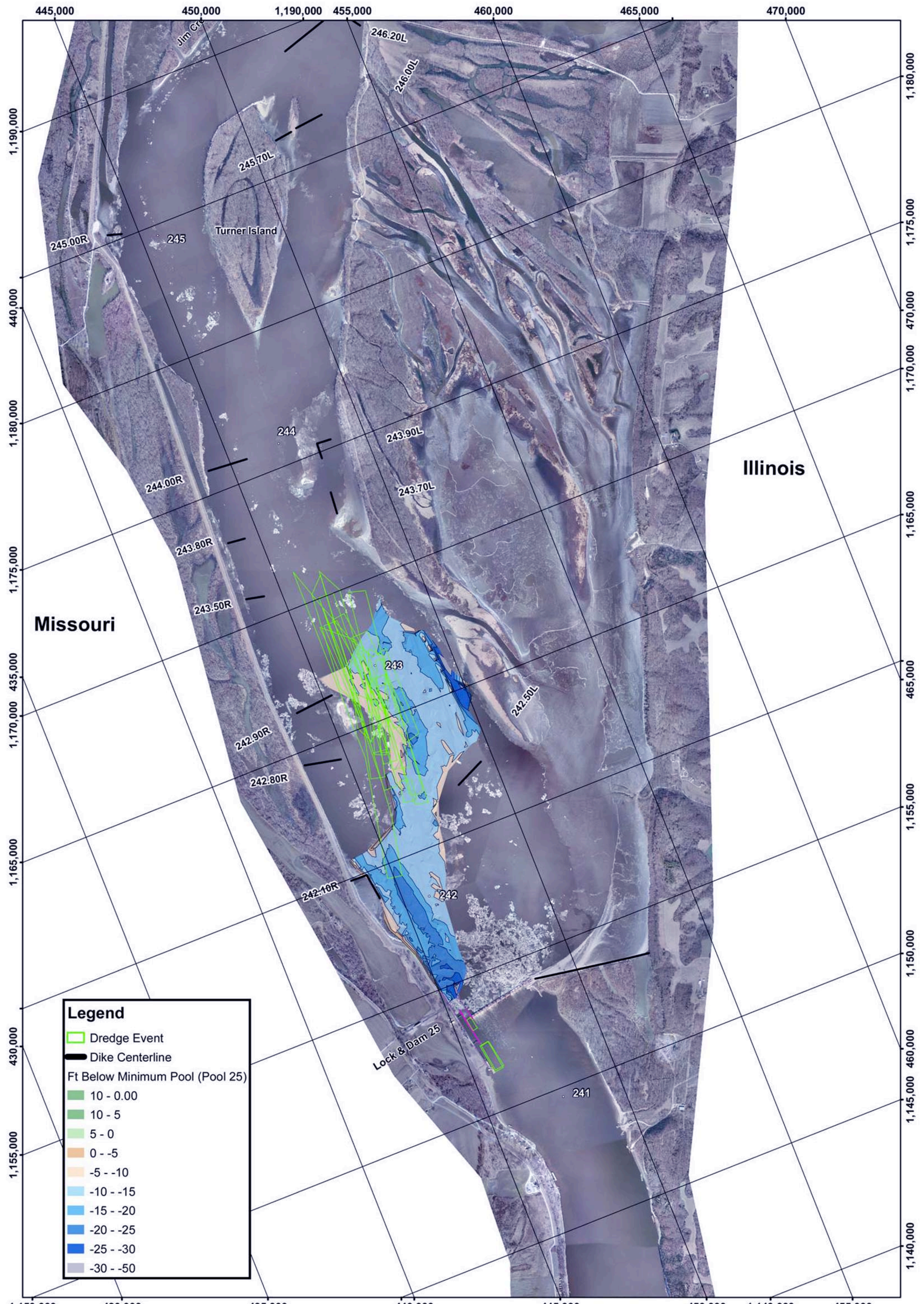

PLATE NUMBER	13

0 600 1,200 2,400 3,600
Feet

2009 Pre-Dredge Survey

2006 AERIAL PHOTOGRAPH

U.S. ARMY ENGINEER DIVISION CORPS OF ENGINEERS ST. LOUIS, MISSOURI	DESIGNED BY: A COX		SURVEY DATE: 05/17/2009
	DRAWN BY: A COX	REVIEWED BY: J BROWN, P.E.	CHECKED BY: E BRAUER, P.E.
Upper Mississippi River Basin St. Louis District Lock and Dam 25 HSR Model	SUBMITTED: A COX		APPROVED: R DAVINROY, P.E.
	FILE NAME: . . . LD25/Plates		PLOT DATE: 04/12/2010

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APPLIED RIVER ENGINEERING CENTER

US Army Corps of Engineers
St. Louis District

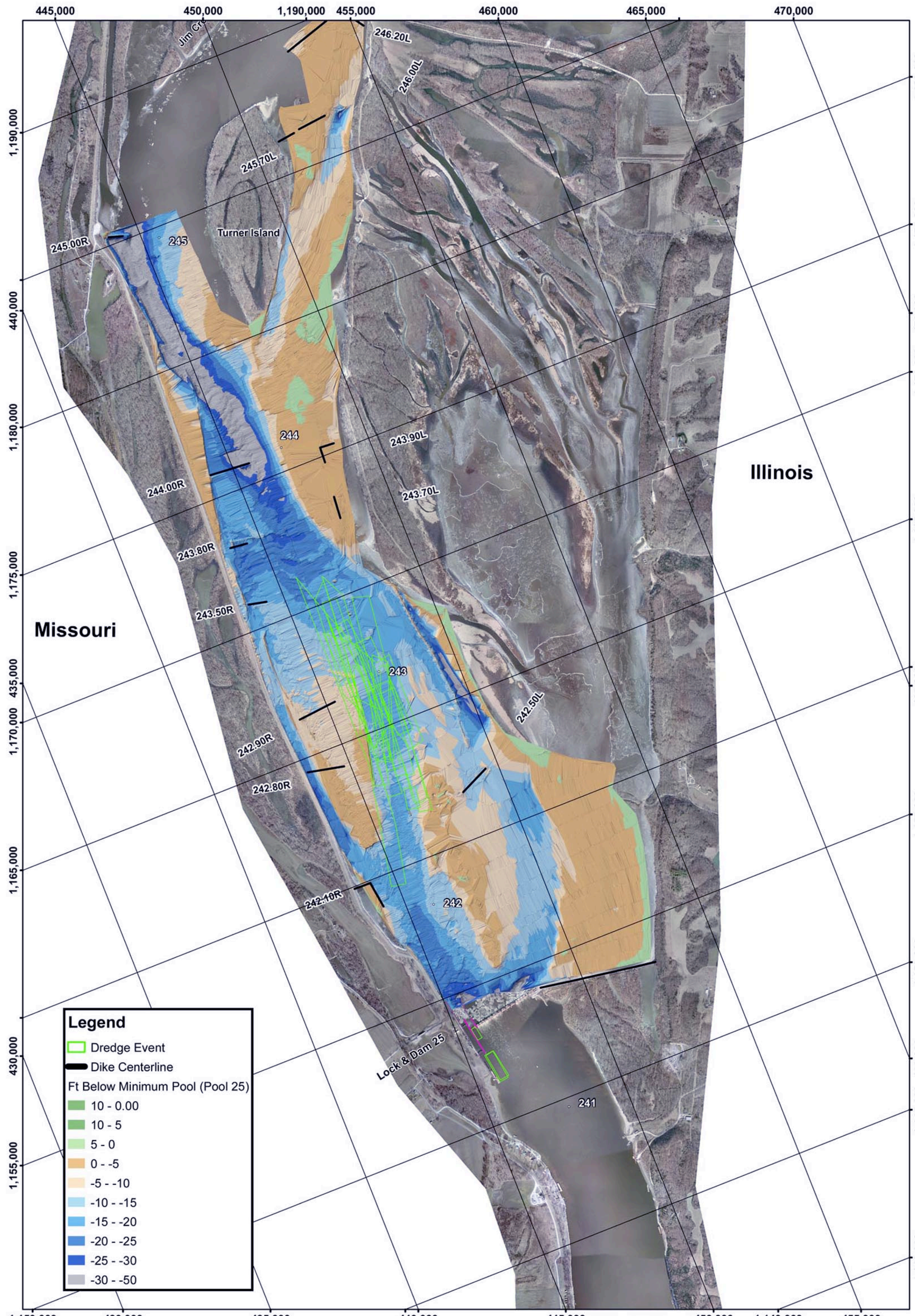

PLATE NUMBER **14**

0 600 1,200 2,400 3,600
Feet

2009 Multi-Sweep Hydrographic Survey
2006 AERIAL PHOTOGRAPH

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

Upper Mississippi River Basin
St. Louis District
Lock and Dam 25
HSR Model

DESIGNED BY:		SURVEY DATE:
A COX		2009
DRAWN BY: A COX	REVIEWED BY: J BROWN, P.E.	CHECKED BY: E BRAUER, P.E.
SUBMITTED: A COX		APPROVED: R DAVINROY, P.E.
FILE NAME: . . . LD25/Plates		PLOT DATE: 04/12/2010

N
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APPLIED RIVER ENGINEERING CENTER

US Army Corps of Engineers
St. Louis District

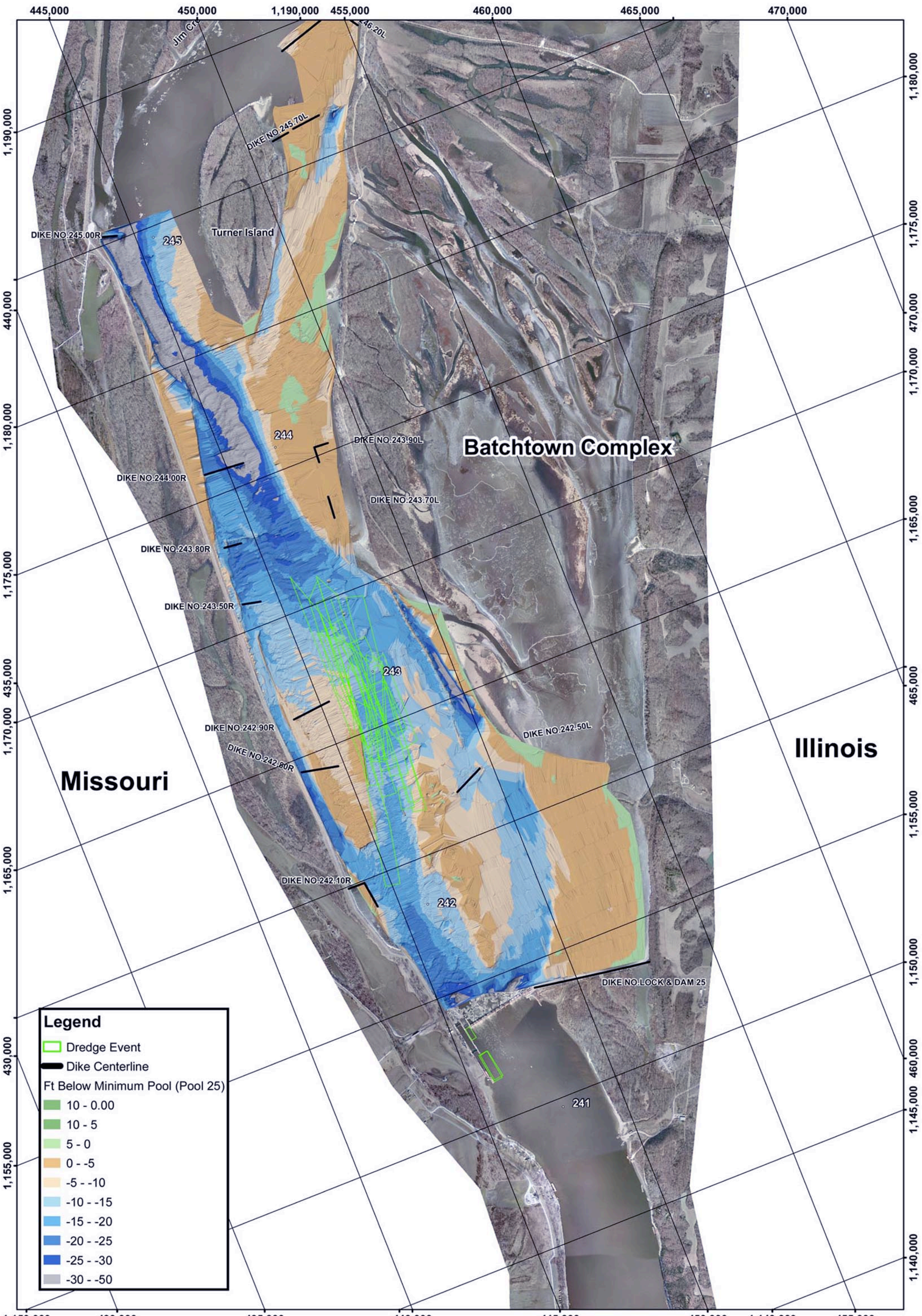

PLATE NUMBER 15

0 600 1,200 2,400 3,600
Feet

2009 Multi-Beam
Hydrographic Survey
2006 AERIAL PHOTOGRAPH

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

Upper Mississippi River Basin
St. Louis District
Lock and Dam 25
HSR Model

DESIGNED BY:		SURVEY DATE:
A COX		2009
DRAWN BY:	REVIEWED BY:	CHECKED BY:
A COX	J BROWN, P.E.	E BRAUER, P.E.
SUBMITTED:		APPROVED:
A COX		R DAVINROY, P.E.
FILE NAME:		PLOT DATE:
. . . LD25/Plates		04/12/2010

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APPLIED RIVER ENGINEERING CENTER

US Army Corps of Engineers
St. Louis District

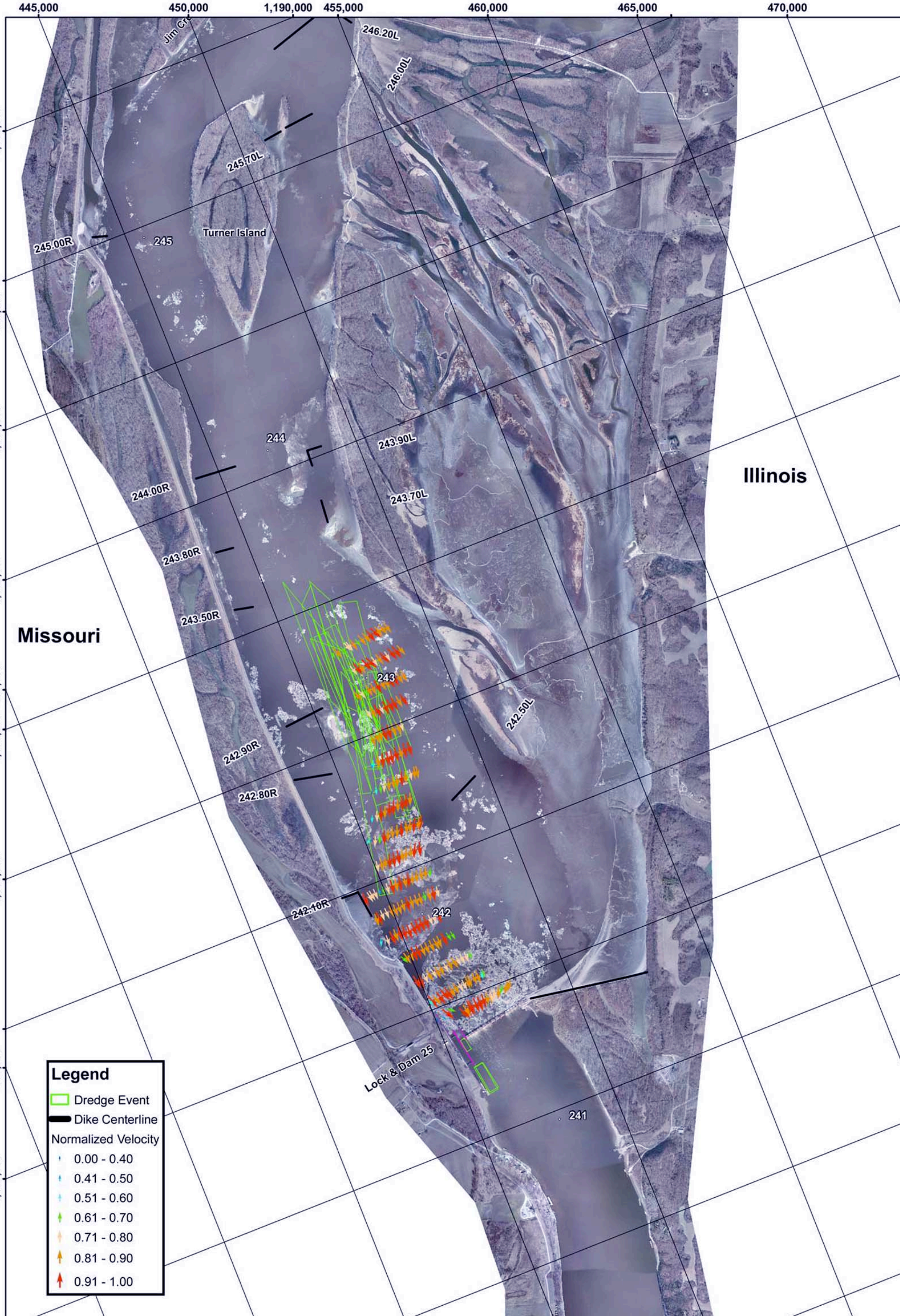

PLATE NUMBER 17

0 600 1,200 2,400 3,600
Feet

ADCP: April 2007
2006 AERIAL PHOTOGRAPH

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

Upper Mississippi River Basin
St. Louis District
Lock and Dam 25
HSR Model

DESIGNED BY:		SURVEY DATE:
A COX		April 2007
DRAWN BY:	REVIEWED BY:	CHECKED BY:
A COX	J BROWN, P.E.	E BRAUER, P.E.
SUBMITTED:		APPROVED:
A COX		R DAVINROY, P.E.
FILE NAME:		PLOT DATE:
. . . LD25/Plates		04/12/2010

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APPLIED RIVER ENGINEERING CENTER

US Army Corps of Engineers
St. Louis District

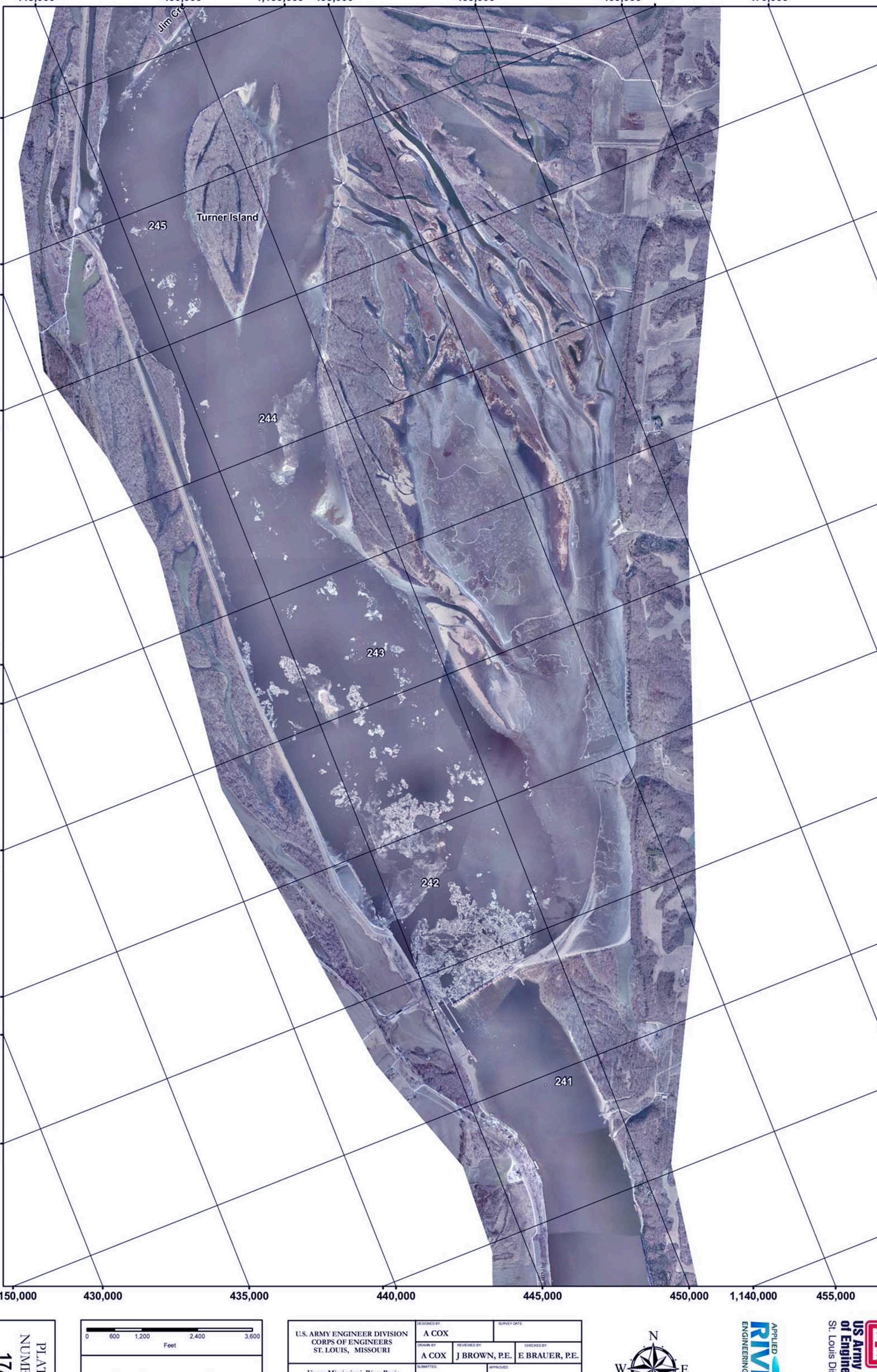

PLATE NUMBER **17A**

0 600 1,200 2,400 3,600
Feet

2006 AERIAL PHOTOGRAPH

U.S. ARMY ENGINEER DIVISION CORPS OF ENGINEERS ST. LOUIS, MISSOURI	DESIGNED BY: A COX		SURVEY DATE:
	DRAWN BY: A COX	REVIEWED BY: J BROWN, P.E.	CHECKED BY: E BRAUER, P.E.
Upper Mississippi River Basin St. Louis District Lock and Dam 25 HSR Model	SUBMITTED: A COX		APPROVED: R DAVINROY, P.E.
	FILE NAME: . . . LD25/Plates		PLOT DATE: 04/12/2010

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APPLIED RIVER ENGINEERING CENTER

US Army Corps of Engineers
St. Louis District

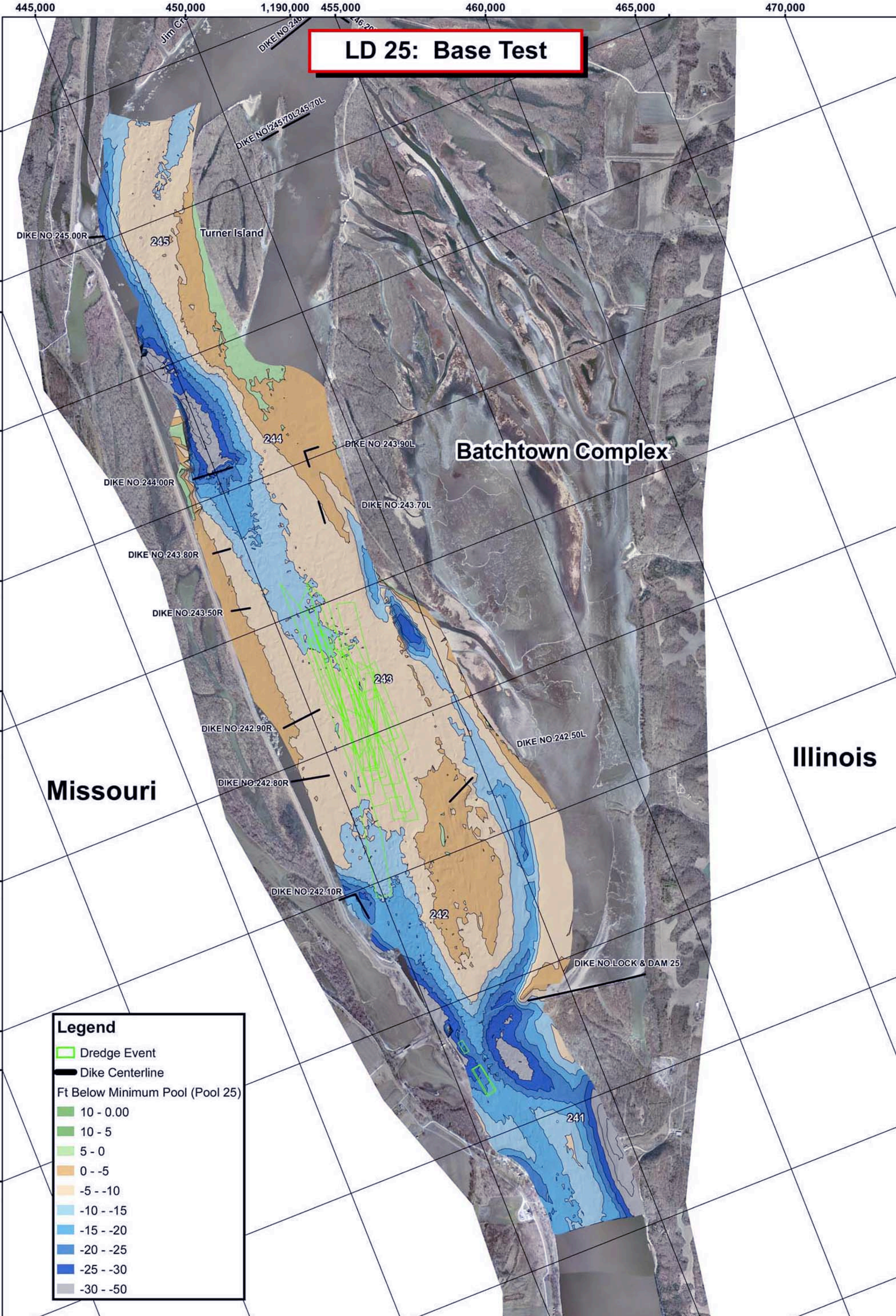

PLATE NUMBER 18

0 600 1,200 2,400 3,600
Feet

Base Test: Bathymetry
2006 AERIAL PHOTOGRAPH

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

Upper Mississippi River Basin
St. Louis District
Lock and Dam 25
HSR Model

DESIGNED BY: A COX	SURVEY DATE: 01/28/10
DRAWN BY: A COX	REVIEWED BY: J BROWN, P.E. / CHECKED BY: E BRAUER, P.E.
SUBMITTED: A COX	APPROVED: R DAVINROY, P.E.
FILE NAME: . . . LD25/Plates	PLOT DATE: 04/26/2010

N W E S

APPLIED RIVER ENGINEERING CENTER

US Army Corps of Engineers
St. Louis District

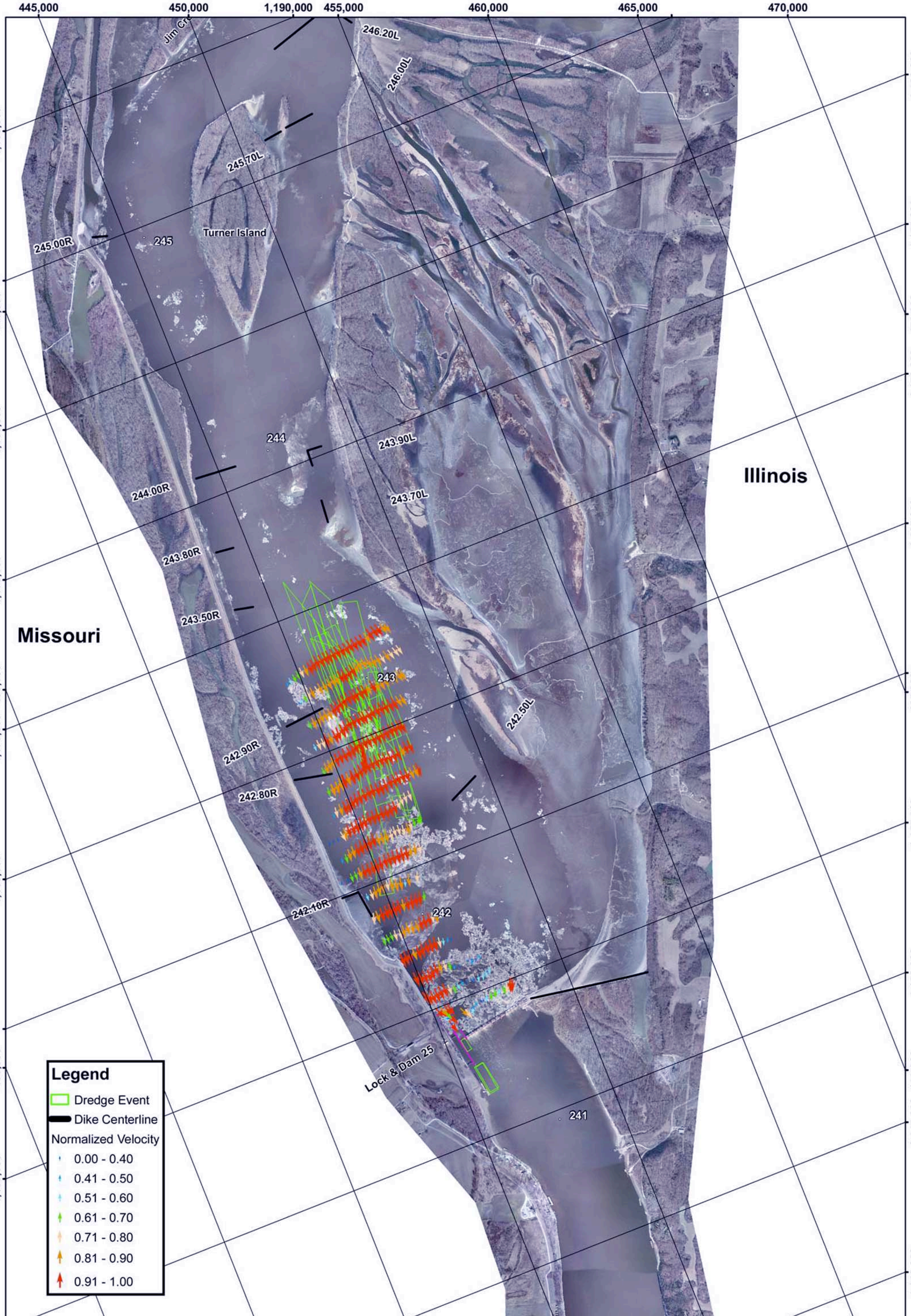

PLATE NUMBER 19

0 600 1,200 2,400 3,600
Feet

Base Test: LDV
2006 AERIAL PHOTOGRAPH

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

Upper Mississippi River Basin
St. Louis District
Lock and Dam 25
HSR Model

DESIGNED BY: A COX		SURVEY DATE: 03/09/2010
DRAWN BY: A COX	REVIEWED BY: J BROWN, P.E.	CHECKED BY: E BRAUER, P.E.
SUBMITTED: A COX		APPROVED: R DAVINROY, P.E.
FILE NAME: . . . LD25/Plates		PLOT DATE: 04/12/2010

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W E
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APPLIED RIVER ENGINEERING CENTER

US Army Corps of Engineers
St. Louis District

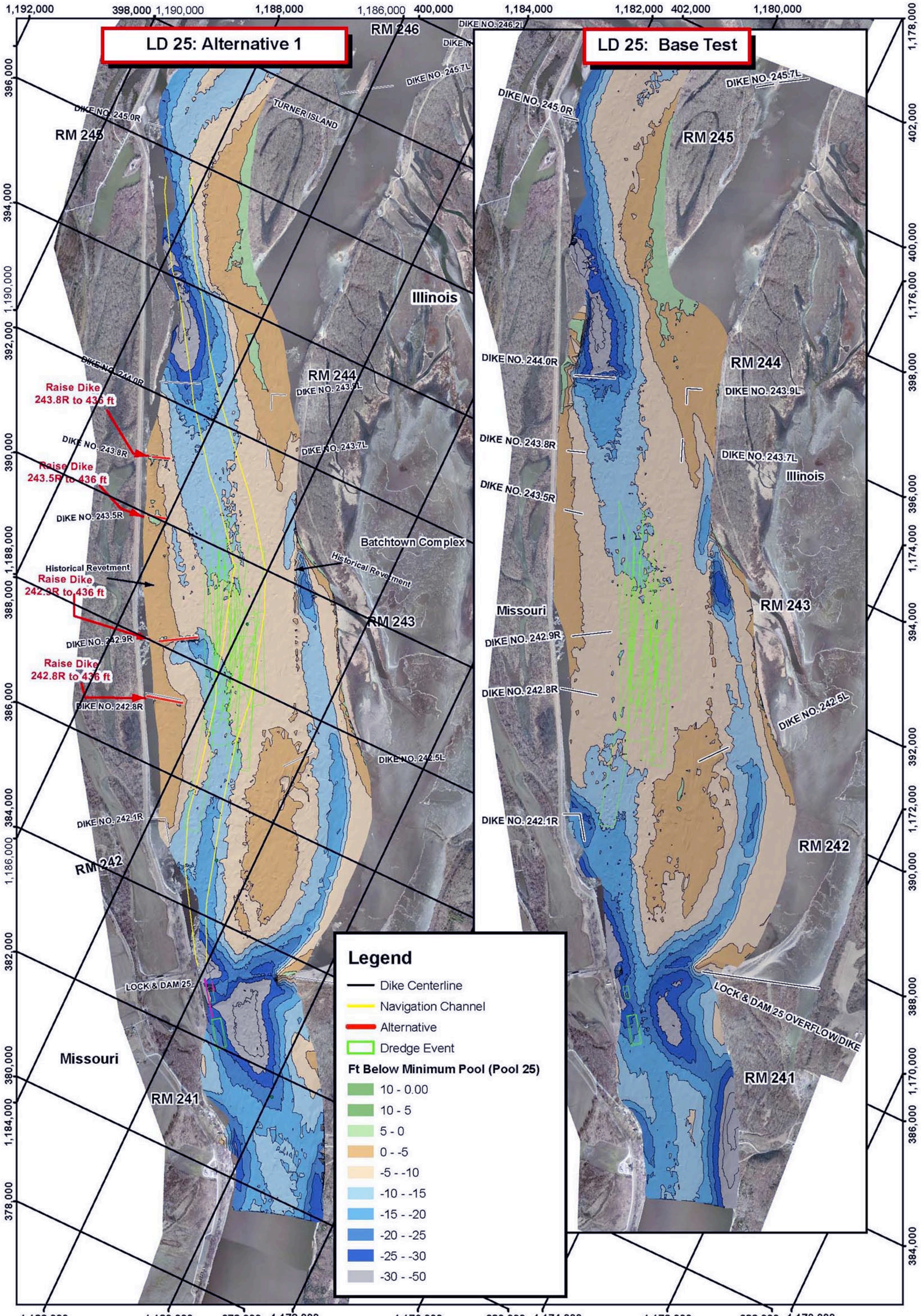

PLATE NUMBER 20

0 1,000 2,000 4,000 6,000
Feet

Alternative 1
2005 AERIAL PHOTOGRAPH

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

Upper Mississippi River Basin
St. Louis District
Lock and Dam 25
HSR Model

DESIGNED BY: A COX		SURVEY DATE: 01/28/2010
DRAWN BY: A COX	REVIEWED BY: J BROWN, P.E.	CHECKED BY: E BRAUER, P.E.
SUBMITTED: A COX		APPROVED: R DAVINROY, P.E.
FILE NAME: . . . LD25/Plates		PLOT DATE: 04/06/2010

APPLIED RIVER ENGINEERING CENTER

US Army Corps of Engineers
St. Louis District

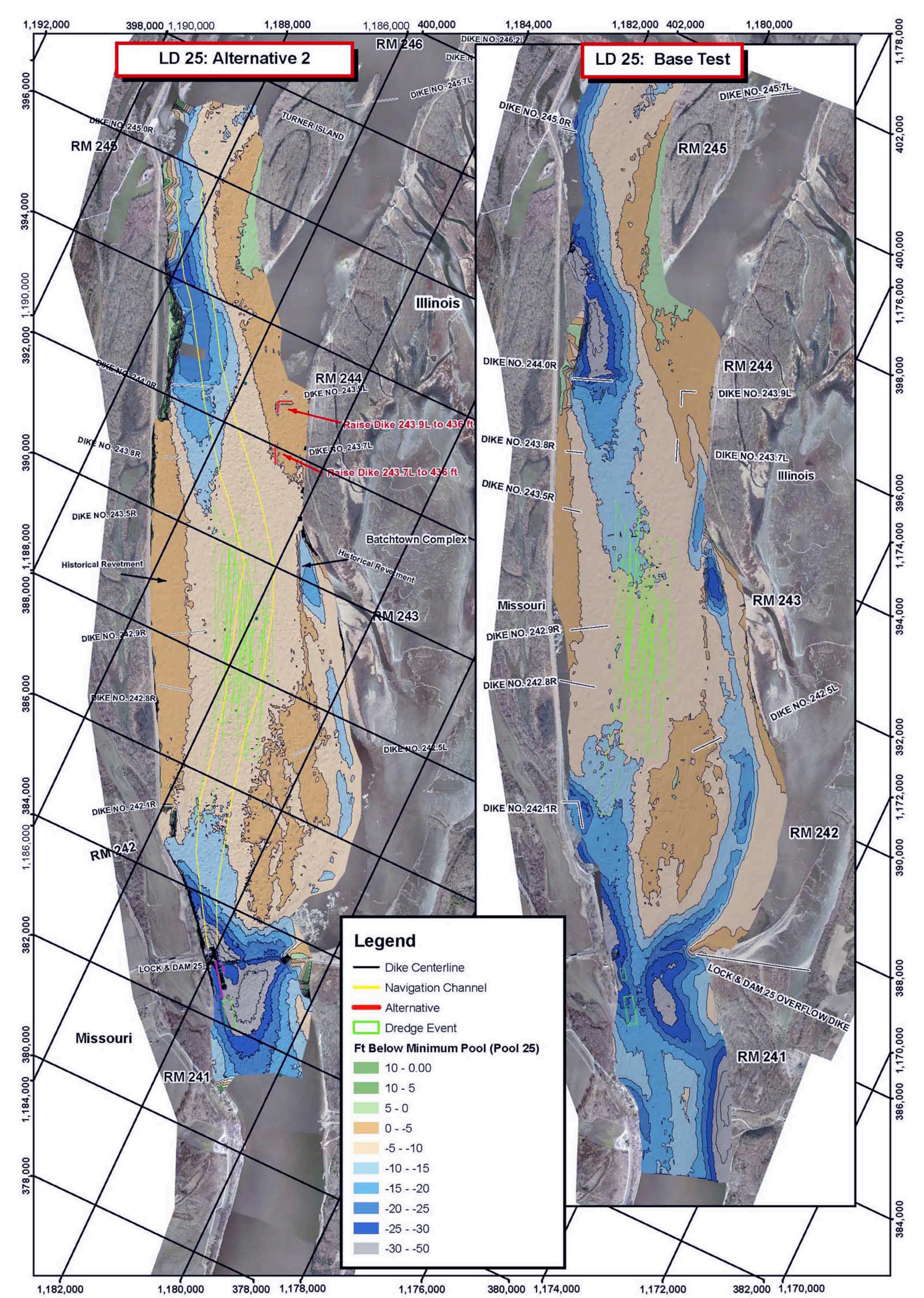

PLATE NUMBER 21

Alternative 2
2005 AERIAL PHOTOGRAPH

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

Upper Mississippi River Basin
St. Louis District
Lock and Dam 25
HSR Model

DESIGNED BY: A COX		SURVEY DATE: 03/08/2010
DRAWN BY: A COX	REVIEWED BY: J BROWN, P.E.	CHECKED BY: E BRAUER, P.E.
SUBMITTED: A COX		APPROVED: R DAVINROY, P.E.
FILE NAME: . . . LD25/Plates		PLOT DATE: 04/06/2010

APPLIED RIVER ENGINEERING CENTER

US Army Corps of Engineers
St. Louis District®

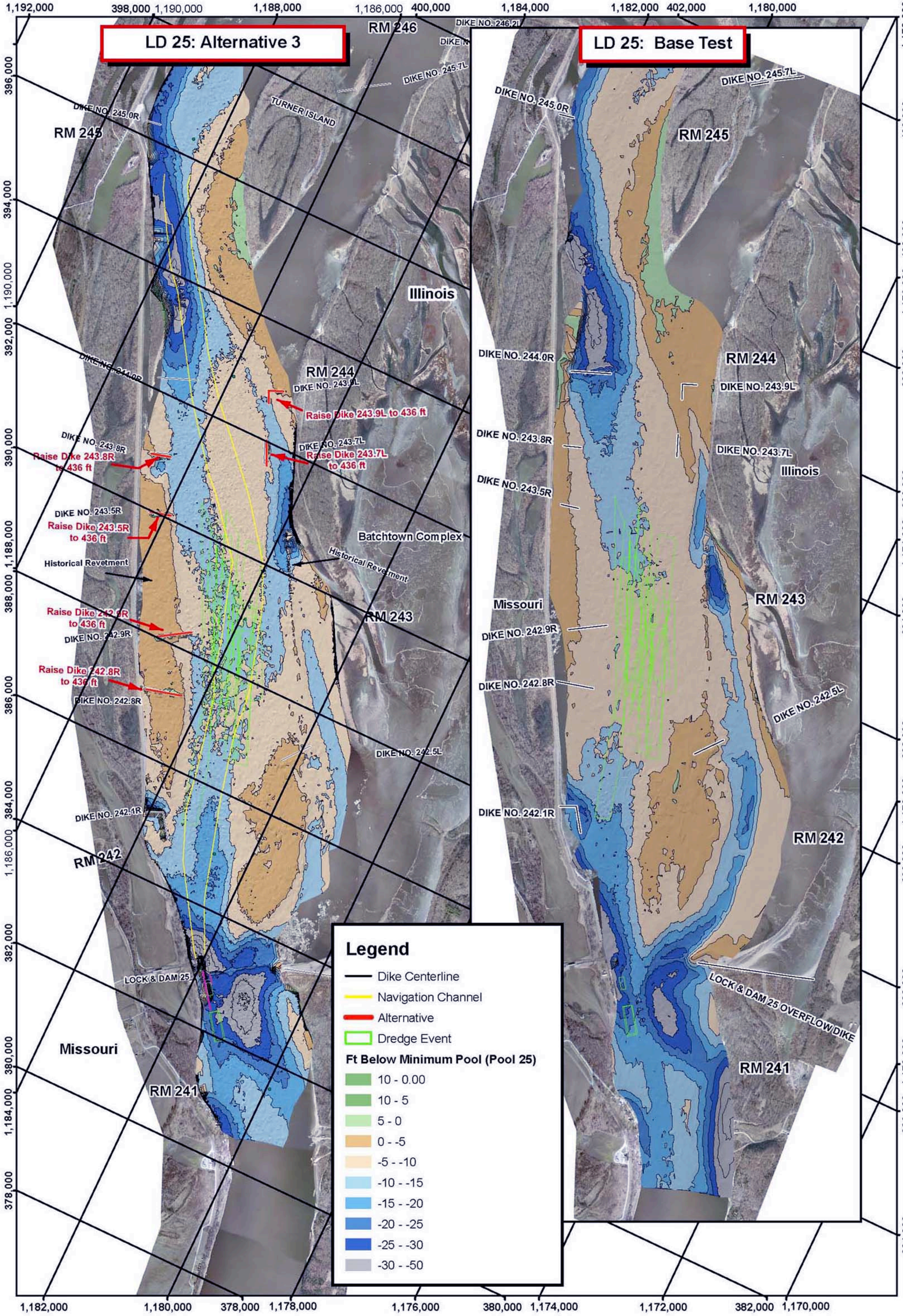

PLATE NUMBER 22

0 1,000 2,000 4,000 6,000
Feet

Alternative 3
2005 AERIAL PHOTOGRAPH

U.S. ARMY ENGINEER DIVISION CORPS OF ENGINEERS ST. LOUIS, MISSOURI	DESIGNED BY: A COX	SURVEY DATE: 03/11/2010
	DRAWN BY: A COX / REVIEWED BY: J BROWN, P.E.	CHECKED BY: E BRAUER, P.E.
Upper Mississippi River Basin St. Louis District Lock and Dam 25 HSR Model	SUBMITTED: A COX	APPROVED: R DAVINROY, P.E.
	FILE NAME: . . . LD25/Plates	PLOT DATE: 04/06/2010

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APPLIED RIVER ENGINEERING CENTER

US Army Corps of Engineers
St. Louis District

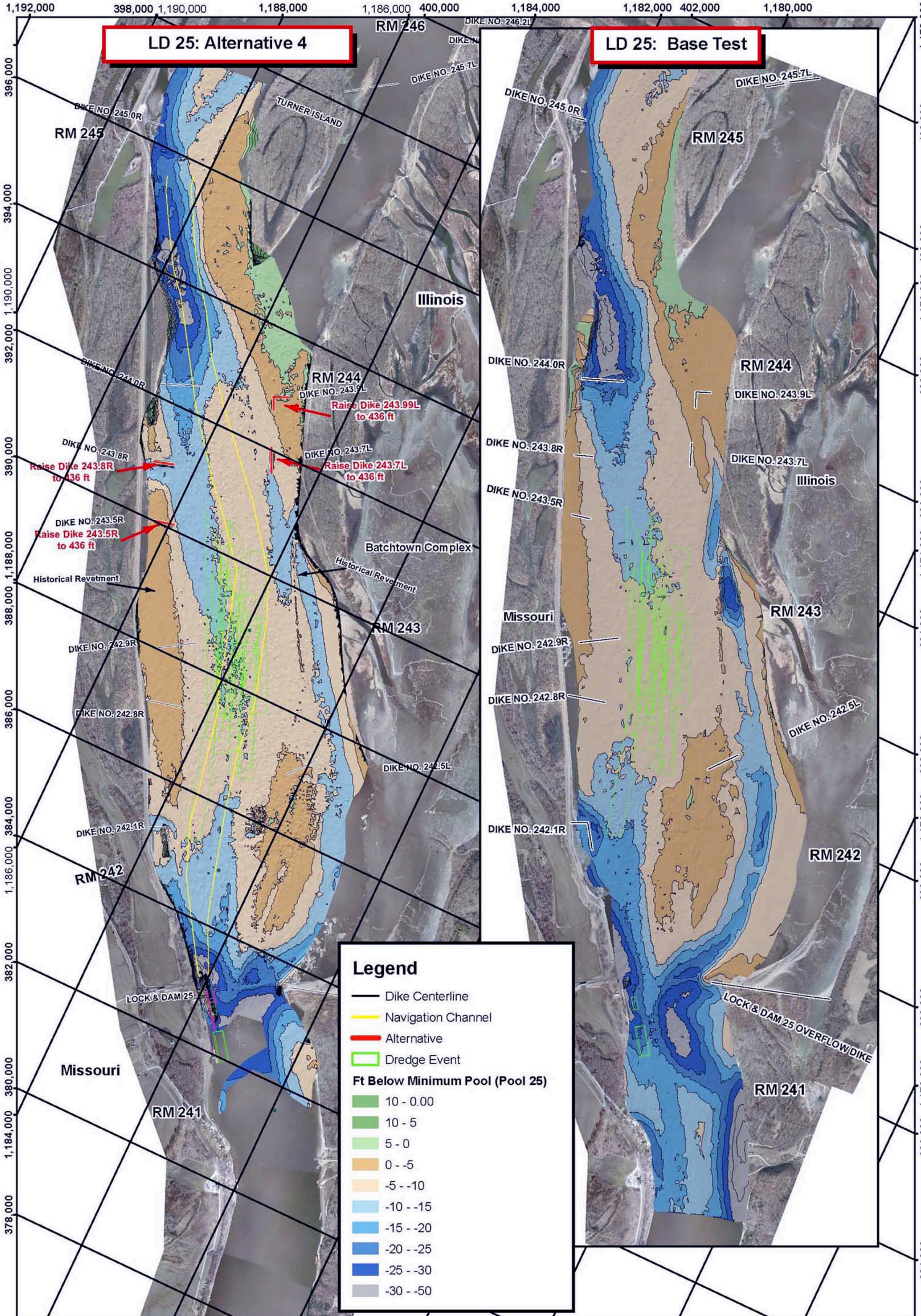

PLATE NUMBER	23

0 1,000 2,000 4,000 6,000
Feet

Alternative 4

2005 AERIAL PHOTOGRAPH

U.S. ARMY ENGINEER DIVISION CORPS OF ENGINEERS ST. LOUIS, MISSOURI	DESIGNED BY: A COX	SURVEY DATE: 03/15/2010	
	DRAWN BY: A COX	REVIEWED BY: J BROWN, P.E.	CHECKED BY: E BRAUER, P.E.
Upper Mississippi River Basin St. Louis District Lock and Dam 25 HSR Model	SUBMITTED: A COX	APPROVED: R DAVINROY, P.E.	
	FILE NAME: . . . LD25/Plates	PLOT DATE: 04/06/2010	

APPLIED RIVER ENGINEERING CENTER

US Army Corps of Engineers
St. Louis District

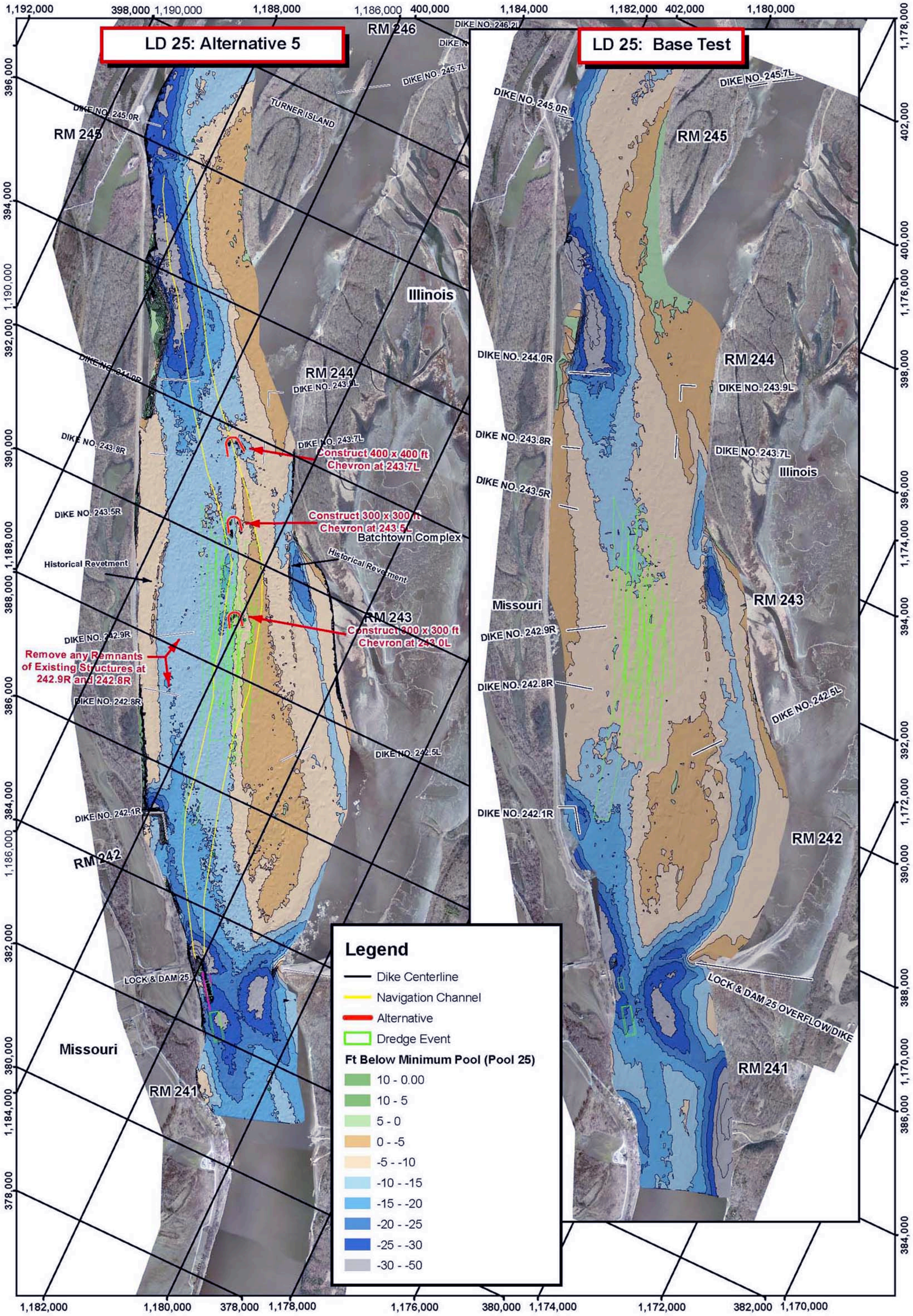

PLATE NUMBER 24

0 1,000 2,000 4,000 6,000
Feet

Alternative 5
2005 AERIAL PHOTOGRAPH

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

Upper Mississippi River Basin
St. Louis District
Lock and Dam 25
HSR Model

DESIGNED BY:	SURVEY DATE:	
A COX	03/18/2010	
DRAWN BY: A COX	REVIEWED BY: J BROWN, P.E.	CHECKED BY: E BRAUER, P.E.
SUBMITTED: A COX	APPROVED: R DAVINROY, P.E.	
FILE NAME: . . . LD25/Plates	PLOT DATE: 04/06/2010	

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APPLIED RIVER ENGINEERING CENTER

US Army Corps of Engineers
St. Louis District

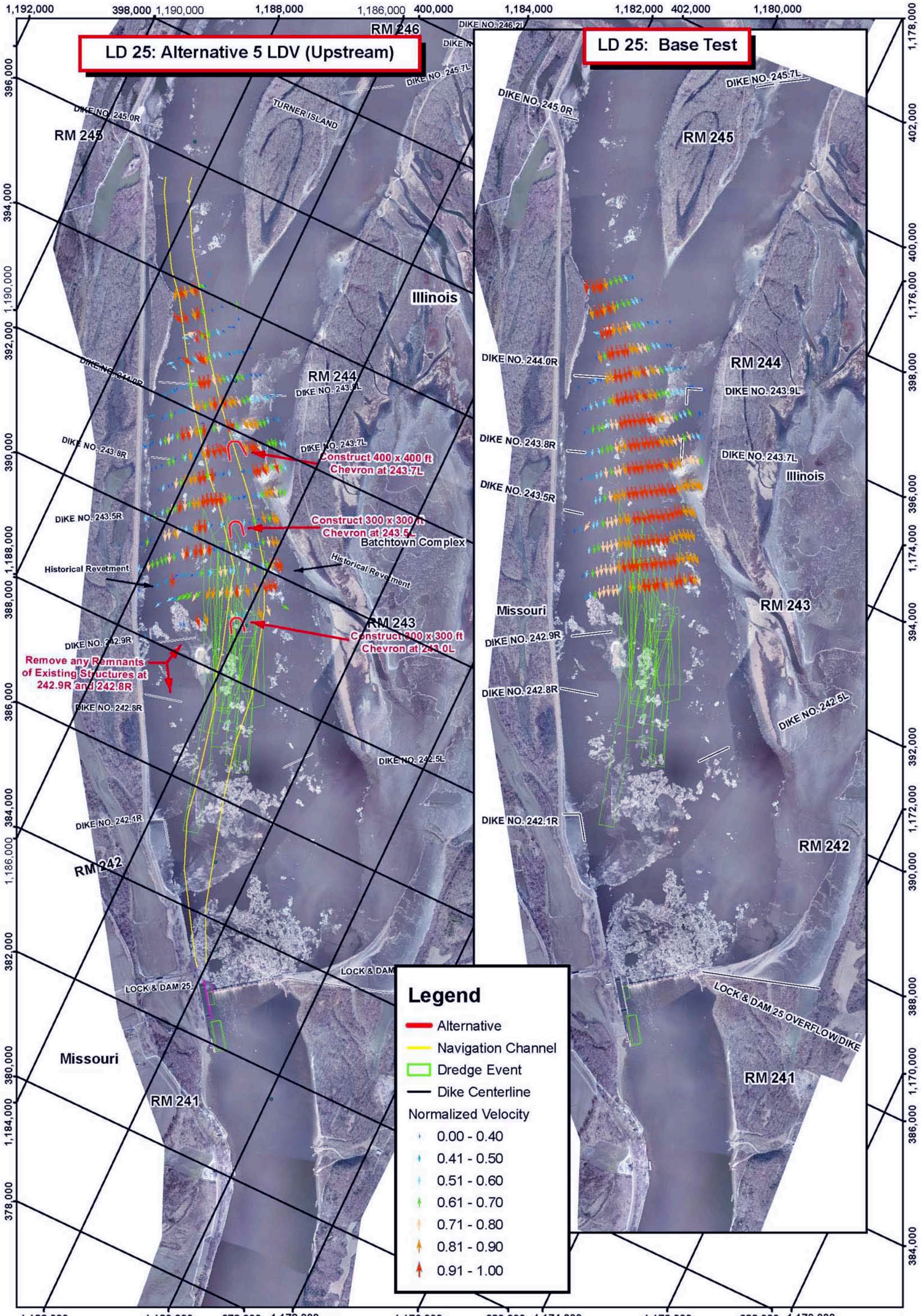

PLATE NUMBER 25

0 1,000 2,000 4,000 6,000
Feet

Alternative 5 LDV (Upstream)

2005 AERIAL PHOTOGRAPH

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

Upper Mississippi River Basin
St. Louis District
Lock and Dam 25
HSR Model

DESIGNED BY: A COX	SURVEY DATE: 05/10/2010
DRAWN BY: A COX	REVIEWED BY: J BROWN, P.E. / CHECKED BY: E BRAUER, P.E.
SUBMITTED: A COX	APPROVED: R DAVINROY, P.E.
FILE NAME: . . . LD25/Plates	PLOT DATE: 05/17/2010

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APPLIED RIVER ENGINEERING CENTER

US Army Corps of Engineers
St. Louis District

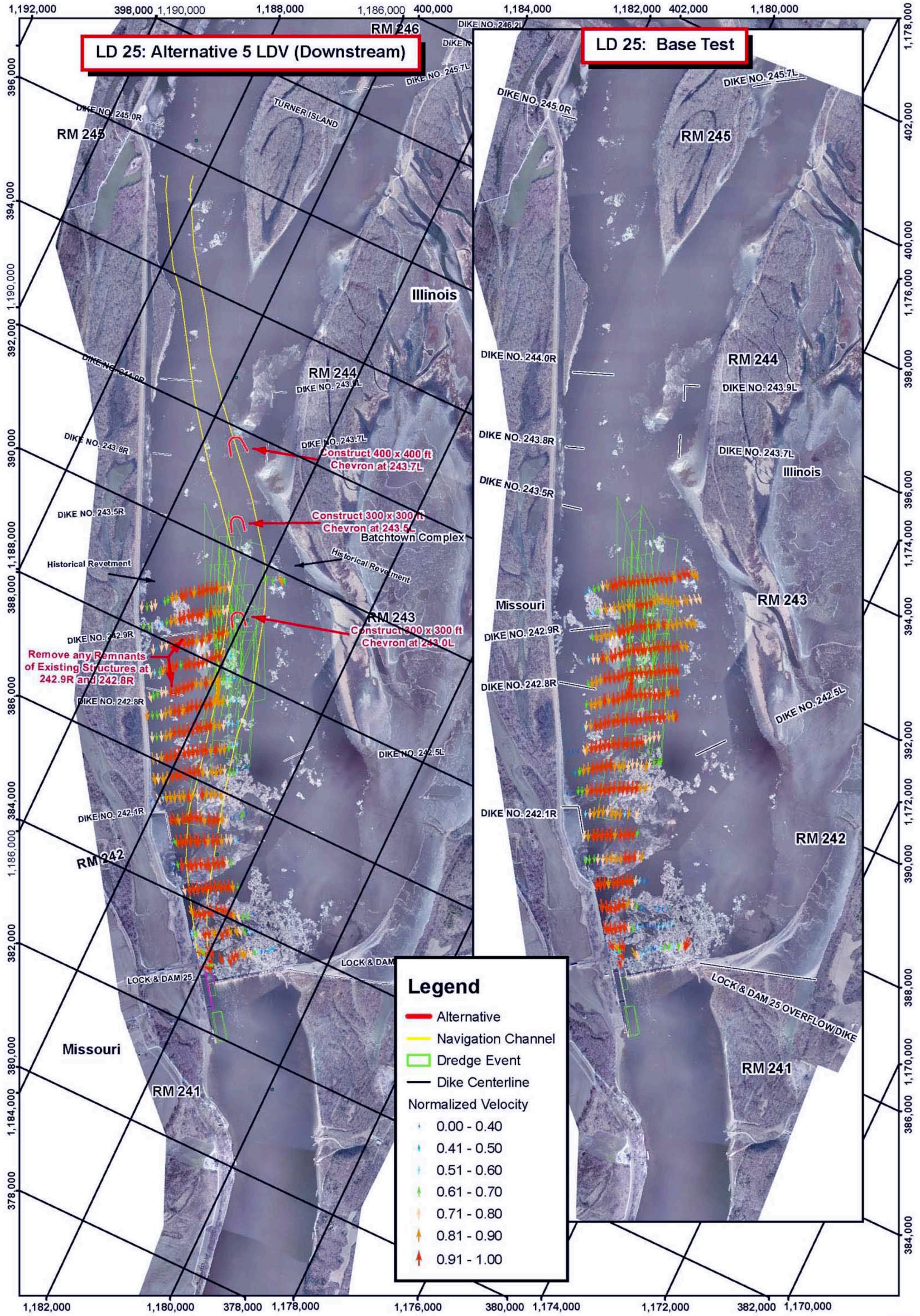

PLATE NUMBER 26	Alternative 5 LDV (Downstream) 2005 AERIAL PHOTOGRAPH	U.S. ARMY ENGINEER DIVISION CORPS OF ENGINEERS ST. LOUIS, MISSOURI Upper Mississippi River Basin St. Louis District Lock and Dam 25 HSR Model

Scale: 0 1,000 2,000 4,000 6,000 Feet

DESIGNED BY: A COX	SURVEY DATE: 03/18/2010
DRAWN BY: A COX	REVIEWED BY: J BROWN, P.E. / CHECKED BY: E BRAUER, P.E.
SUBMITTED: A COX	APPROVED: R DAVINROY, P.E.
FILE NAME: . . . LD25/Plates	PLOT DATE: 05/14/2010

APPLIED RIVER ENGINEERING CENTER

US Army Corps of Engineers St. Louis District®

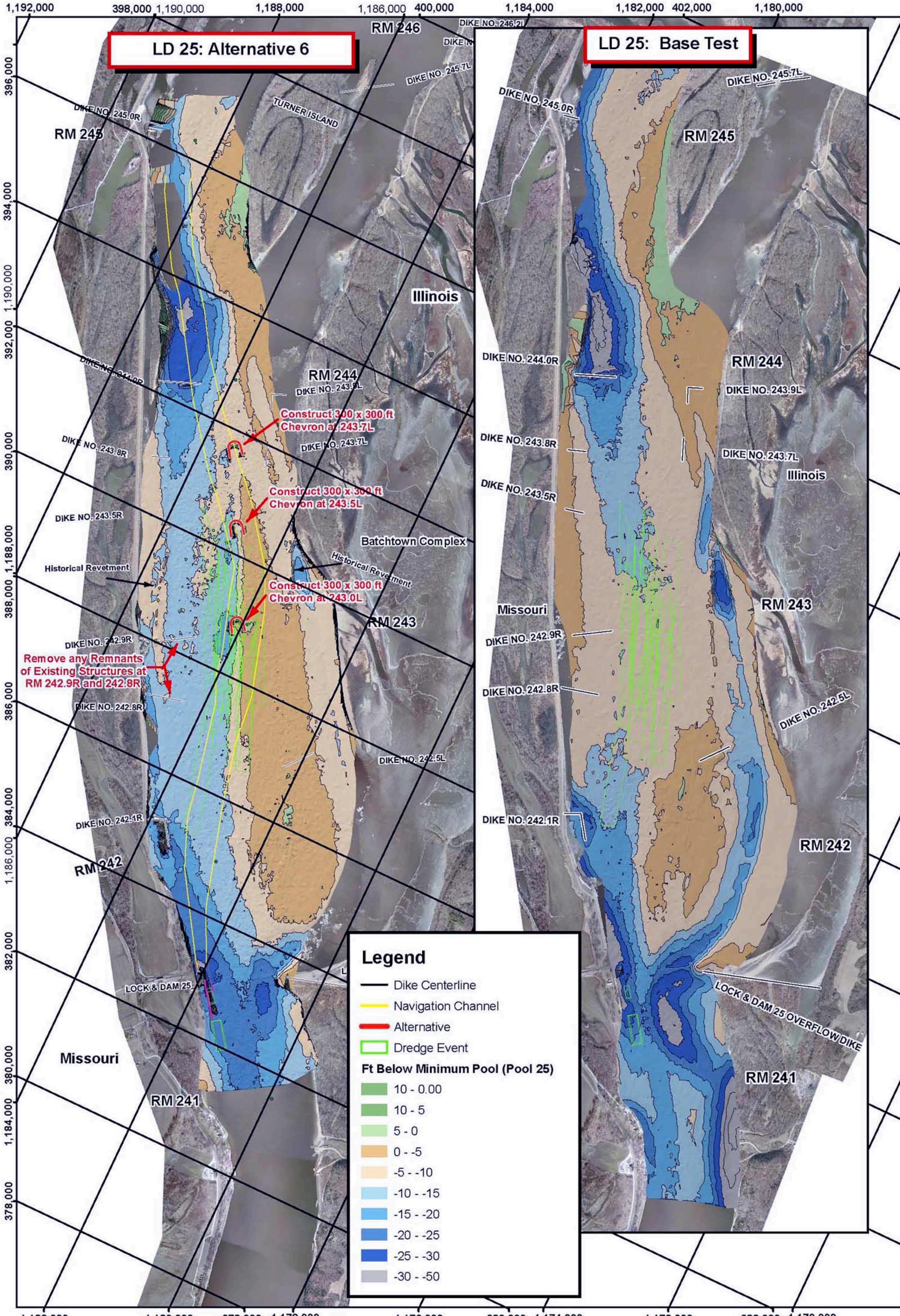

PLATE NUMBER **27**

0 1,000 2,000 4,000 6,000
Feet

Alternative 6

2005 AERIAL PHOTOGRAPH

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

Upper Mississippi River Basin
St. Louis District
Lock and Dam 25
HSR Model

DESIGNED BY: A COX	SURVEY DATE: 03/22/2010
DRAWN BY: A COX	REVIEWED BY: J BROWN, P.E. / CHECKED BY: E BRAUER, P.E.
SUBMITTED: A COX	APPROVED: R DAVINROY, P.E.
FILE NAME: . . . LD25/Plates	PLOT DATE: 05/14/2010

APPLIED RIVER ENGINEERING CENTER

US Army Corps of Engineers
St. Louis District

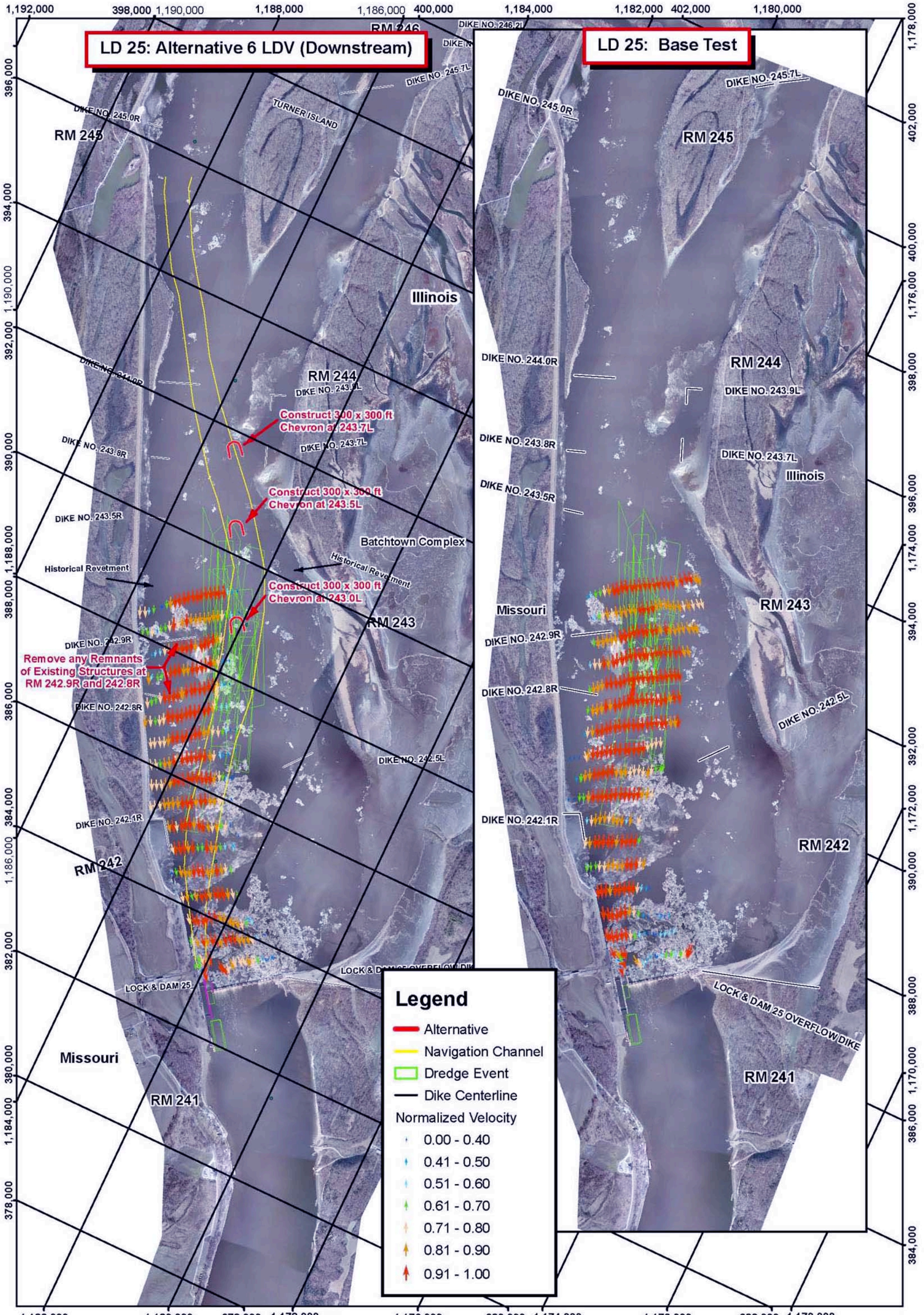

PLATE NUMBER
28

0 1,000 2,000 4,000 6,000
Feet

Alternative 6 LDV (Downstream)

2005 AERIAL PHOTOGRAPH

U.S. ARMY ENGINEER DIVISION CORPS OF ENGINEERS ST. LOUIS, MISSOURI	DESIGNED BY: A COX		SURVEY DATE: 03/22/2010
	DRAWN BY: A COX	REVIEWED BY: J BROWN, P.E.	CHECKED BY: E BRAUER, P.E.
Upper Mississippi River Basin St. Louis District Lock and Dam 25 HSR Model	SUBMITTED: A COX		APPROVED: R DAVINROY, P.E.
	FILE NAME: . . . LD25/Plates		PLOT DATE: 05/14/2010

APPLIED RIVER ENGINEERING CENTER

US Army Corps of Engineers®
St. Louis District

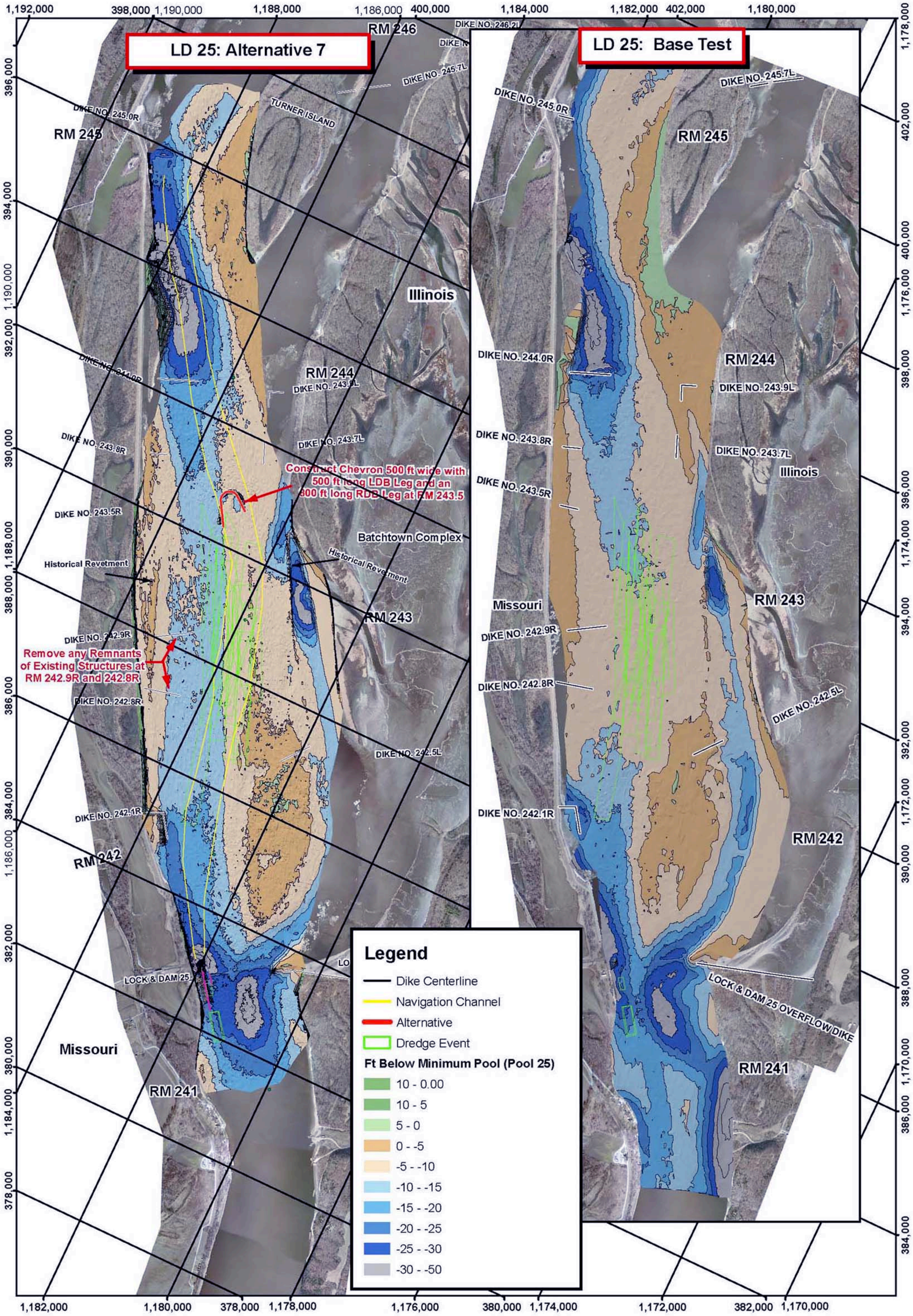

PLATE NUMBER 29

Alternative 7

2005 AERIAL PHOTOGRAPH

U.S. ARMY ENGINEER DIVISION CORPS OF ENGINEERS ST. LOUIS, MISSOURI	DESIGNED BY: A COX	SURVEY DATE: 03/25/2010
	DRAWN BY: A COX; REVIEWED BY: J BROWN, P.E.	CHECKED BY: E BRAUER, P.E.
Upper Mississippi River Basin St. Louis District Lock and Dam 25 HSR Model	SUBMITTED: A COX	APPROVED: R DAVINROY, P.E.
	FILE NAME: . . . LD25/Plates	PLOT DATE: 05/14/2010

APPLIED RIVER ENGINEERING CENTER

US Army Corps of Engineers St. Louis District®

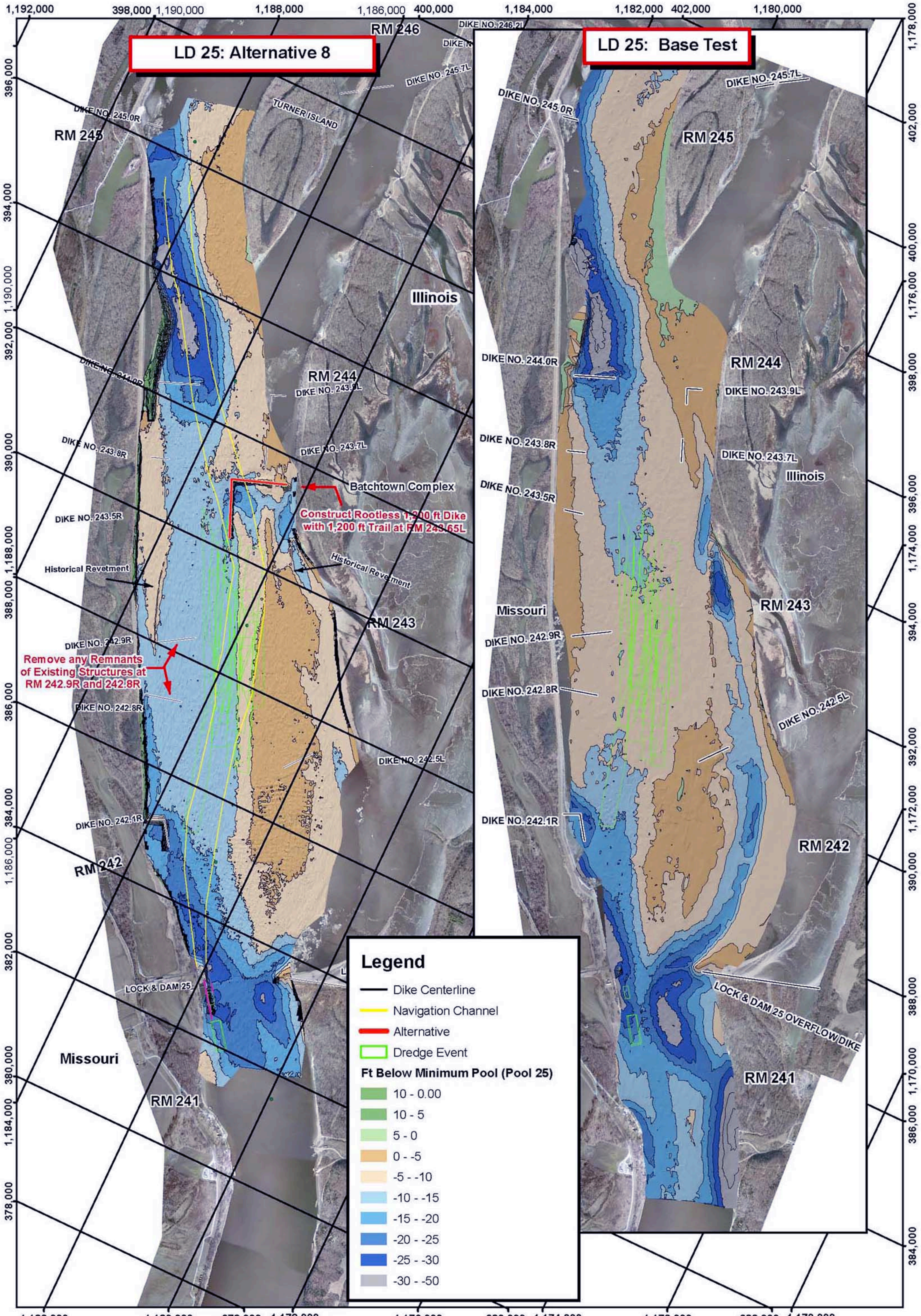

PLATE NUMBER 30

0 1,000 2,000 4,000 6,000
Feet

Alternative 8

2005 AERIAL PHOTOGRAPH

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

Upper Mississippi River Basin
St. Louis District
Lock and Dam 25
HSR Model

DESIGNED BY:		SURVEY DATE:
A COX		03/26/2010
DRAWN BY: A COX	REVIEWED BY: J BROWN, P.E.	CHECKED BY: E BRAUER, P.E.
SUBMITTED: A COX		APPROVED: R DAVINROY, P.E.
FILE NAME: ...LD25/Plates		PLOT DATE: 05/14/2010

N E S W

APPLIED RIVER ENGINEERING CENTER

US Army Corps of Engineers
St. Louis District

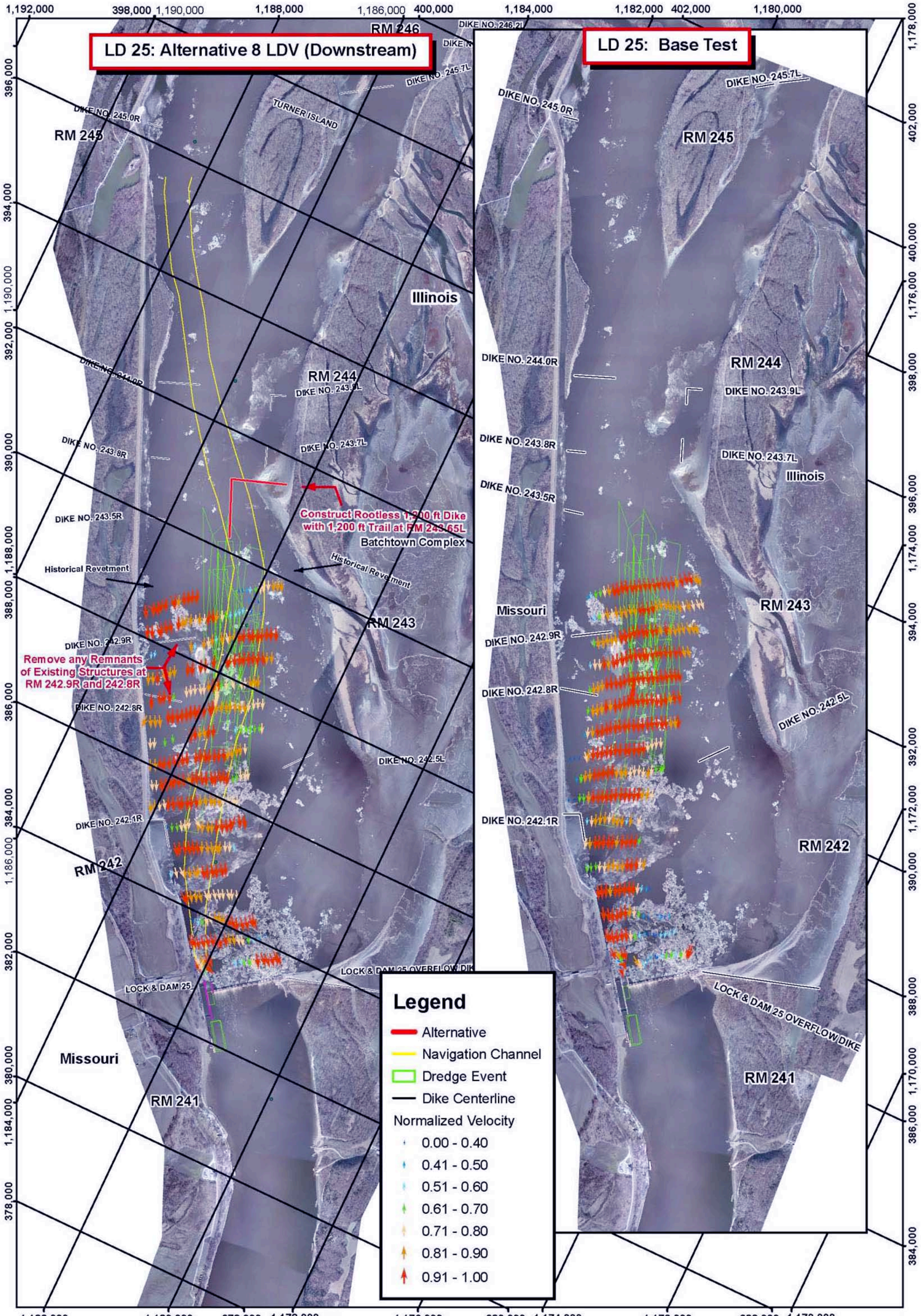

PLATE NUMBER 31

Feet: 0 1,000 2,000 4,000 6,000

Alternative 8 LDV (Downstream)

2005 AERIAL PHOTOGRAPH

U.S. ARMY ENGINEER DIVISION CORPS OF ENGINEERS ST. LOUIS, MISSOURI	DESIGNED BY: A COX	SURVEY DATE: 03/29/2010
	DRAWN BY: A COX	REVIEWED BY: J BROWN, P.E. / CHECKED BY: E BRAUER, P.E.
Upper Mississippi River Basin St. Louis District Lock and Dam 25 HSR Model	SUBMITTED: A COX	APPROVED: R DAVINROY, P.E.
	FILE NAME: ...LD25/Plates	PLOT DATE: 05/14/2010

N E S W

APPLIED RIVER ENGINEERING CENTER

US Army Corps of Engineers St. Louis District

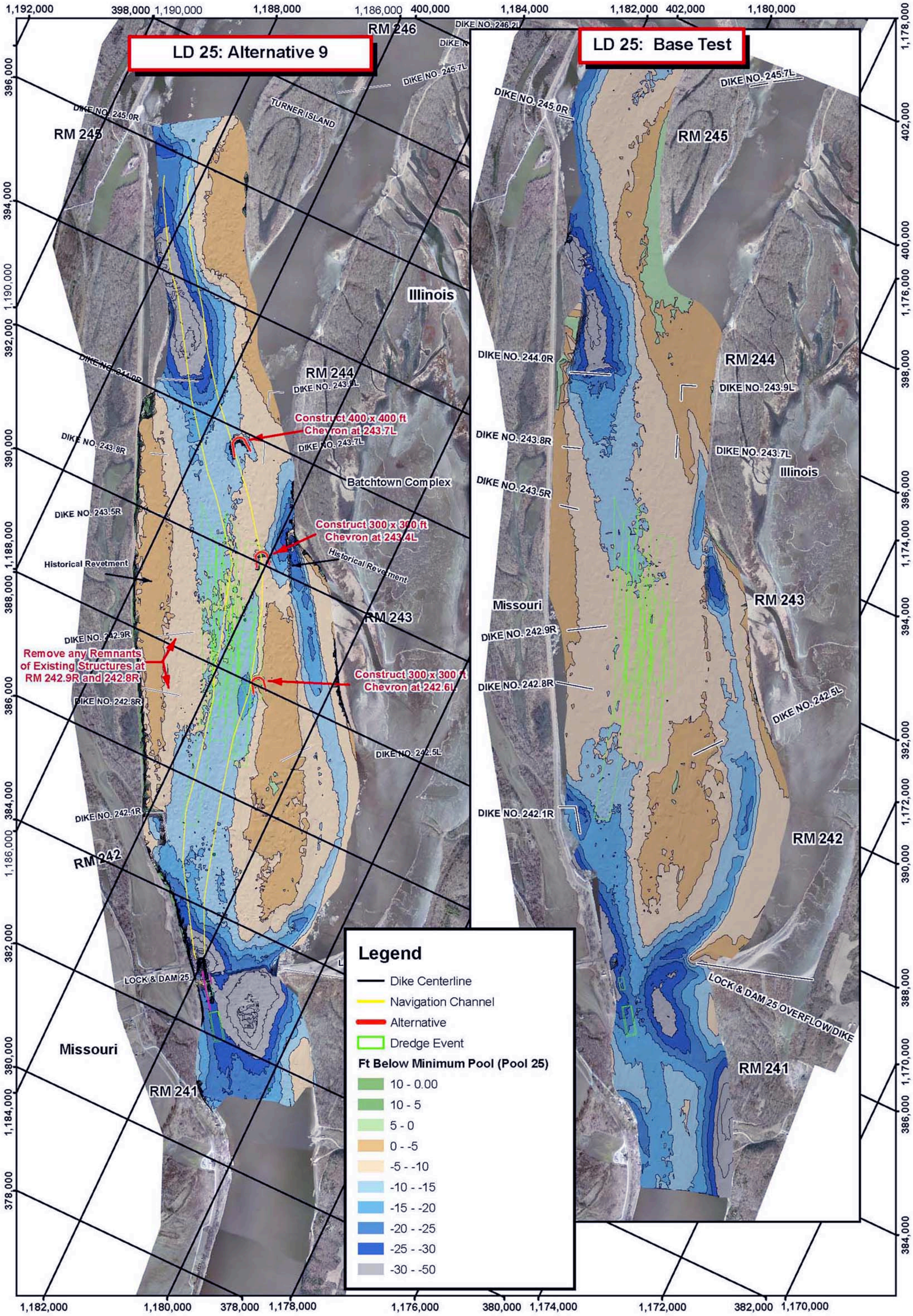

PLATE NUMBER 32

0 1,000 2,000 4,000 6,000
Feet

Alternative 9
2005 AERIAL PHOTOGRAPH

U.S. ARMY ENGINEER DIVISION CORPS OF ENGINEERS ST. LOUIS, MISSOURI	DESIGNED BY: A COX		SURVEY DATE: 04/02/2010
	DRAWN BY: A COX	REVIEWED BY: J BROWN, P.E.	CHECKED BY: E BRAUER, P.E.
Upper Mississippi River Basin St. Louis District Lock and Dam 25 HSR Model	SUBMITTED: A COX		APPROVED: R DAVINROY, P.E.
	FILE NAME: ...LD25/Plates		PLOT DATE: 05/14/2010

APPLIED RIVER ENGINEERING CENTER

US Army Corps of Engineers
St. Louis District

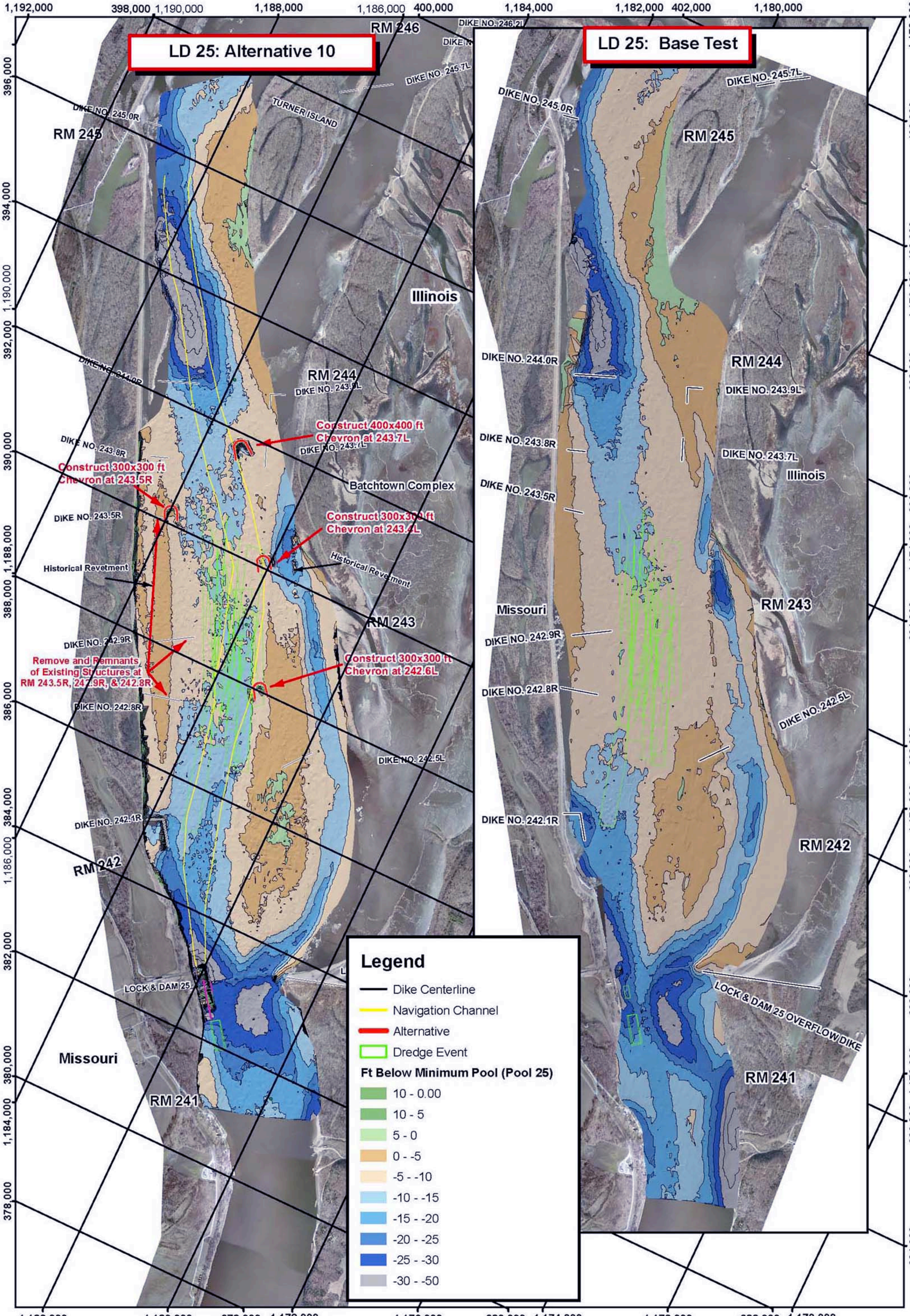

PLATE NUMBER 33

0 1,000 2,000 4,000 6,000
Feet

Alternative 10

2005 AERIAL PHOTOGRAPH

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

Upper Mississippi River Basin
St. Louis District
Lock and Dam 25
HSR Model

DESIGNED BY: A COX	SURVEY DATE: 04/02/2010	
DRAWN BY: A COX	REVIEWED BY: J BROWN, P.E.	CHECKED BY: E BRAUER, P.E.
SUBMITTED: A COX	APPROVED: R DAVINROY, P.E.	
FILE NAME: . . . LD25/Plates	PLOT DATE: 05/14/2010	

APPLIED RIVER ENGINEERING CENTER

US Army Corps of Engineers
St. Louis District

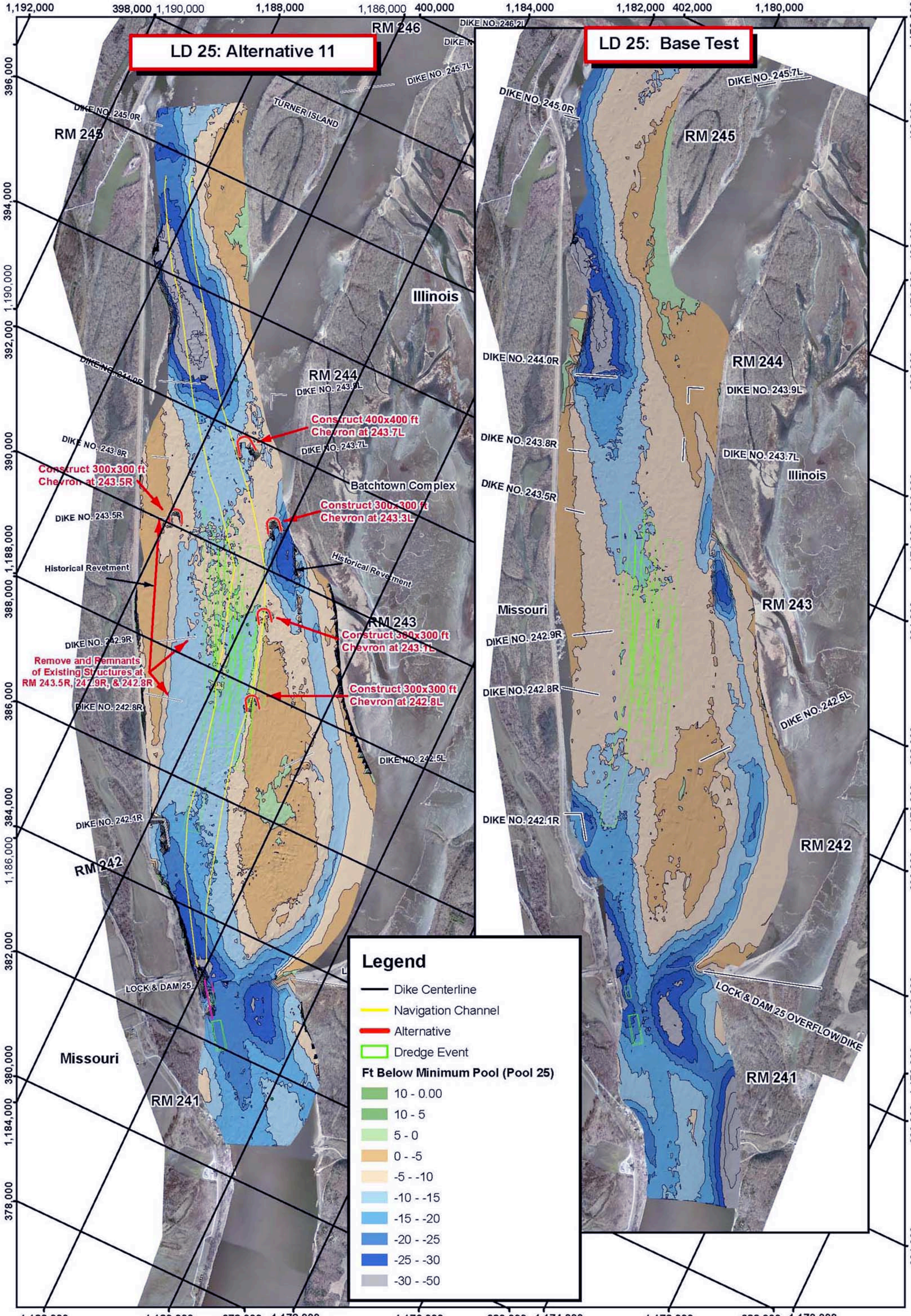

PLATE NUMBER 34	0 1,000 2,000 4,000 6,000 Feet Alternative 11 2005 AERIAL PHOTOGRAPH	U.S. ARMY ENGINEER DIVISION CORPS OF ENGINEERS ST. LOUIS, MISSOURI Upper Mississippi River Basin St. Louis District Lock and Dam 25 HSR Model	DESIGNED BY: A COX — SURVEY DATE: 04/15/2010 DRAWN BY: A COX — REVIEWED BY: J BROWN, P.E. — CHECKED BY: E BRAUER, P.E. SUBMITTED: A COX — APPROVED: R DAVINROY, P.E. FILE NAME: . . . LD25/Plates — PLOT DATE: 05/14/2010

APPLIED RIVER ENGINEERING CENTER

US Army Corps of Engineers St. Louis District

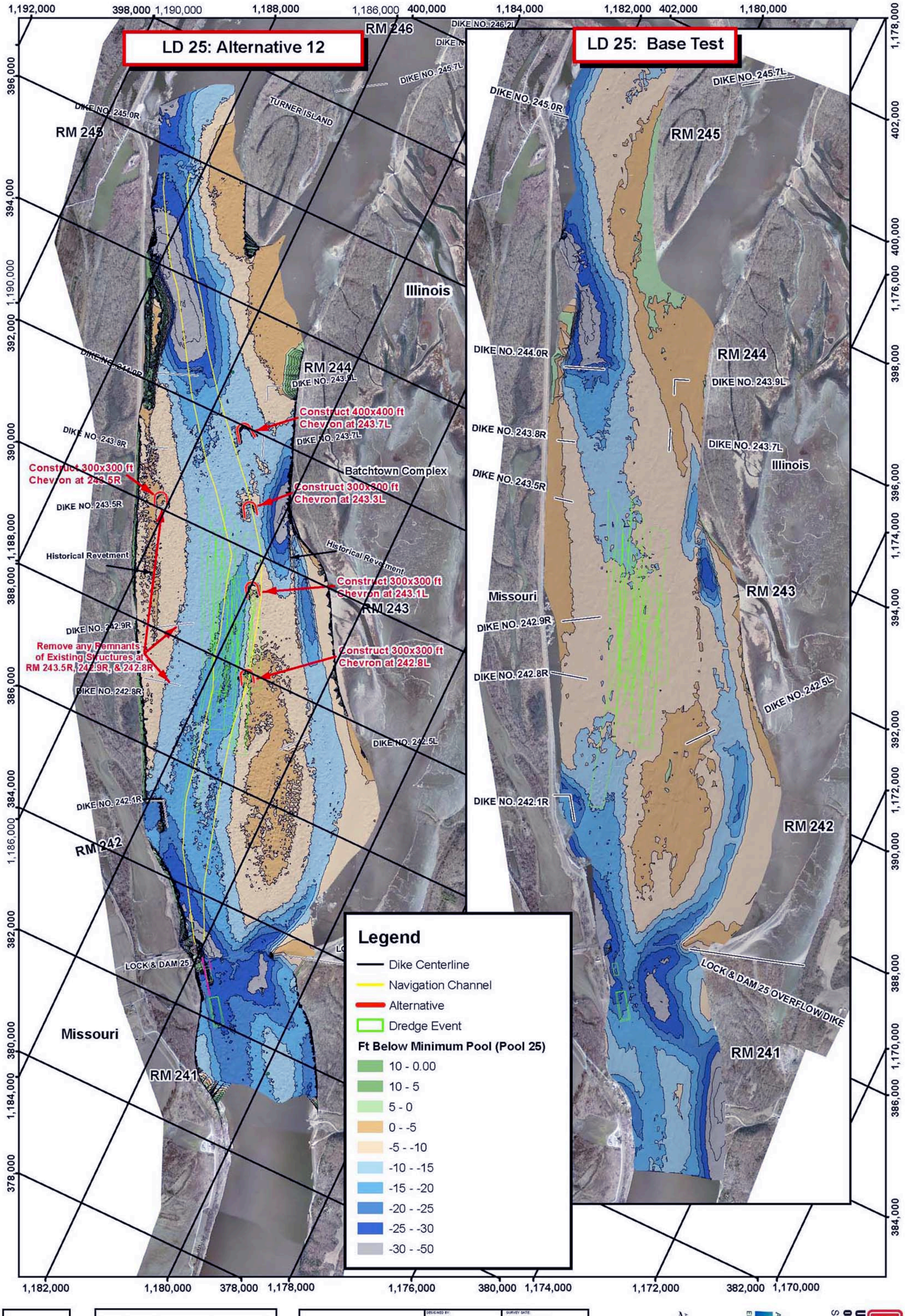

PLATE NUMBER 35

0 1,000 2,000 4,000 6,000
Feet

Alternative 12
2005 AERIAL PHOTOGRAPH

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

Upper Mississippi River Basin
St. Louis District
Lock and Dam 25
HSR Model

DESIGNED BY: A COX	SURVEY DATE: 04/20/2010
DRAWN BY: A COX	REVIEWED BY: J BROWN, P.E. / CHECKED BY: E BRAUER, P.E.
SUBMITTED: A COX	APPROVED: R DAVINROY, P.E.
FILE NAME: ...LD25/Plates	PLOT DATE: 05/17/2010

APPLIED RIVER ENGINEERING CENTER

US Army Corps of Engineers
St. Louis District

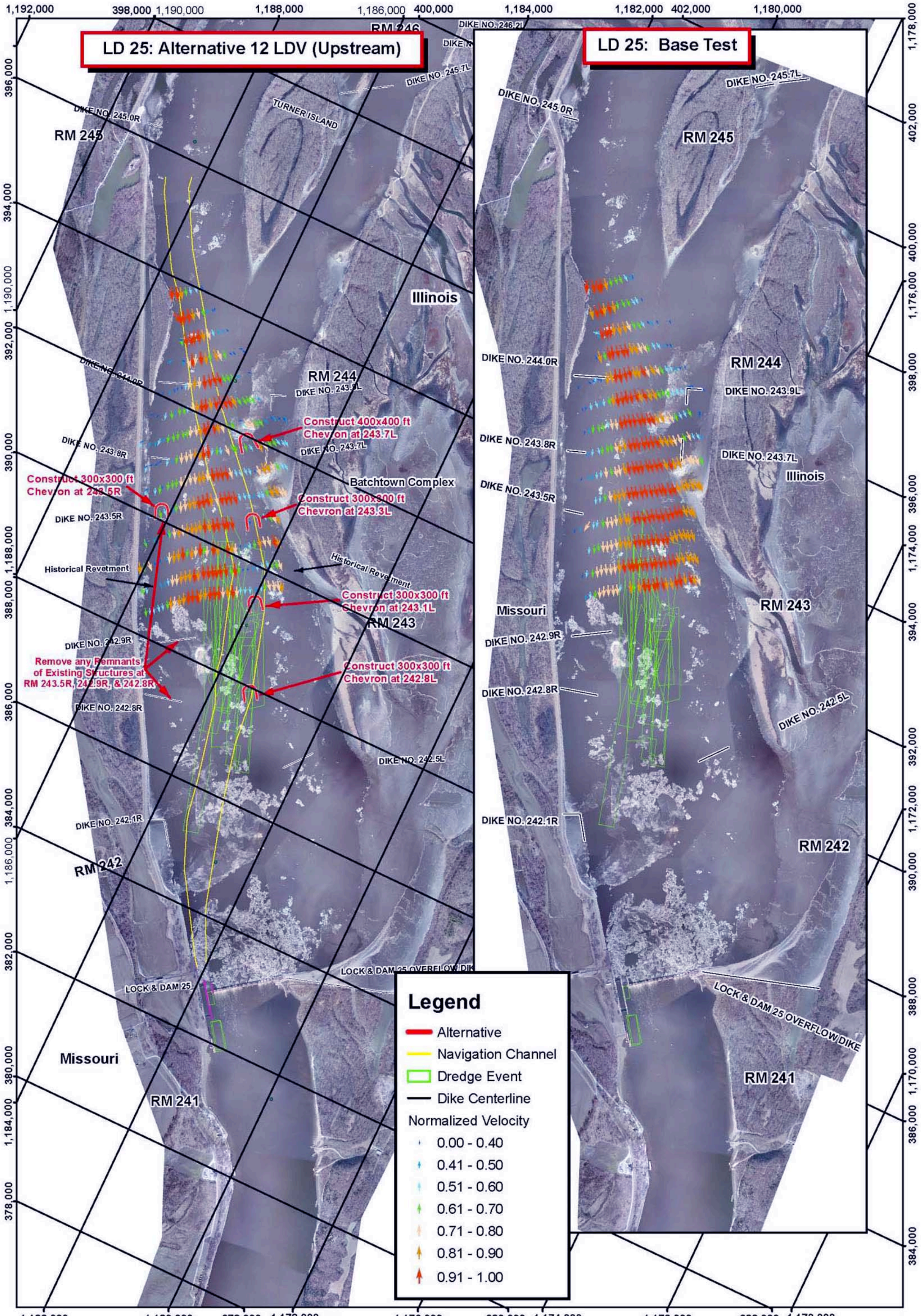

PLATE NUMBER
36

0 1,000 2,000 4,000 6,000
Feet

Alternative 12 LDV (Upstream)
2005 AERIAL PHOTOGRAPH

U.S. ARMY ENGINEER DIVISION CORPS OF ENGINEERS ST. LOUIS, MISSOURI	DESIGNED BY: A COX	SURVEY DATE: 05/12/2010
	DRAWN BY: A COX	REVIEWED BY: J BROWN, P.E. / CHECKED BY: E BRAUER, P.E.
Upper Mississippi River Basin St. Louis District Lock and Dam 25 HSR Model	SUBMITTED: A COX	APPROVED: R DAVINROY, P.E.
	FILE NAME: . . . LD25/Plates	PLOT DATE: 05/17/2010

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St. Louis District

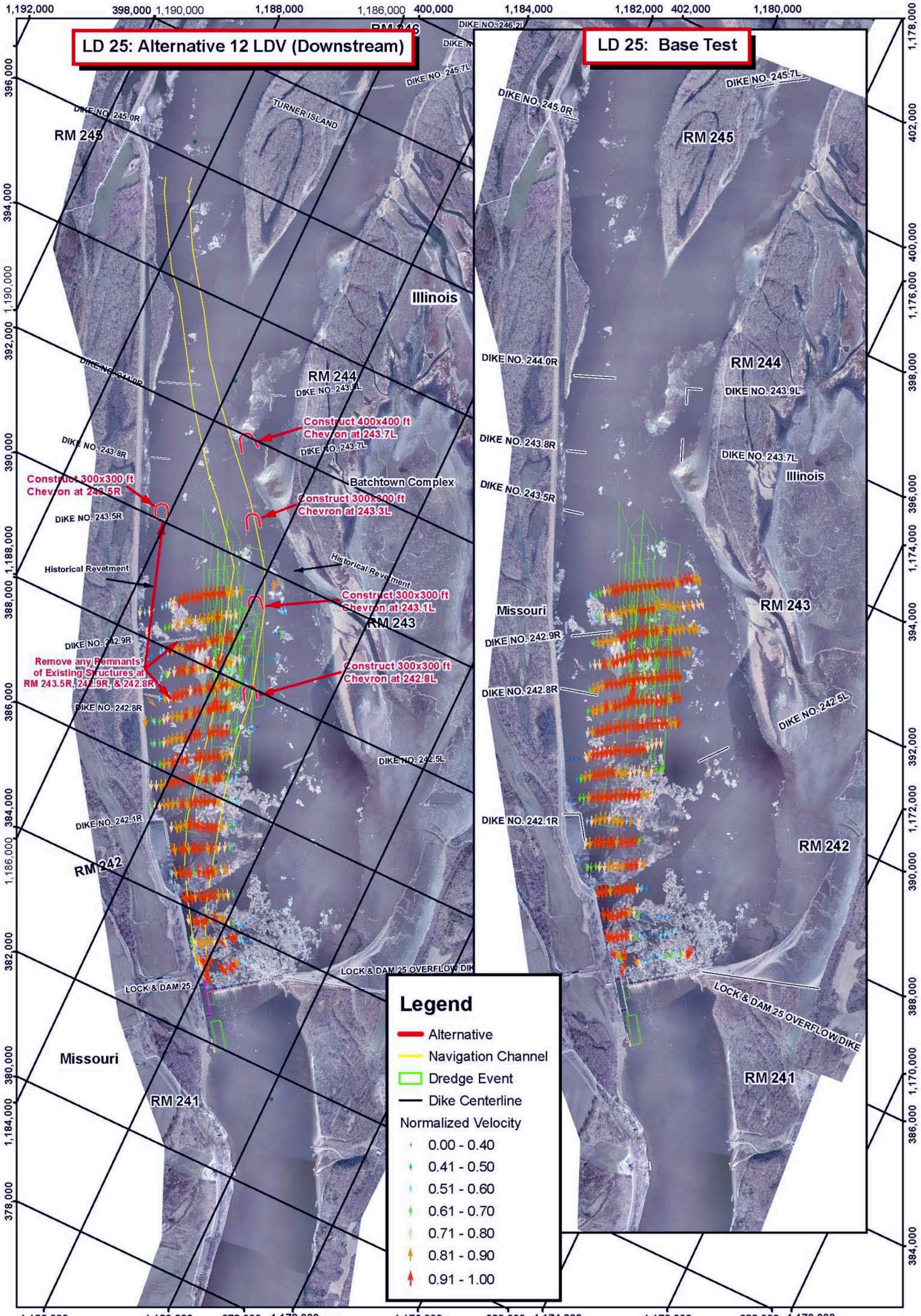

PLATE NUMBER 37

0 1,000 2,000 4,000 6,000 Feet

Alternative 12 LDV (Downstream)

2005 AERIAL PHOTOGRAPH

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

Upper Mississippi River Basin
St. Louis District
Lock and Dam 25
HSR Model

DESIGNED BY: A COX	SURVEY DATE: 04/20/2010	
DRAWN BY: A COX	REVIEWED BY: J BROWN, P.E.	CHECKED BY: E BRAUER, P.E.
SUBMITTED: A COX	APPROVED: R DAVINROY, P.E.	
FILE NAME: ...LD25/Plates	PLOT DATE: 05/17/2010	

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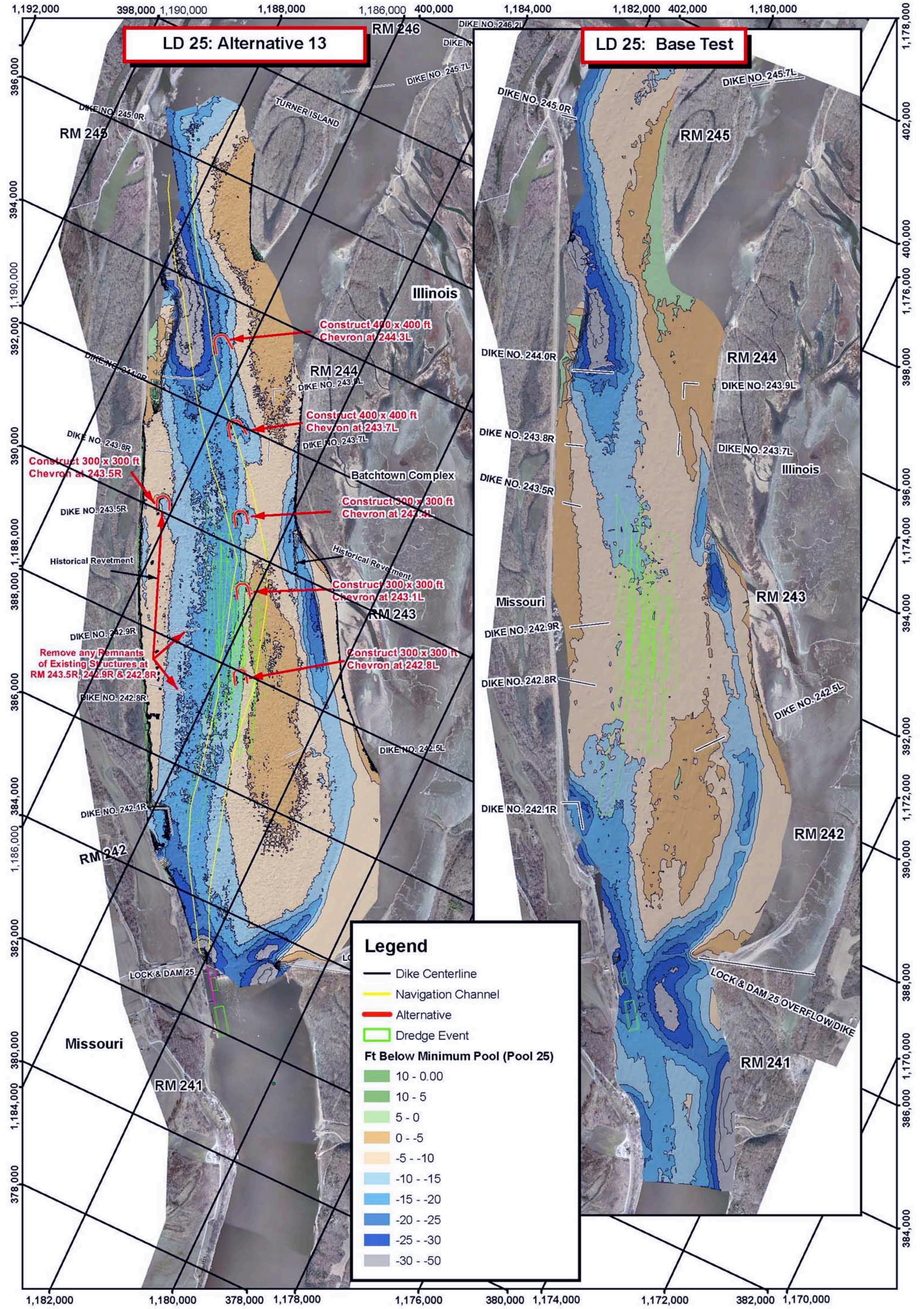

0 1,000 2,000 4,000 6,000
Feet

PLATE NUMBER 38

Alternative 13
2005 AERIAL PHOTOGRAPH

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

Upper Mississippi River Basin
St. Louis District
Lock and Dam 25
HSR Model

DESIGNED BY: A COX	SURVEY DATE: 05/12/2010
DRAWN BY: A COX	REVIEWED BY: J BROWN, P.E. / CHECKED BY: E BRAUER, P.E.
SUBMITTED: A COX	APPROVED: R DAVINROY, P.E.
FILE NAME: . . . LD25/Plates	PLOT DATE: 05/17/2010

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St. Louis District

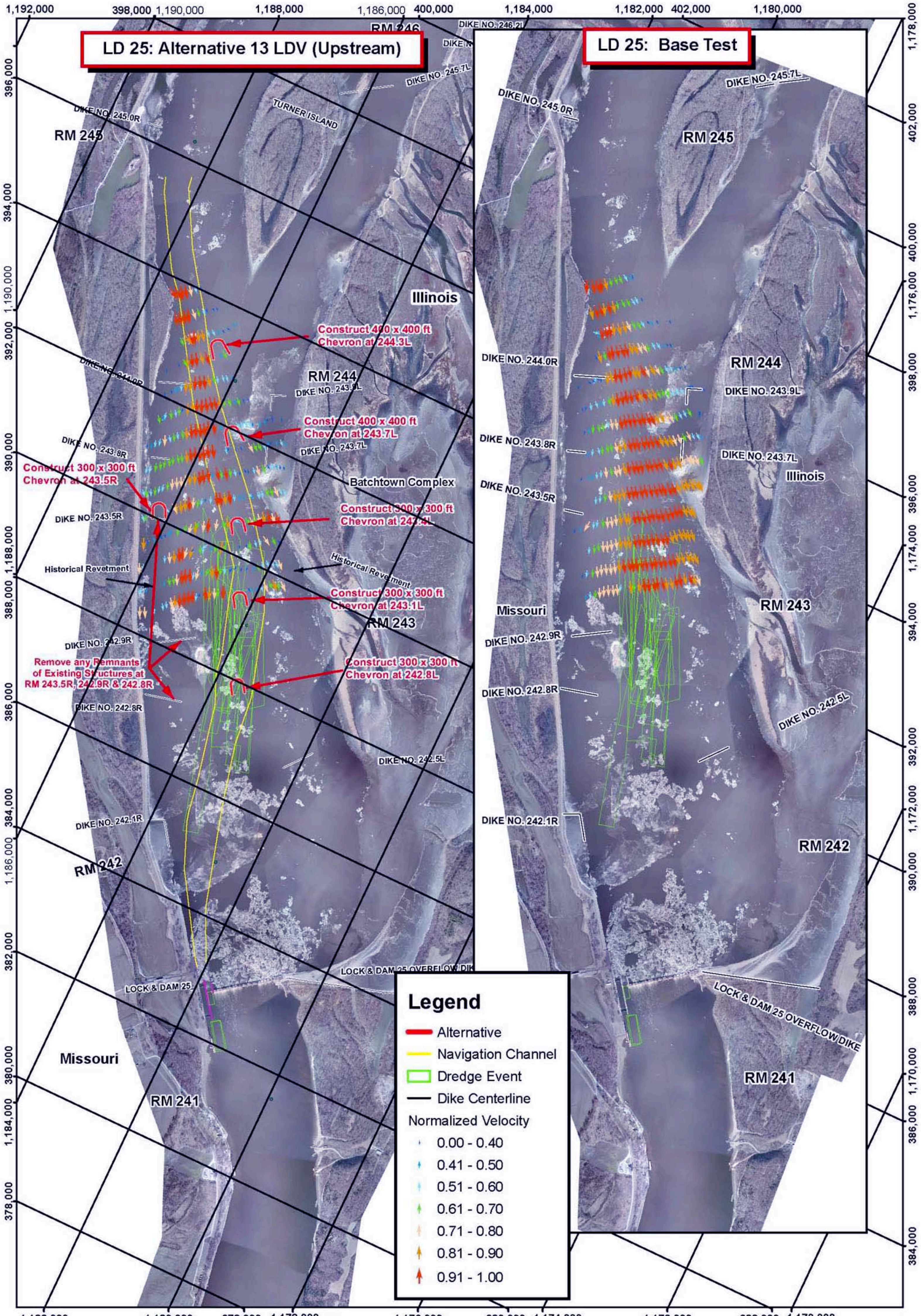

PLATE NUMBER 39

0 1,000 2,000 4,000 6,000
Feet

Alternative 13 LDV (Upstream)

2005 AERIAL PHOTOGRAPH

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CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

Upper Mississippi River Basin
St. Louis District
Lock and Dam 25
HSR Model

DESIGNED BY: A COX		SURVEY DATE: 05/13/2010
DRAWN BY: A COX	REVIEWED BY: J BROWN, P.E.	CHECKED BY: E BRAUER, P.E.
SUBMITTED: A COX		APPROVED: R DAVINROY, P.E.
FILE NAME: ...LD25/Plates		PLOT DATE: 05/17/2010

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St. Louis District

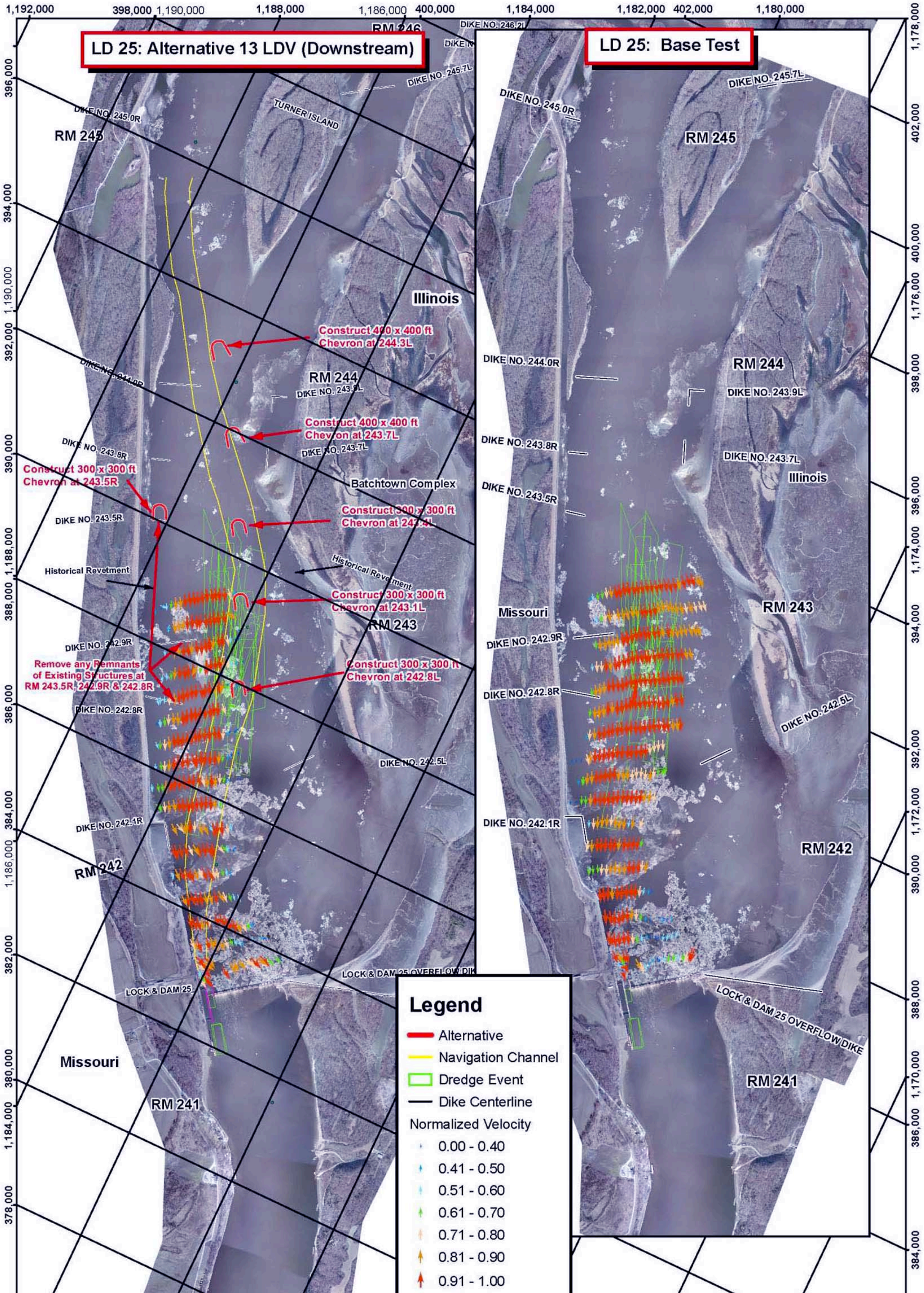

PLATE NUMBER 40

0 1,000 2,000 4,000 6,000
Feet

Alternative 13 LDV (Downstream)
2005 AERIAL PHOTOGRAPH

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

DESIGNED BY: A COX		SURVEY DATE: 05/18/2010
DRAWN BY: A COX	REVIEWED BY: J BROWN, P.E.	CHECKED BY: E BRAUER, P.E.
SUBMITTED: A COX		APPROVED: R DAVINROY, P.E.
FILE NAME: ...LD25/Plates		PLOT DATE: 05/19/2010

Upper Mississippi River Basin
St. Louis District
Lock and Dam 25
HSR Model

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St. Louis District®

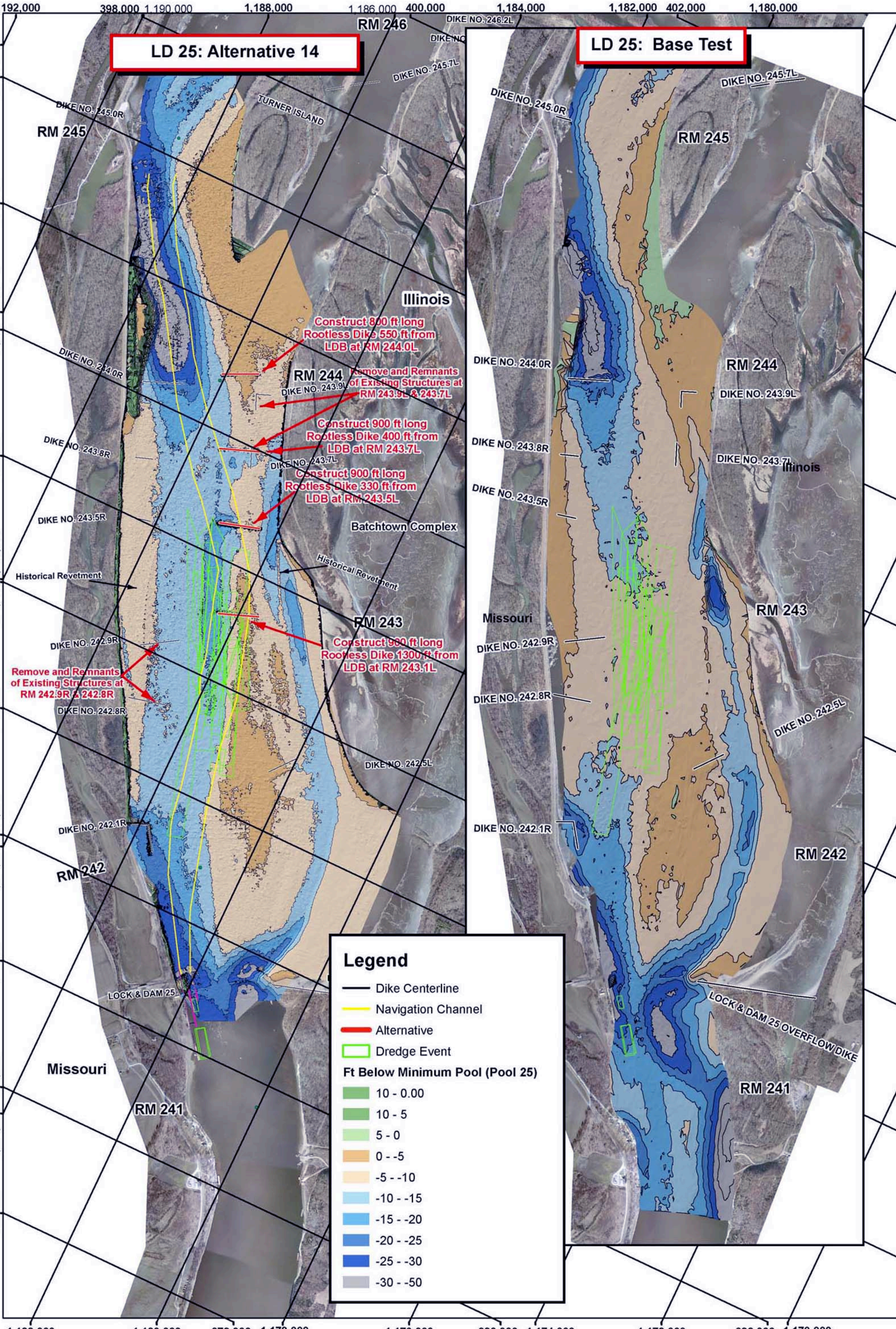

PLATE NUMBER 41

0 1,000 2,000 4,000 6,000
Feet

Alternative 14
2005 AERIAL PHOTOGRAPH

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

Upper Mississippi River Basin
St. Louis District
Lock and Dam 25
HSR Model

DESIGNED BY: A COX	SURVEY DATE: 05/19/2010	
DRAWN BY: A COX	REVIEWED BY: J BROWN, P.E.	CHECKED BY: E BRAUER, P.E.
SUBMITTED: A COX	APPROVED: R DAVINROY, P.E.	
FILE NAME: . . . LD25/Plates	PLOT DATE: 05/20/2010	

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St. Louis District

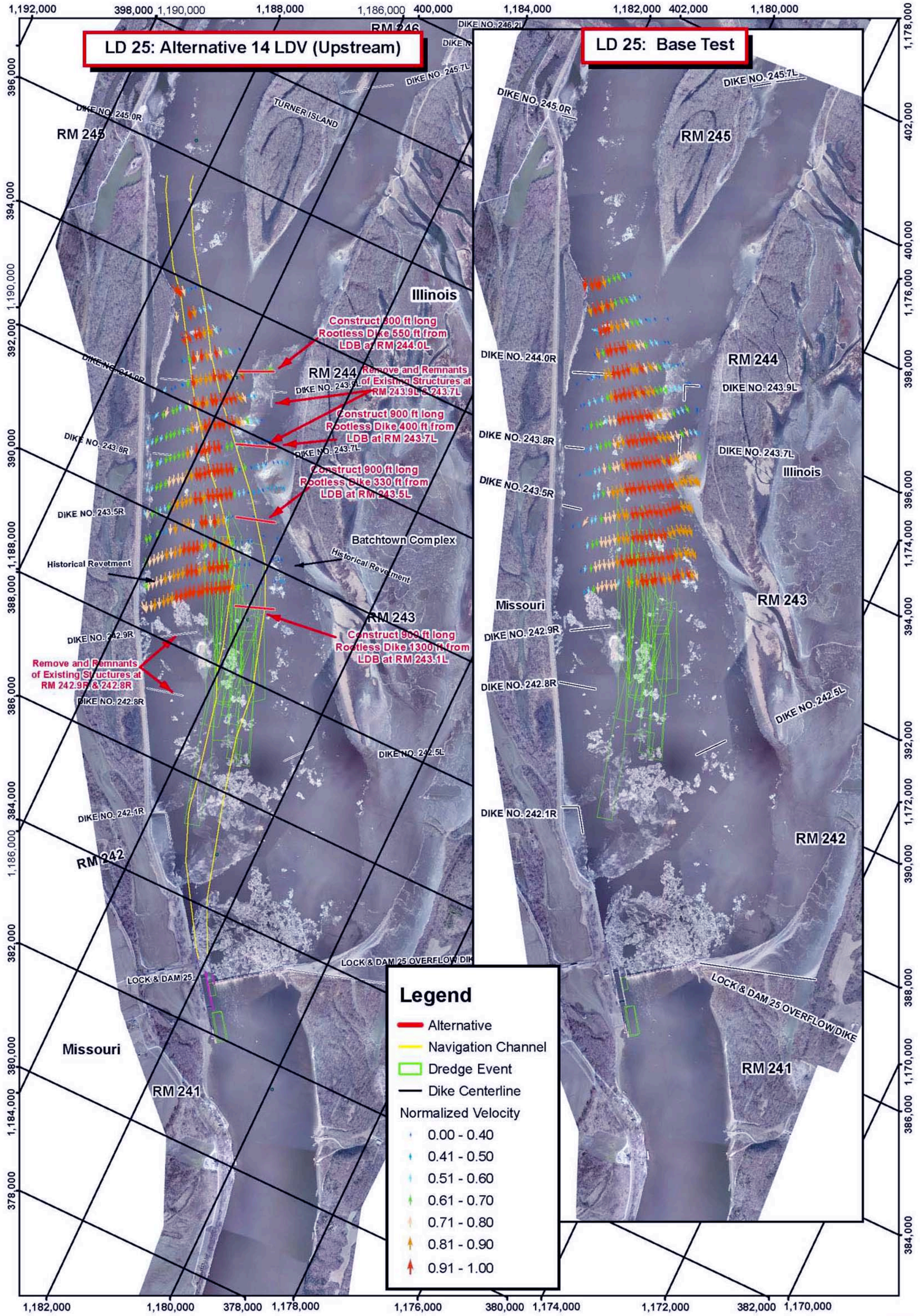

PLATE NUMBER 42

Alternative 14 LDV (Upstream)

2005 AERIAL PHOTOGRAPH

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

Upper Mississippi River Basin
St. Louis District
Lock and Dam 25
HSR Model

DESIGNED BY: A COX	SURVEY DATE: 05/20/2010	
DRAWN BY: A COX	REVIEWED BY: J BROWN, P.E.	CHECKED BY: E BRAUER, P.E.
SUBMITTED: A COX	APPROVED: R DAVINROY, P.E.	
FILE NAME: . . . LD25/Plates	PLOT DATE: 05/20/2010	

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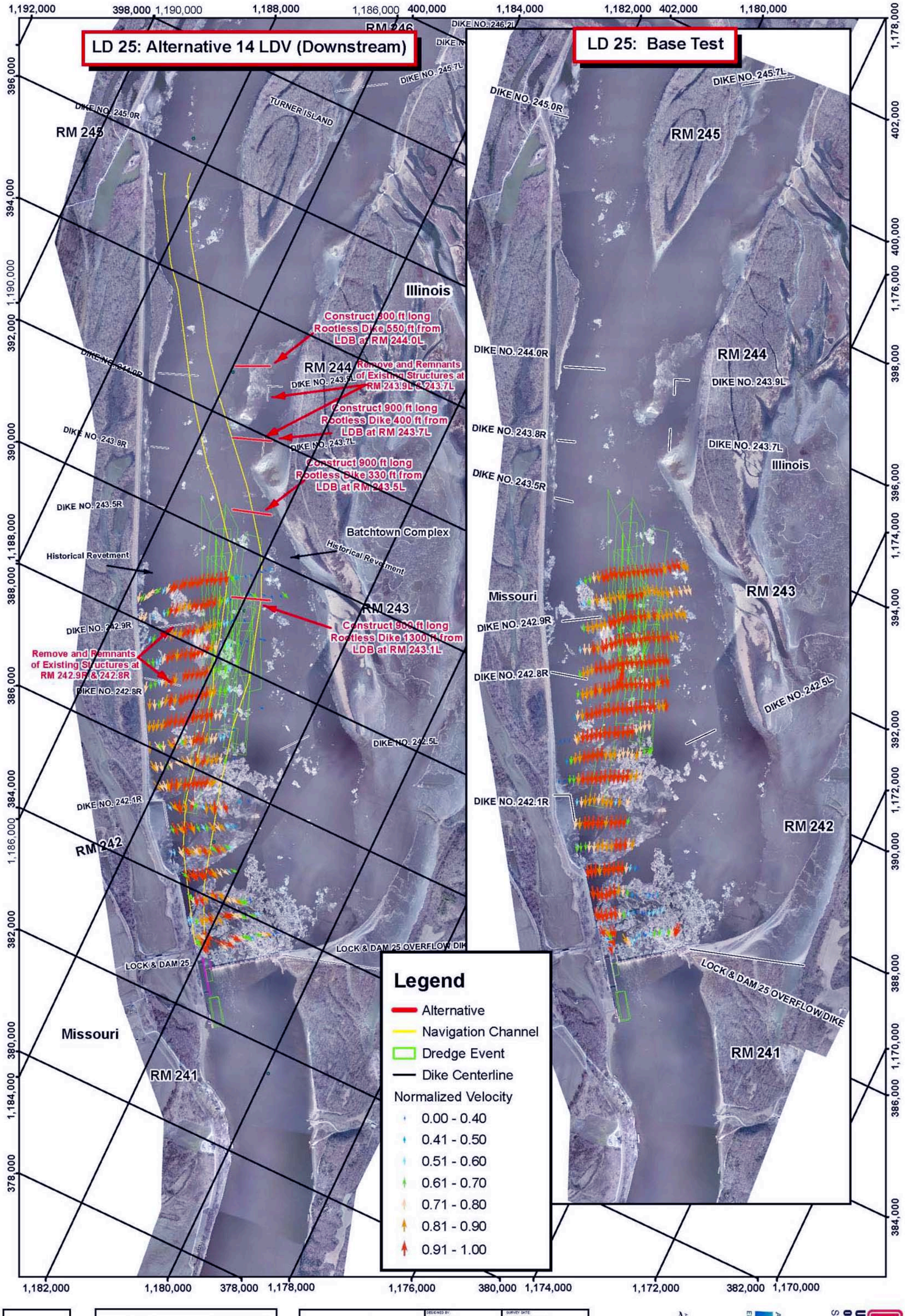

PLATE NUMBER 43

0 1,000 2,000 4,000 6,000
Feet

Alternative 14 LDV (Downstream)

2005 AERIAL PHOTOGRAPH

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

Upper Mississippi River Basin
St. Louis District
Lock and Dam 25
HSR Model

DESIGNED BY: A COX	SURVEY DATE: 05/19/2010	
DRAWN BY: A COX	REVIEWED BY: J BROWN, P.E.	CHECKED BY: E BRAUER, P.E.
SUBMITTED: A COX	APPROVED: R DAVINROY, P.E.	
FILE NAME: . . . LD25/Plates	PLOT DATE: 05/20/2010	

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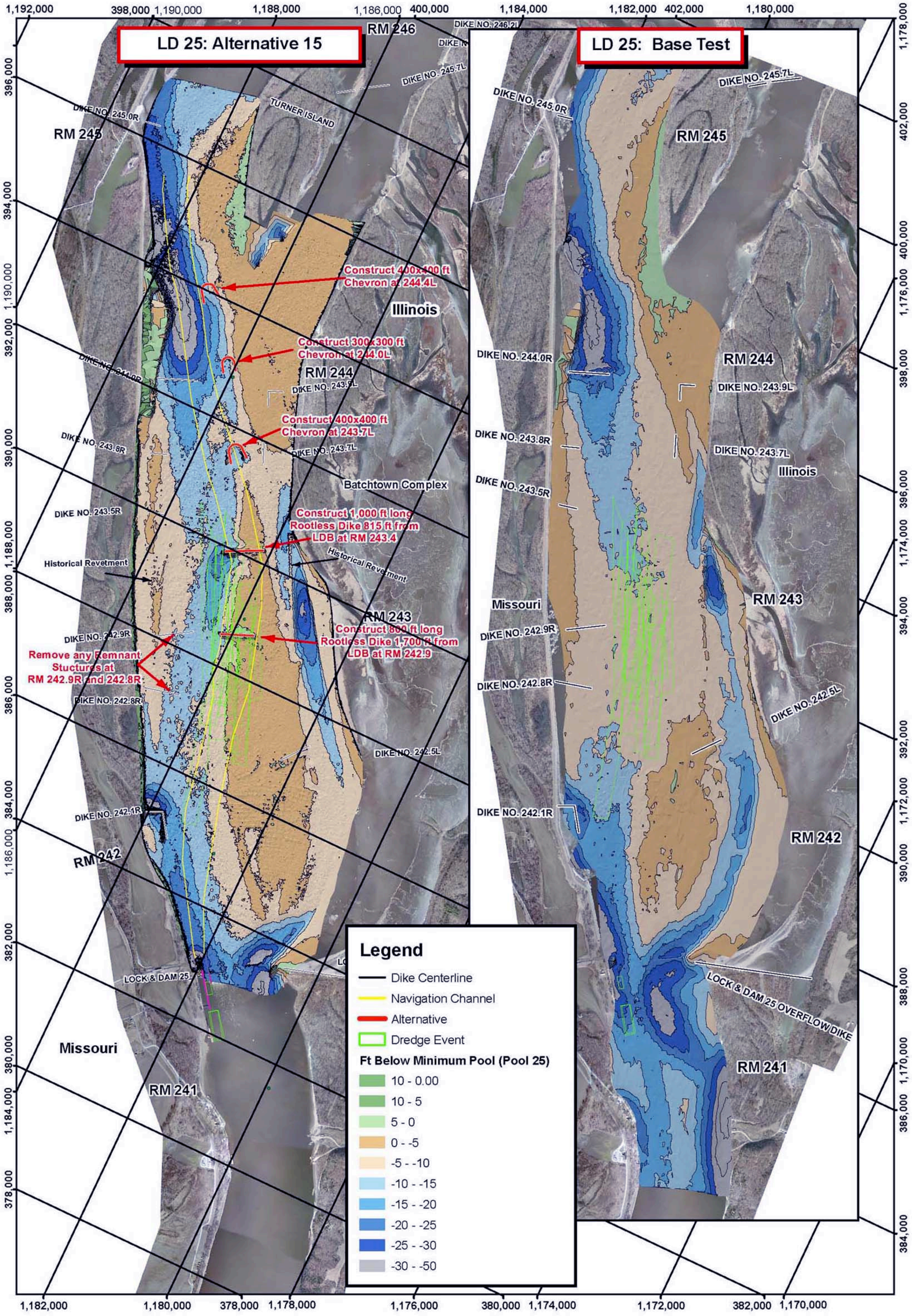

PLATE NUMBER 44

0 1,000 2,000 4,000 6,000
Feet

Alternative 15

2005 AERIAL PHOTOGRAPH

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

Upper Mississippi River Basin
St. Louis District
Lock and Dam 25
HSR Model

DESIGNED BY: A COX		SURVEY DATE: 06/02/2010
DRAWN BY: A COX	REVIEWED BY: J BROWN, P.E.	CHECKED BY: E BRAUER, P.E.
SUBMITTED: A COX		APPROVED: R DAVINROY, P.E.
FILE NAME: . . . LD25 /Plates		PLOT DATE: 06/02/2010

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St. Louis District

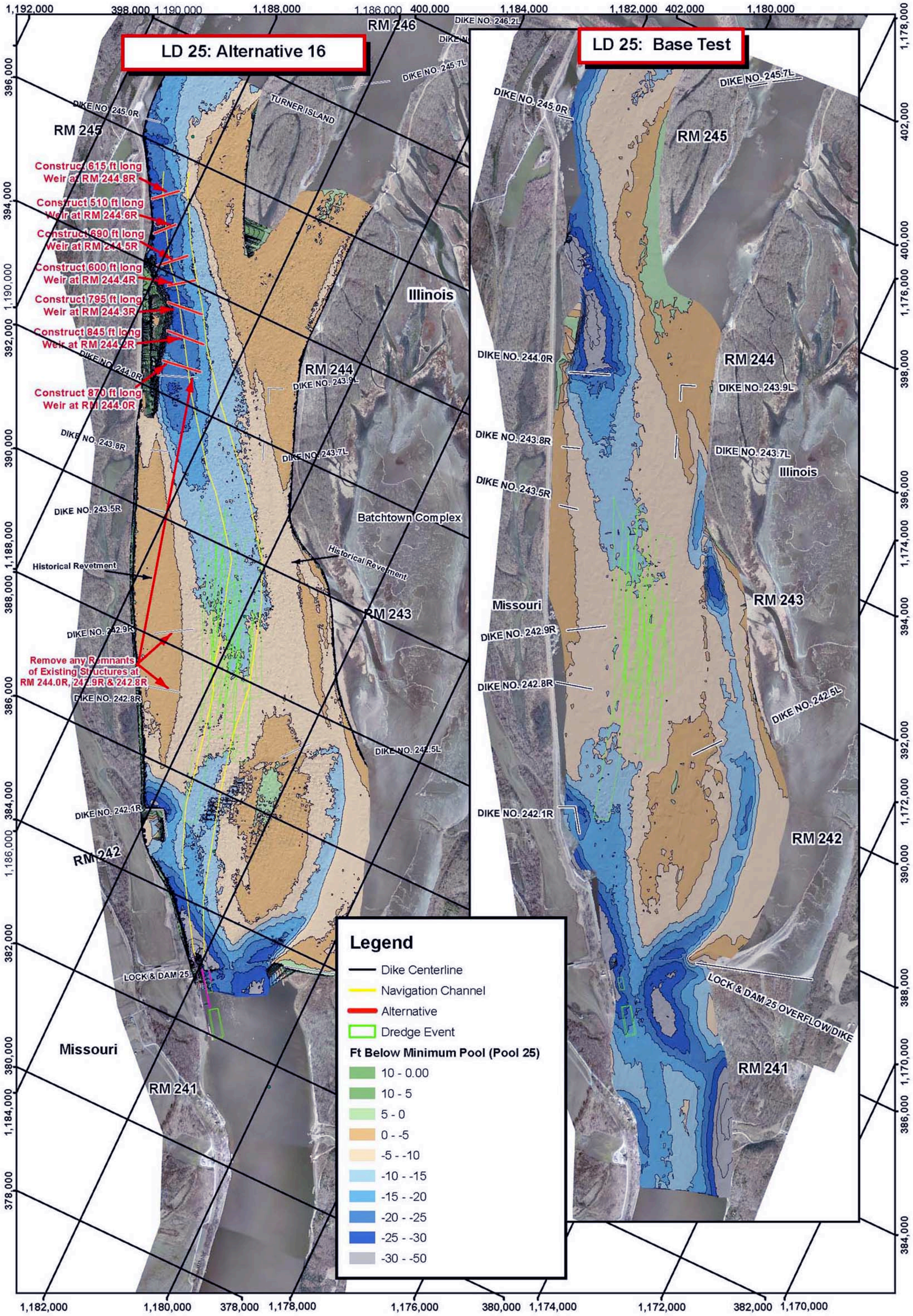

PLATE NUMBER 45

0 1,000 2,000 4,000 6,000
Feet

Alternative 16
2005 AERIAL PHOTOGRAPH

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Upper Mississippi River Basin
St. Louis District
Lock and Dam 25
HSR Model

DESIGNED BY: A COX		SURVEY DATE: 06/29/2010
DRAWN BY: A COX	REVIEWED BY: J BROWN, P.E.	CHECKED BY: E BRAUER, P.E.
SUBMITTED: A COX		APPROVED: R DAVINROY, P.E.
FILE NAME: . . . LD25/Plates		PLOT DATE: 07/06/2010

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St. Louis District

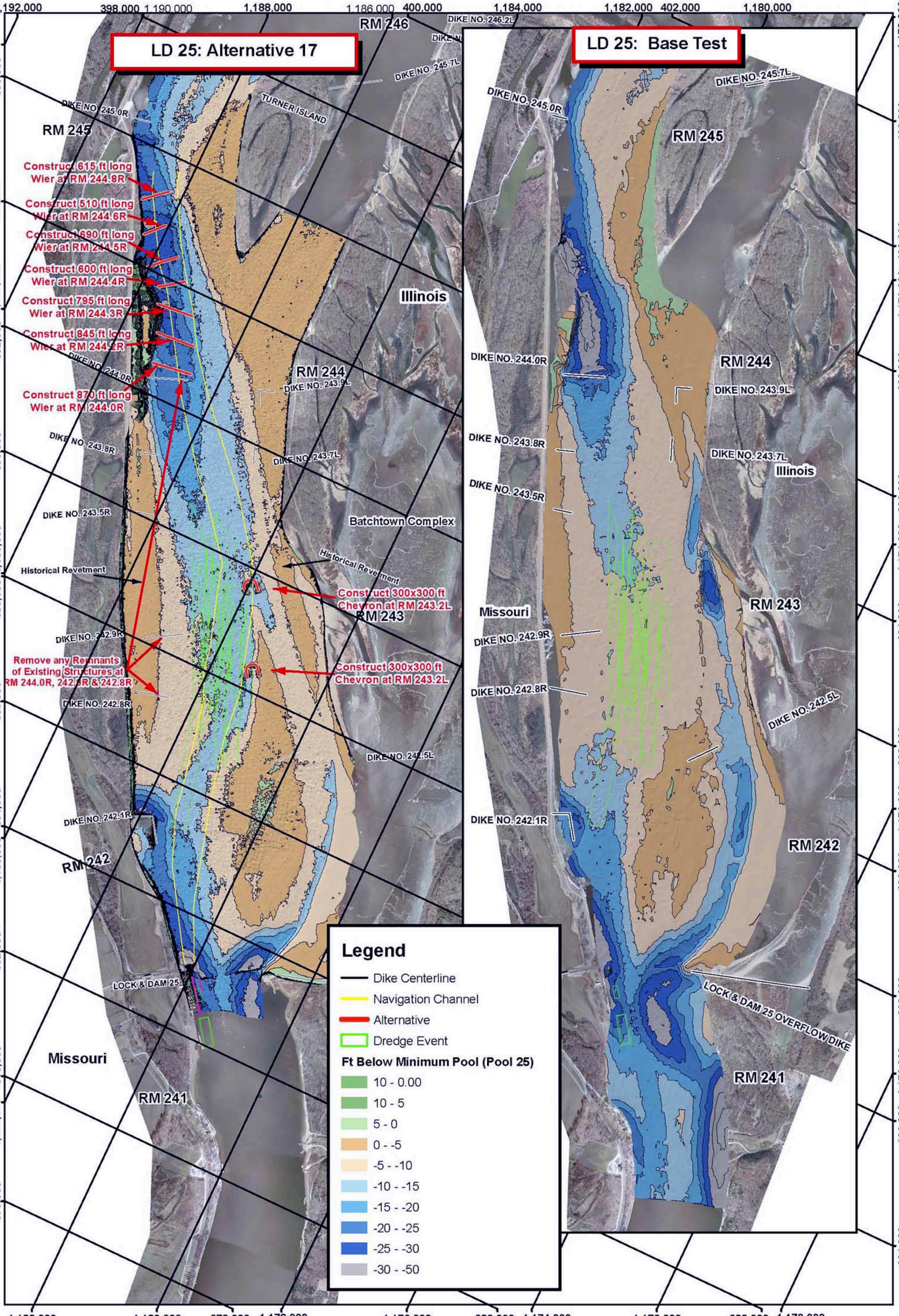

PLATE NUMBER 46

Alternative 17
2005 AERIAL PHOTOGRAPH

US. ARMY ENGINEER DIVISION
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Upper Mississippi River Basin
St. Louis District
Lock and Dam 25
HSR Model

DESIGNED BY: A COX		SURVEY DATE: 07/06/2010
DRAWN BY: A COX	REVIEWED BY: J BROWN, P.E.	CHECKED BY: E BRAUER, P.E.
SUBMITTED: A COX		APPROVED: R DAVINROY, P.E.
FILE NAME: ...LD25/Plates		PLOT DATE: 07/06/2010

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St. Louis District

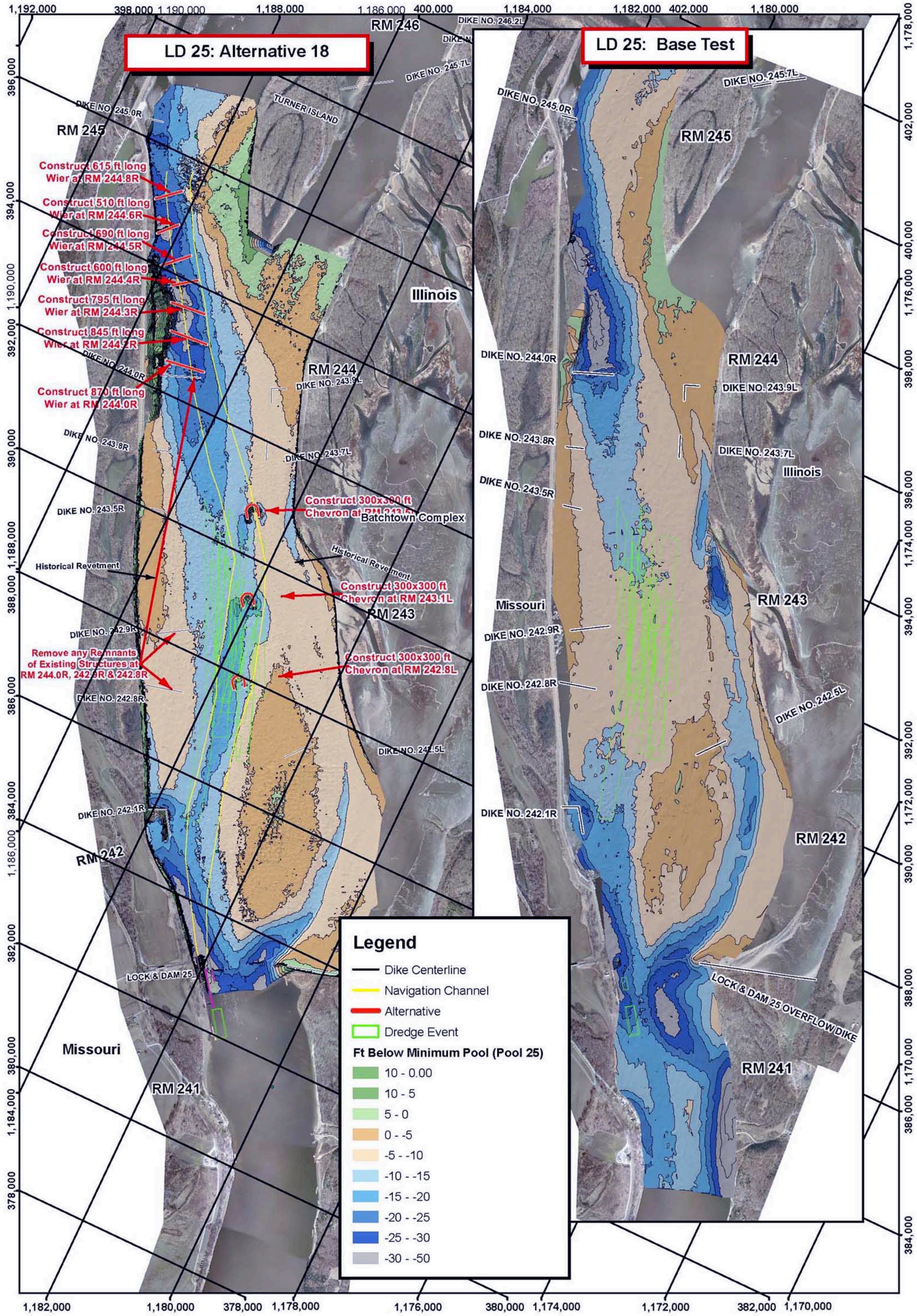

PLATE NUMBER 47

0 1,000 2,000 4,000 6,000
Feet

Alternative 18

2005 AERIAL PHOTOGRAPH

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

Upper Mississippi River Basin
St. Louis District
Lock and Dam 25
HSR Model

DESIGNED BY: A COX		SURVEY DATE: 07/09/2010
DRAWN BY: A COX	REVIEWED BY: J BROWN, P.E.	CHECKED BY: E BRAUER, P.E.
SUBMITTED: A COX		APPROVED: R DAVINROY, P.E.
FILE NAME: . . . LD25/Plates		PLOT DATE: 07/12/2010

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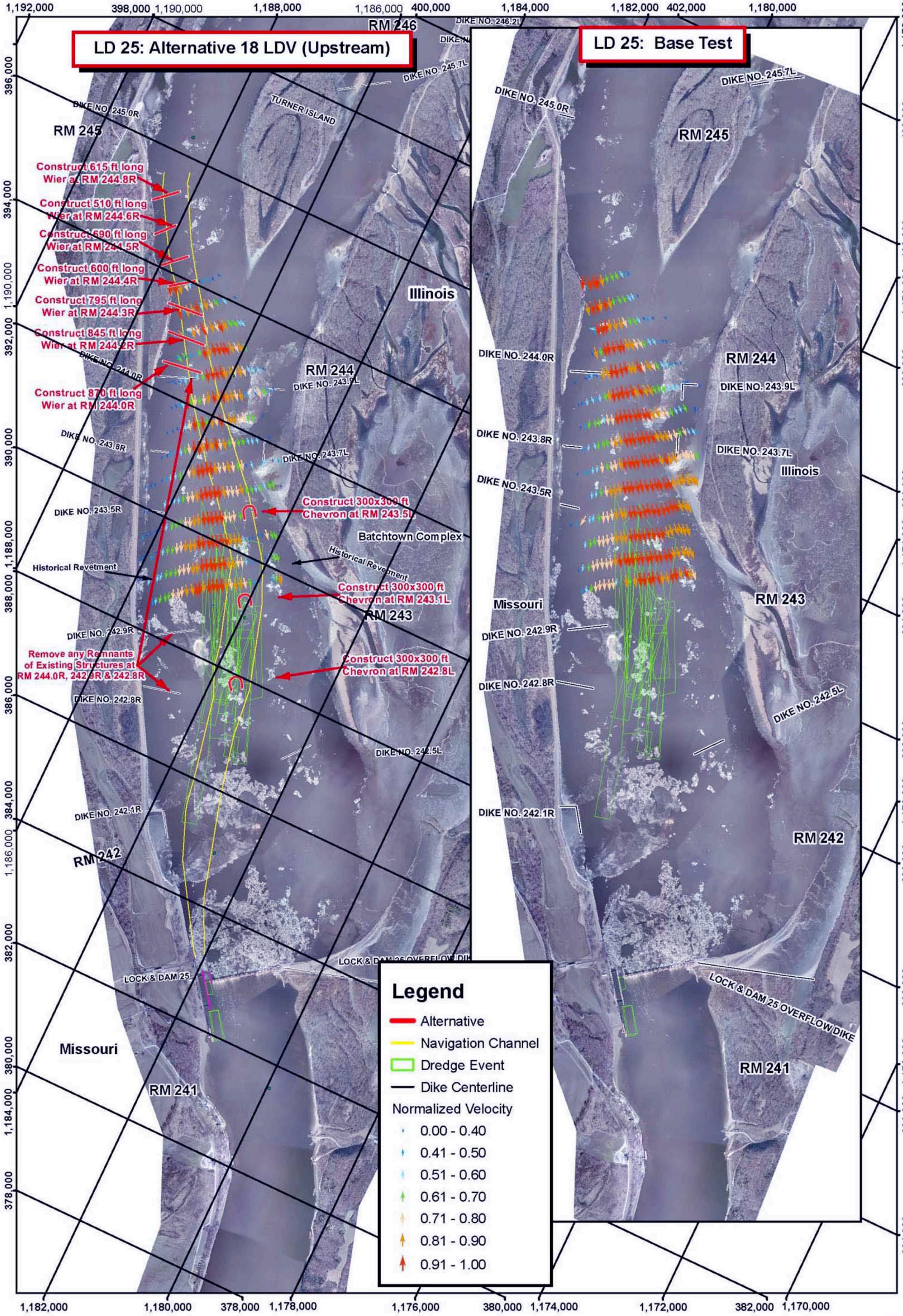

PLATE NUMBER 48

0 1,000 2,000 4,000 6,000 Feet

Alternative 18 LDV (Upstream)

2005 AERIAL PHOTOGRAPH

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

Upper Mississippi River Basin
St. Louis District
Lock and Dam 25
HSR Model

DESIGNED BY: A COX	SURVEY DATE: 07/12/2010	
DRAWN BY: A COX	REVIEWED BY: J BROWN, P.E.	CHECKED BY: E BRAUER, P.E.
SUBMITTED: A COX	APPROVED: R DAVINROY, P.E.	
FILE NAME: . . . LD25/Plates	PLOT DATE: 07/13/2010	

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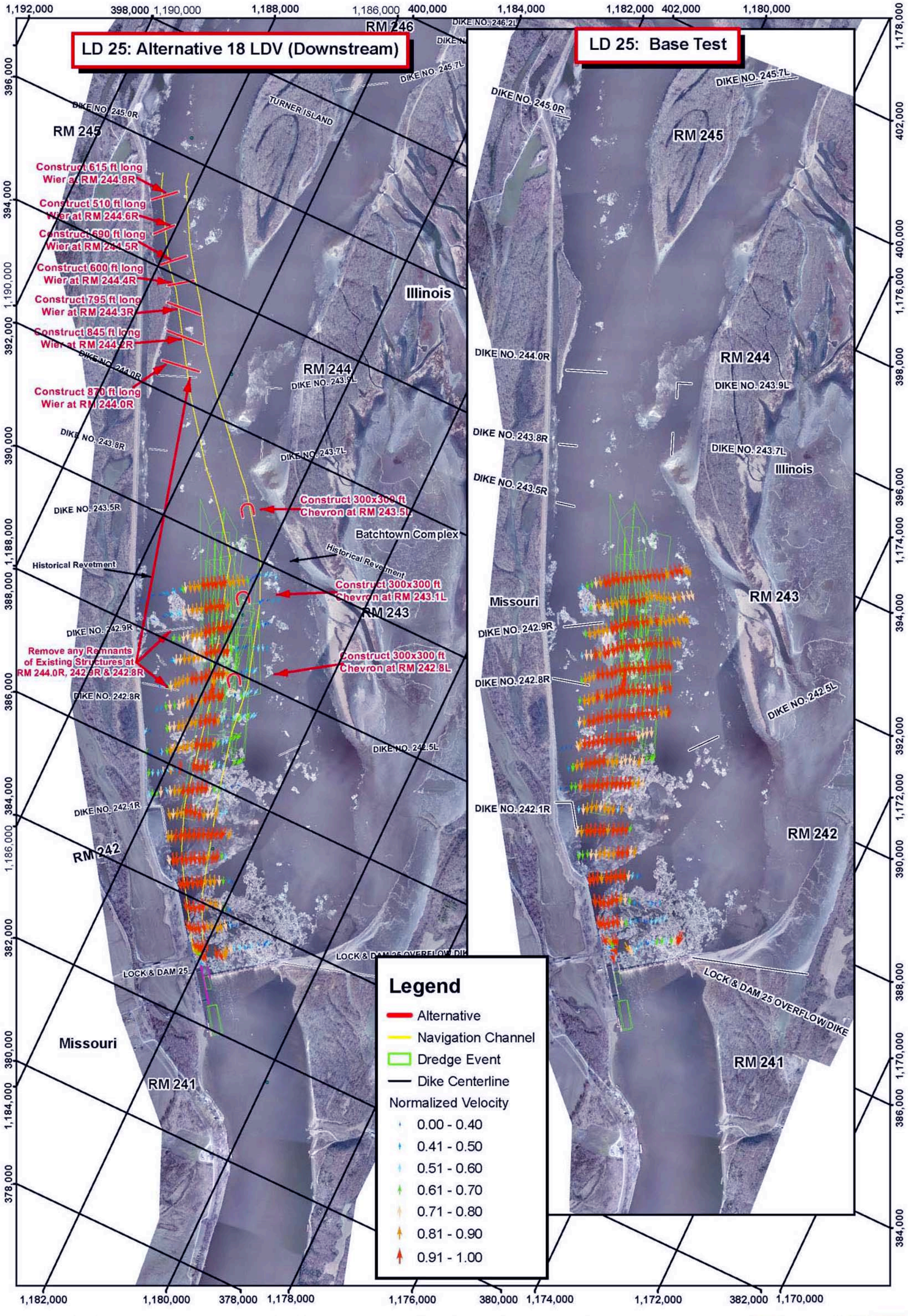

PLATE NUMBER 49

0 1,000 2,000 4,000 6,000 Feet

Alternative 18 LDV (Downstream)

2005 AERIAL PHOTOGRAPH

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

Upper Mississippi River Basin
St. Louis District
Lock and Dam 25
HSR Model

DESIGNED BY: A COX	SURVEY DATE: 07/09/2010
DRAWN BY: A COX	REVIEWED BY: J BROWN, P.E. / CHECKED BY: E BRAUER, P.E.
SUBMITTED: A COX	APPROVED: R DAVINROY, P.E.
FILE NAME: ...LD25/Plates	PLOT DATE: 07/13/2010

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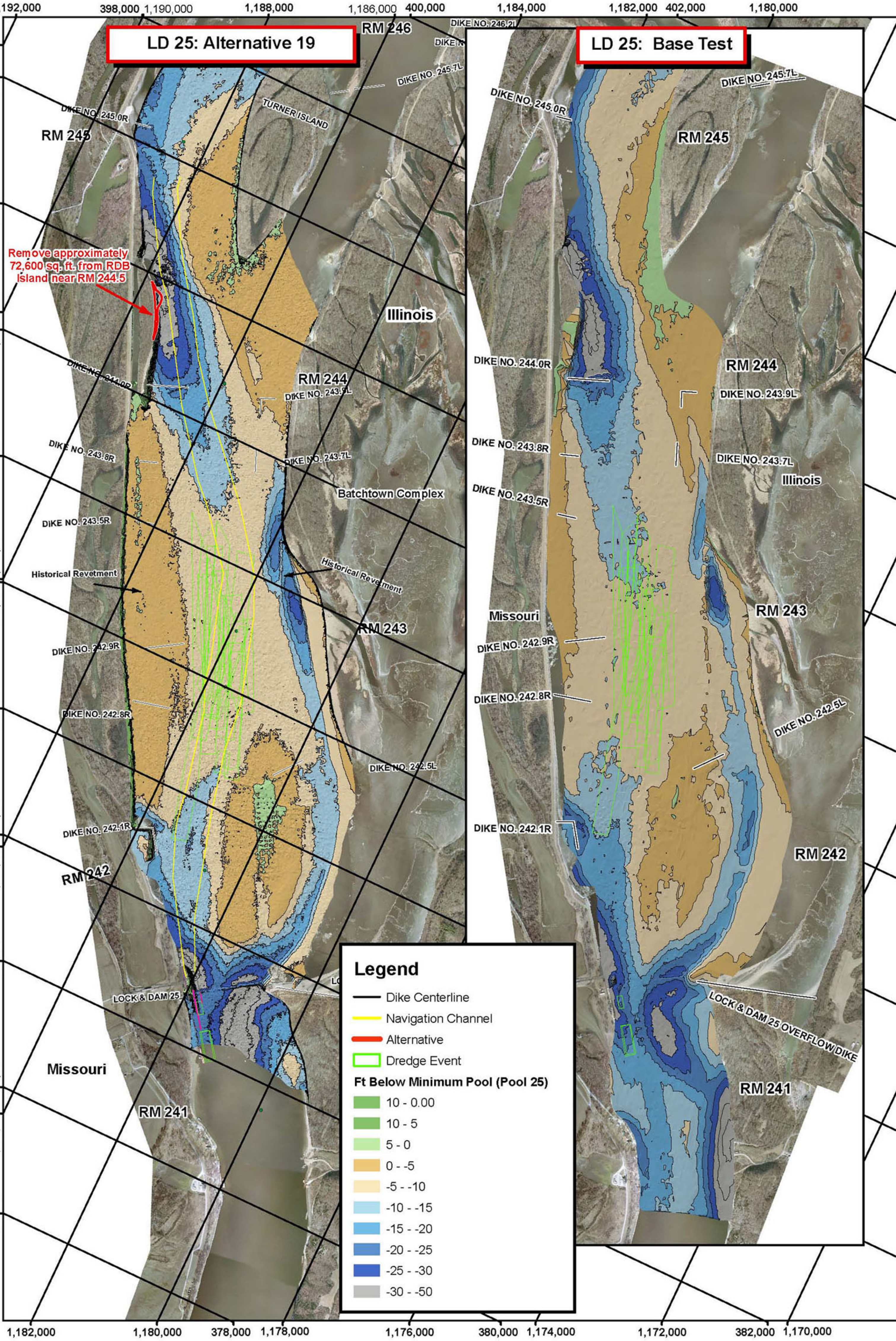

PLATE NUMBER 50

0 1,000 2,000 4,000 6,000
Feet

Alternative 19

2005 AERIAL PHOTOGRAPH

U.S. ARMY ENGINEER DIVISION CORPS OF ENGINEERS ST. LOUIS, MISSOURI	DESIGNED BY: A COX	SURVEY DATE: 08/30/2010
	DRAWN BY: A COX	REVIEWED BY: J BROWN, P.E. / CHECKED BY: E BRAUER, P.E.
Upper Mississippi River Basin St. Louis District Lock and Dam 25 HSR Model	SUBMITTED: A COX	APPROVED: R DAVINROY, P.E.
	FILE NAME: . . . LD25/Plates	PLOT DATE: 08/30/2010

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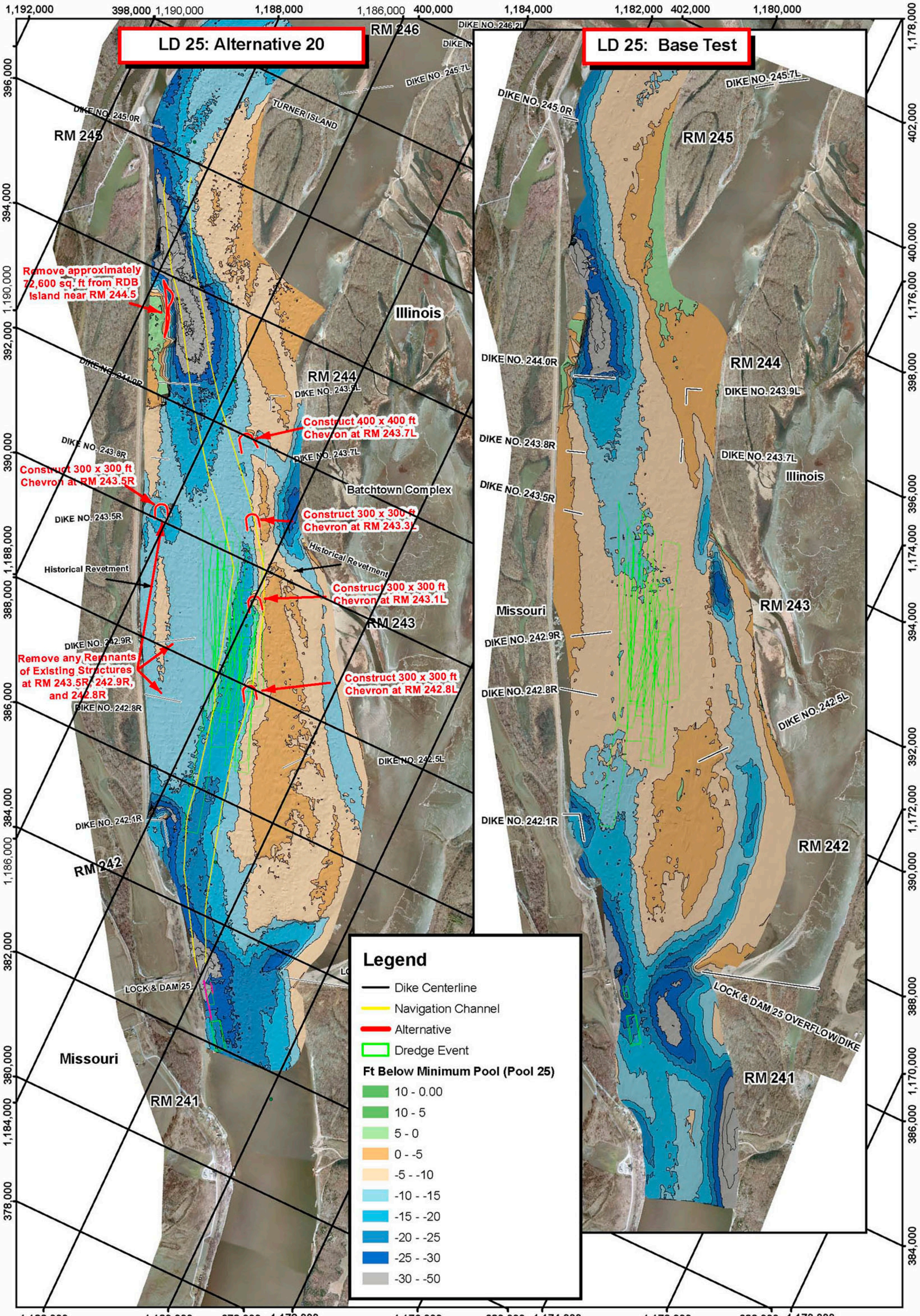

PLATE NUMBER 51

0 1,000 2,000 4,000 6,000
Feet

Alternative 20
2005 AERIAL PHOTOGRAPH

US. ARMY ENGINEER DIVISION
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

Upper Mississippi River Basin
St. Louis District
Lock and Dam 25
HSR Model

DESIGNED BY: A COX	SURVEY DATE: 09/09/2010	
DRAWN BY: A COX	REVIEWED BY: J BROWN, P.E.	CHECKED BY: E BRAUER, P.E.
SUBMITTED: A COX	APPROVED: R DAVINROY, P.E.	
FILE NAME: . . . LD25/Plates	PLOT DATE: 09/09/2010	

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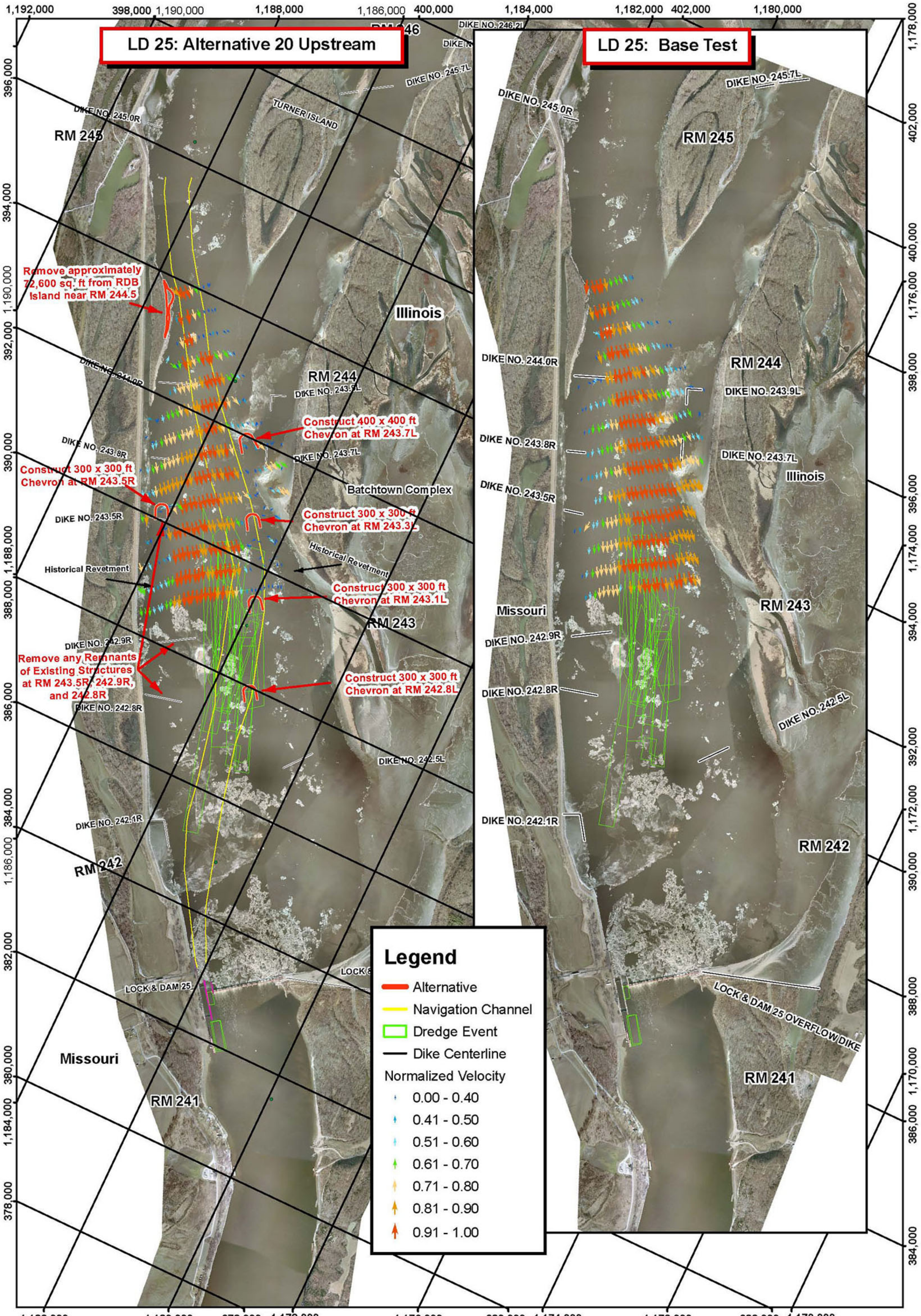

PLATE NUMBER 52

0 1,000 2,000 4,000 6,000
Feet

Alternative 20 LDV (Upstream)

2005 AERIAL PHOTOGRAPH

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ST. LOUIS, MISSOURI

DESIGNED BY: A COX		SURVEY DATE: 09/13/2010
DRAWN BY: A COX	REVIEWED BY: J BROWN, P.E.	CHECKED BY: E BRAUER, P.E.
SUBMITTED: A COX		APPROVED: R DAVINROY, P.E.
FILE NAME: ...LD25/Plates		PLOT DATE: 09/13/2010

Upper Mississippi River Basin
St. Louis District
Lock and Dam 25
HSR Model

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St. Louis District

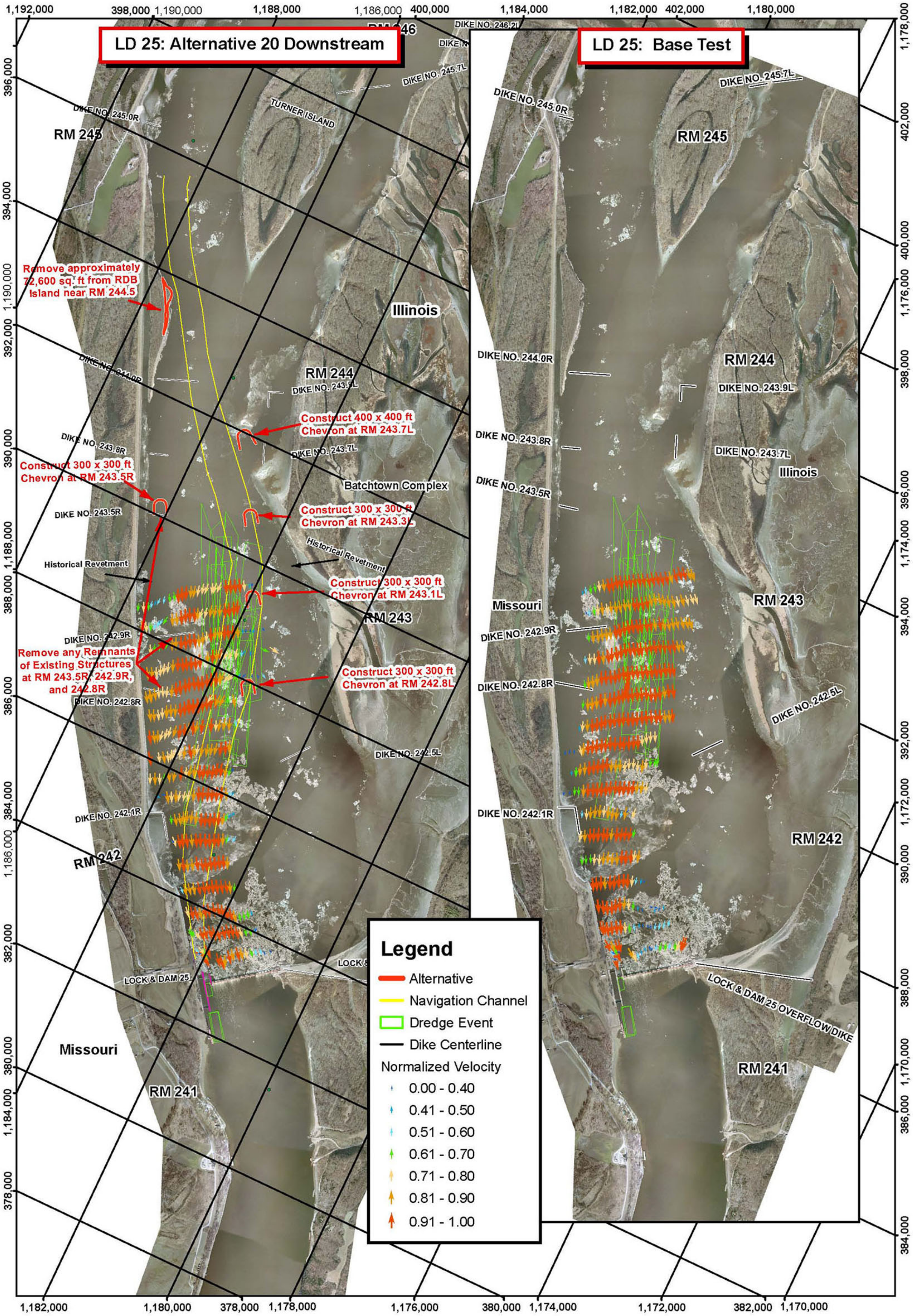

PLATE NUMBER 53

0 1,000 2,000 4,000 6,000
Feet

Alternative 20 LDV (Downstream)

2005 AERIAL PHOTOGRAPH

U.S. ARMY ENGINEER DIVISION CORPS OF ENGINEERS ST. LOUIS, MISSOURI	DESIGNED BY: A COX	SURVEY DATE: 09/13/2010
	DRAWN BY: A COX	REVIEWED BY: J BROWN, P.E. / CHECKED BY: E BRAUER, P.E.
Upper Mississippi River Basin St. Louis District Lock and Dam 25 HSR Model	SUBMITTED: A COX	APPROVED: R DAVINROY, P.E.
	FILE NAME: . . . LD25/Plates	PLOT DATE: 09/13/2010

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St. Louis District

August 26, 2010 LD 25 HSR Model Meeting Minutes

Ashley provided background information and a brief discussion of the features in the study reach.

Ashley then provided a thorough explanation of 3 alternatives that had the best results. She explained the criteria she used to evaluate the alternatives and why she recommended Alternative 12.

After Ashley asked for other alternative ideas, it was suggested to adjust the Left Descending Bank (LDB) of the island at RM 244.5-243.8. There is a point that juts out into the navigation channel possibly influencing the flow to cross over to the LDB further upstream than it might if the bank line was smooth. So Ashley said she would test the alternative and let the group know the results.

Following, the group gathered around the model and observed Alternative 12 in the model. Some questions were raised about the bank line near the Batchtown Complex. Ashley told them she had recommended revetting some of the bank line near scour at RM 243.6 LDB. Brian Markert and Ron Dieckmann also noted the recent water control structure, low berm, and revetment constructed on Batchtown's LDB.

The project manager, June Jeffries, mentioned that the earliest the model study results could be built would be FY 12 or 13.

After the open discussion, Ashley confirmed with the group, which consisted of both industry, corps members, and environmental partners, that Alternative 12 was agreed upon and their alternative of choice as well. She then told the group that she would run Alternative 19 (adjust the bank of island at RM 244.5-243.8L) and inform the group of the results. Everybody thought that was a good plan of action.

Attendees:

Jasen Brown	Lance Engle	Shannon Hughes	Brian Markert
Jason Crites	David Goin	June Jeffries	Ivan Nguyen
Rob Davinroy	David Gordon	Brian Johnson	David Ostendorf
Ron Dieckmann	Donovan Henry	Brad Krischel	Jeff Stamper
Charlie Deutsch	Bernard Heroff	Matthew Mangan	Amanda Sutter
Alan Edmondson	Leonard Hopkins	Jason Mewes	Bob Vaughn

APPENDIX B. August 26, 2010 LD 25 HSR Model Meeting Minutes

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Ashley then provided a thorough explanation of 3 alternatives that had the best results. She explained the criteria she used to evaluate the alternatives and why she recommended Alternative 12.

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Jasen Brown	Lance Engle	Shannon Hughes	Brian Markert
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Ron Dieckmann	Donovan Henry	Brad Krischel	Jeff Stamper
Charlie Deutsch	Bernard Heroff	Matthew Mangan	Amanda Sutter
Alan Edmondson	Leonard Hopkins	Jason Mewes	Bob Vaughn

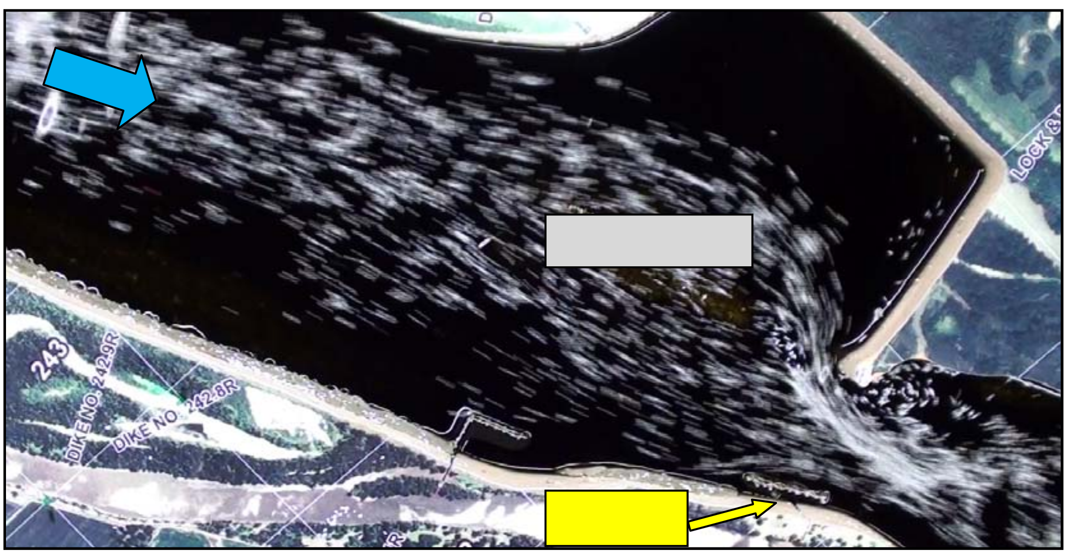
APPENDIX C. OUTDRAFT ANALYSIS

C.1 Flow Visualization

Because of the navigational importance of the study area, it was determined that the Lock and Dam 25 Hydraulic Sediment Response (HSR) model study needed additional review regarding velocity and outdraft conditions. Flow visualization was conducted on the HSR model.

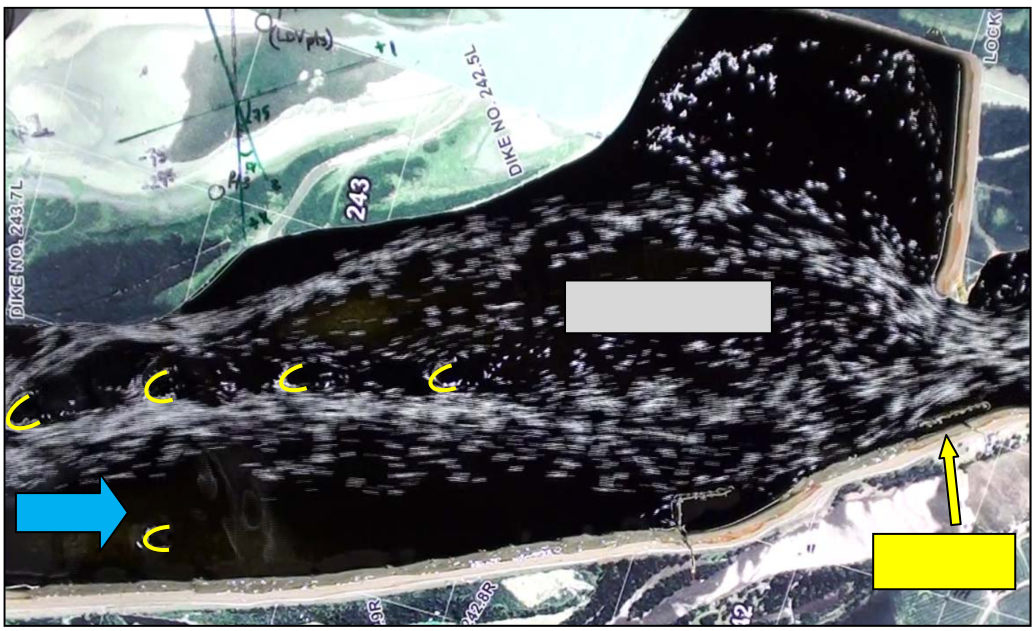
Flow visualization is a tool used to monitor the flow patterns in an HSR model. The preferred method at the Applied River Engineering Center is to dye the water black and seed the water surface with dry white sediment (Poly-Urea grit) at the model entrance. The dry sediment floats on the top of the water surface and provides a visual representation of surface flow patterns in the model. A high definition video camera is used to record approximately 60 seconds of the sediment floating through the study area. The recording is processed with software that reduces the original recording to approximately 20% of the original speed. The video speed reduction allows viewers to more easily track the flow patterns.

The first condition recorded was the base test, or existing conditions as seen in Figure 1 below. (Please note that there is a DVD available with this report to view the videos.)



The flow exited the sharp bend at RM 245.0 just upstream of Figure 1's extents. As seen in the snapshot of the existing conditions, the resultant flow was concentrated near the LDB at the upper left corner of Figure 1. Immediately downstream, the flow was dispersed across the channel. The stump field (degraded island) acted as a grade control and caused the flow to split. There was minimal flow near the L dike on the RDB. Significant outdraft patterns were evident near the upstream lock guidewall.

The next condition recorded was post construction with the recommended alternative of four chevrons on the Left Descending Bank (LDB) side of the navigation channel and one chevron on the Right Descending Bank (RDB) side in place as seen in Figure 2 below. The chevrons are highlighted in yellow for increased visibility.



Again, the flow exited the sharp bend at RM 245.0 just upstream of Figure 2's extents. As seen in the snapshot of the post construction conditions, the resultant flow was concentrated near the LDB at the left corner of Figure 2. The lead chevron split the concentrated flow, sending a majority of the flow towards the navigation channel and a small amount towards the LDB. The rest of the chevrons maintained the flow split and constricted the flow which created a more straight alignment and approach for the navigation channel. Again, the stump field acted as a grade control and maintained the flow split behind the chevrons. When compared to the existing conditions, there was increased flow near the L dike on the RDB. Outdraft was still evident near the upstream lock guidewall, but it did not worsen.

The flow visualization results were in agreement with the Laser Doppler Velocimeter (LDV) readings collected from the LD 25 HSR model study. According to those studies, after construction of the five chevrons, the alignment of the navigation channel should be significantly improved and outdraft should not worsen.

C.2 Dimensional Model Adaptive Hydraulics (ADH) Evaluation

C.2.1 Procedure

In October of 2010, June Jeffries (PM) called a meeting to discuss the results of the HSR model run by Ashley Cox (EC-HR) to analyze and solve the dredging problem upstream of Lock and Dam 25. Figure 3 shows the configuration of the recommended plan which included 5 chevrons between RM 242.0 and 244.0. The main concern is the possibility of stronger outdraft conditions in the approach to the lock chambers.

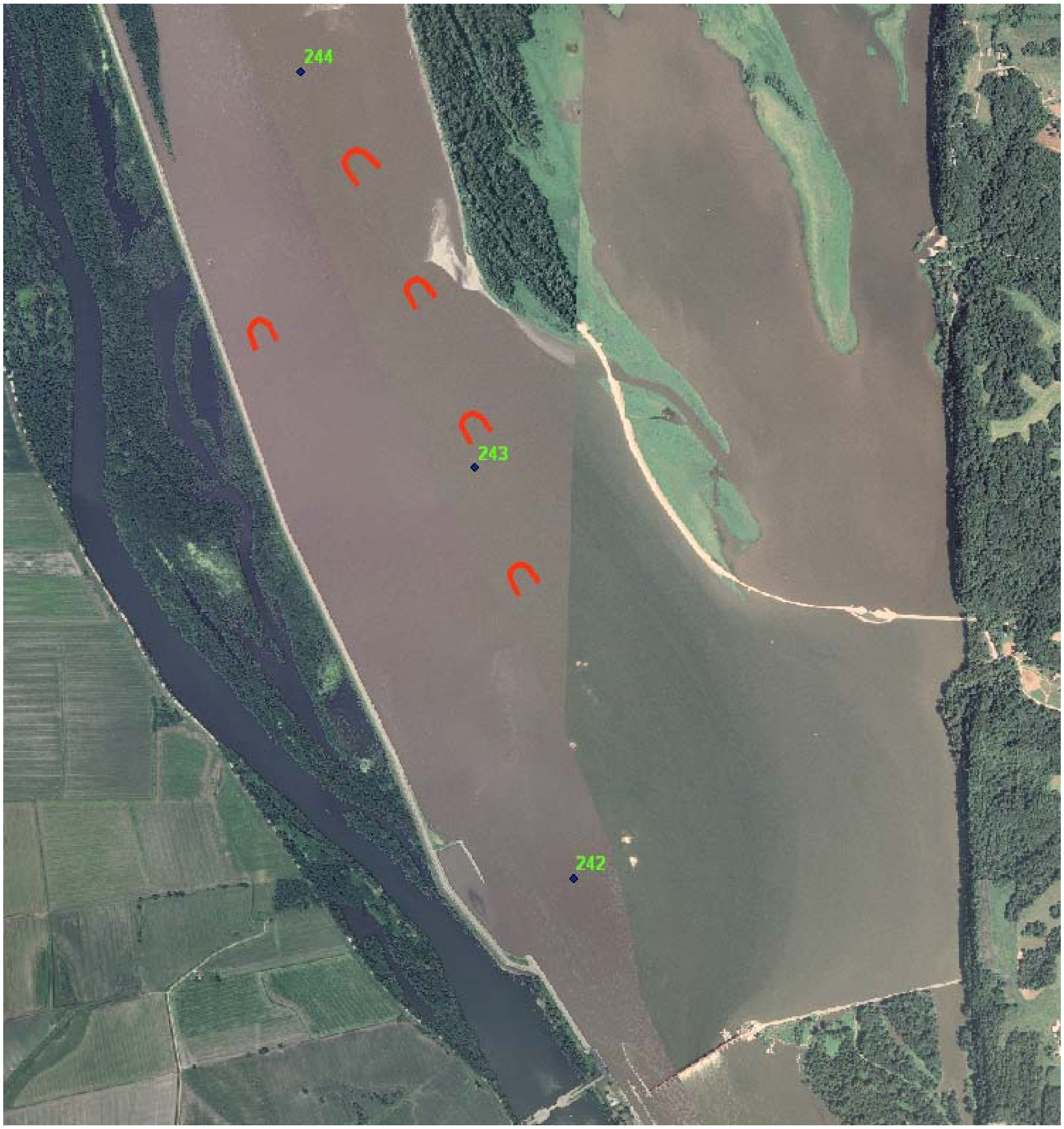


Figure 3: Recommended Layout of Chevrons

The LD25 2-D model that was developed for the design of a new 1200' lock for the Navigation and Ecosystem Sustainability Program (NESP) was used as a base model for this work. Model bathymetry data was provided by Ashley Cox for the baseline testing (base test of the HSR model) and for the post-chevron testing (recommended plan model bathymetry). Her model data was used since this is a proposed project and the chevrons have not yet been constructed in the prototype. The XYZ data from the HSR model was incorporated into the 2-Dimensional Mesh. Four scenarios were run for pre-construction and post-construction: 100,000 cfs (pool), 165,000 cfs (open river), 250,000 cfs (flood), and 340,000 cfs (max navigation). The 2-Dimensional model Adaptive Hydraulics (ADH) was used. Results of the model runs are shown in this report.

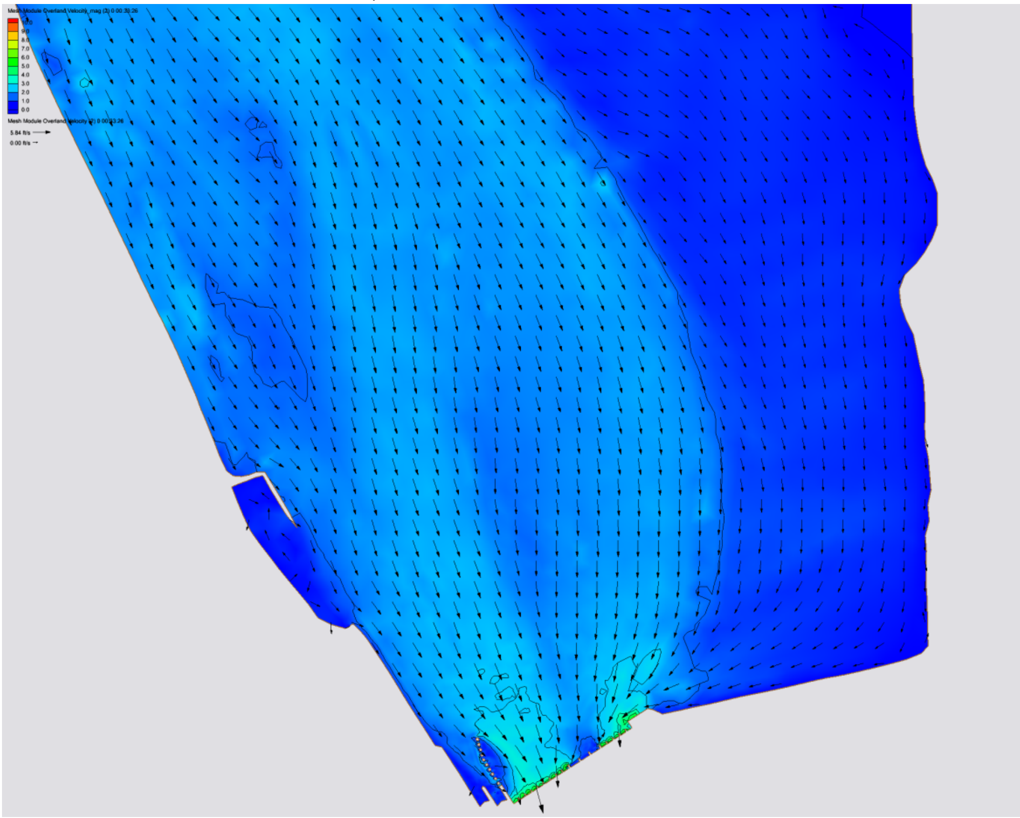
There were many challenges faced during this work. The main issue was the compatibility between the HSR model surveys and the channel bathymetry surveys. The modeler had to blend the data as best as possible to achieve the required mesh elevations for both the pre- and post-construction runs.

Due to the problems with the HSR model baseline XYZ data, another set of runs were made with the original model bathymetry. The baseline data elevations did not define the main channel very well, through the study reach. The modeler believes this is causing issues with the velocities through the main channel, skewing the comparison of velocity results. The results shown are with the old bathymetry (actual river surveys).

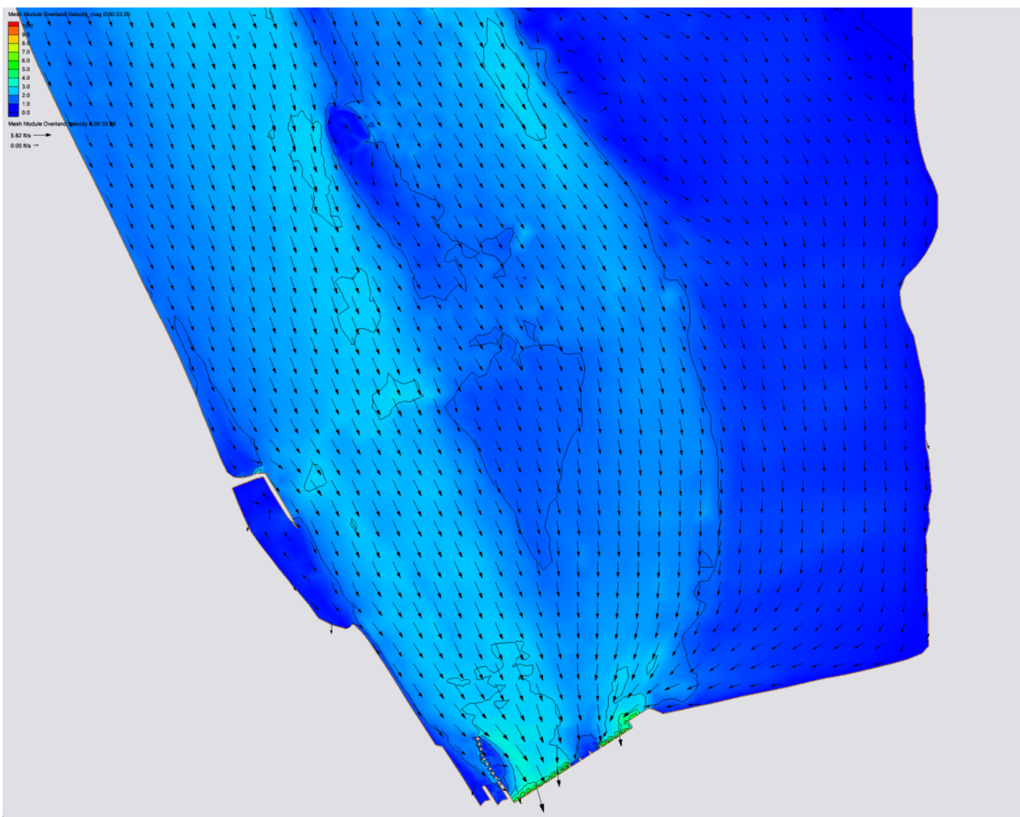
C.2.2 Results Analysis

For all of the flow rates, the model is showing a reduction in velocity immediately downstream of the chevrons (expected) along with an increase in velocity in the main channel (expected). The biggest concern is near the approach to the lock. There appears to be an increase in velocity along the L-Dike upstream of the lock. However, the increase appears to dissipate as you move downstream towards the lock. After discussion with other hydraulic engineers, it does not appear to be enough of a change to warrant any further investigation.

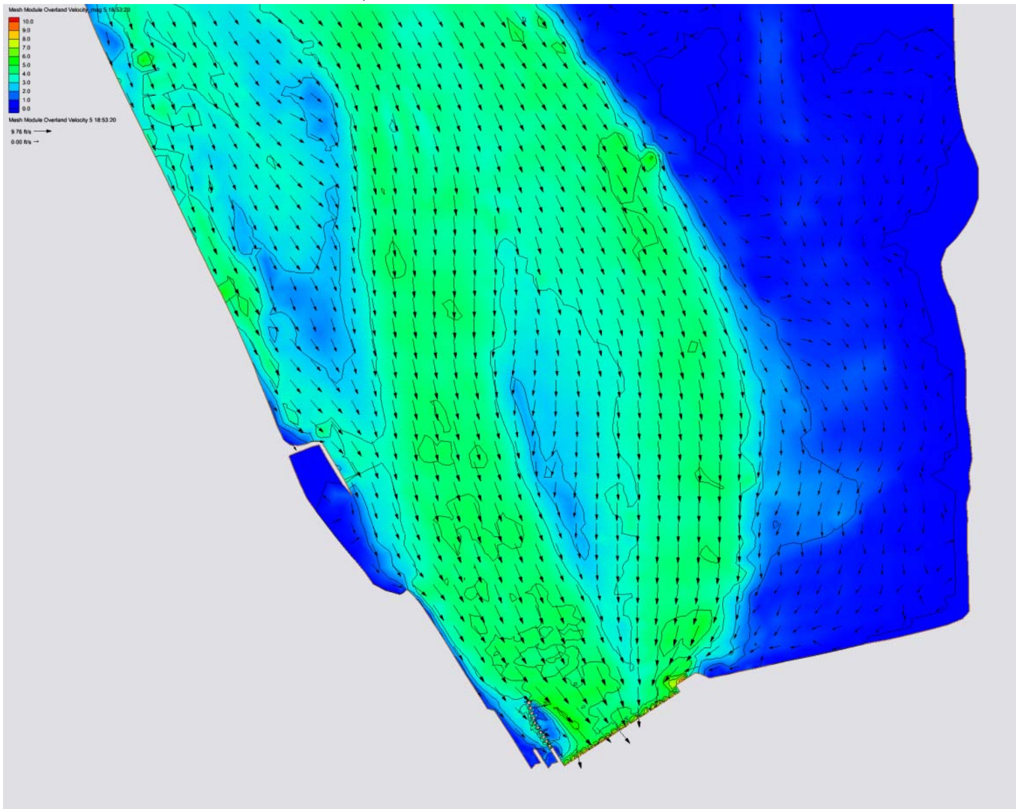
100,000 CFS Without Chevrons



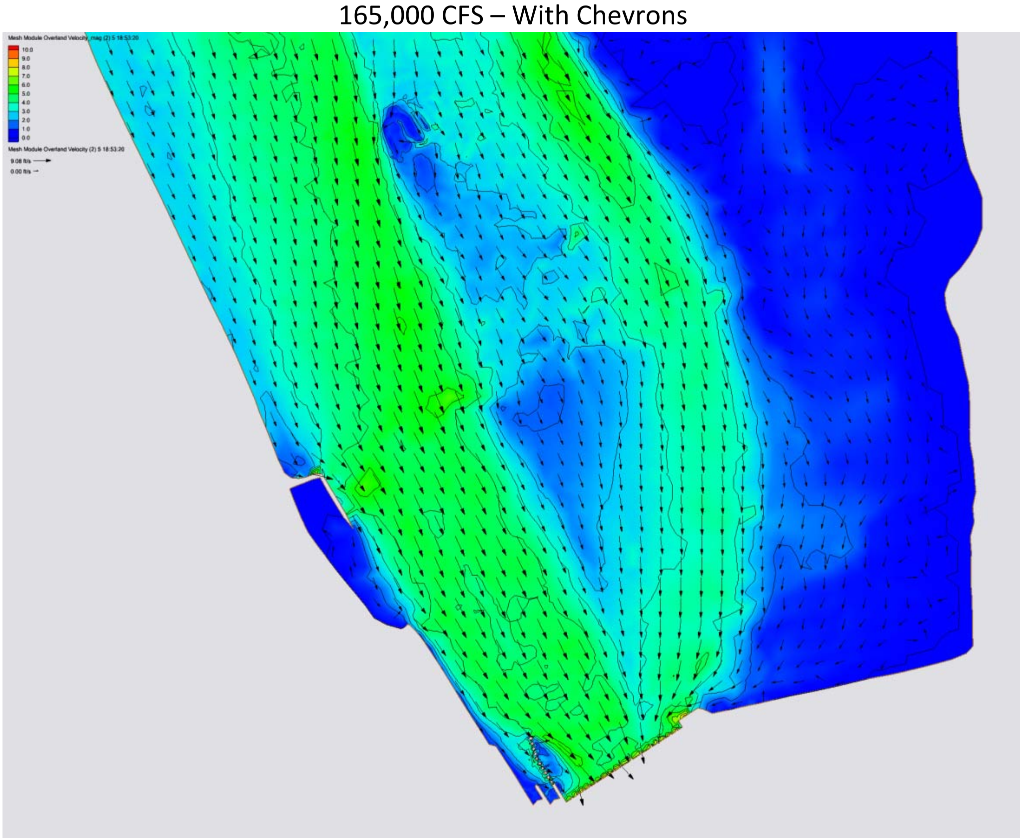
100,000 CFS with Chevrons



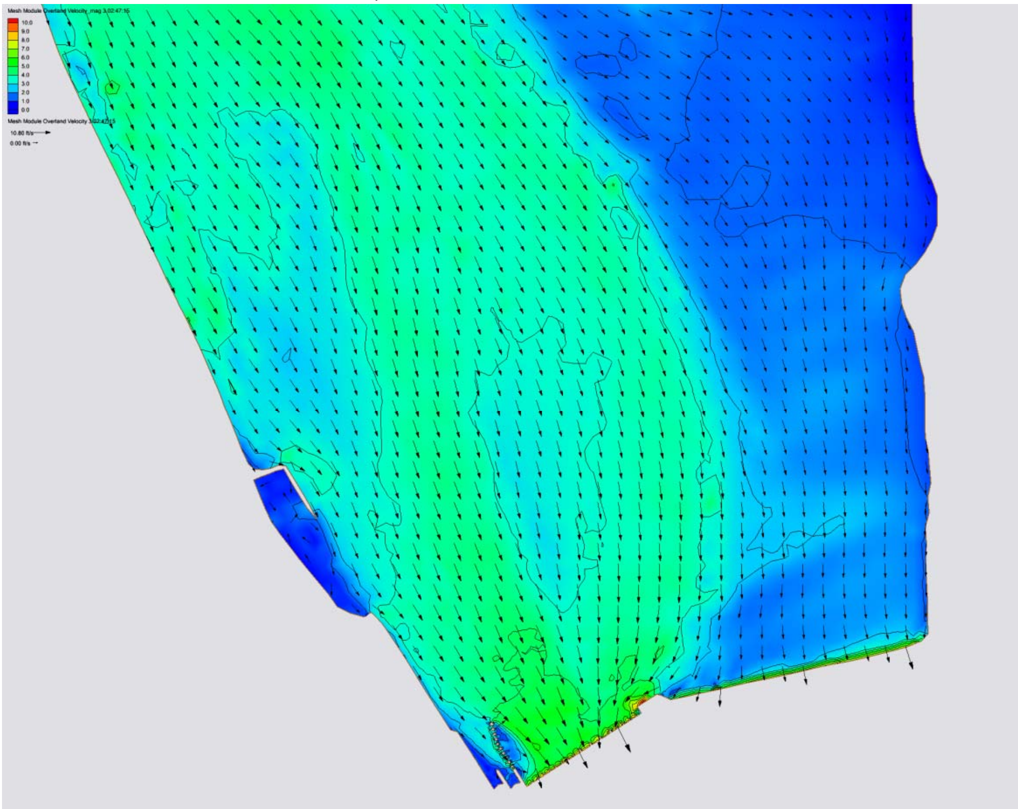
165,000 CFS – Without Chevrons



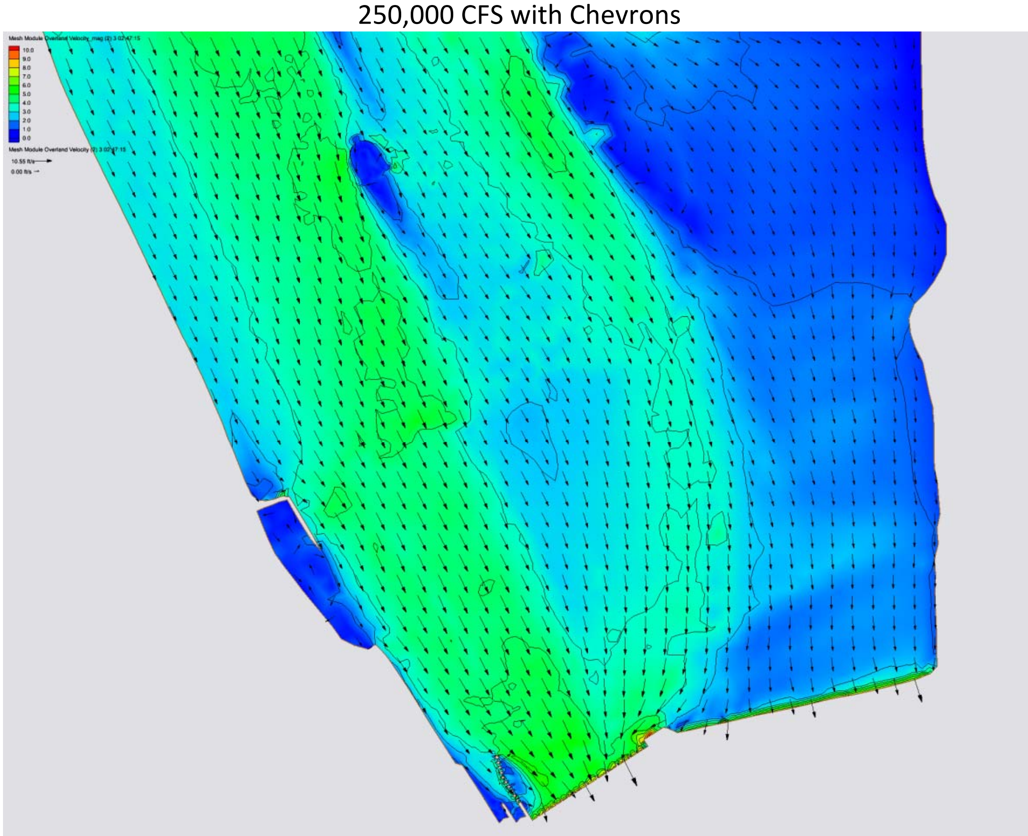
165,000 CFS – With Chevrons



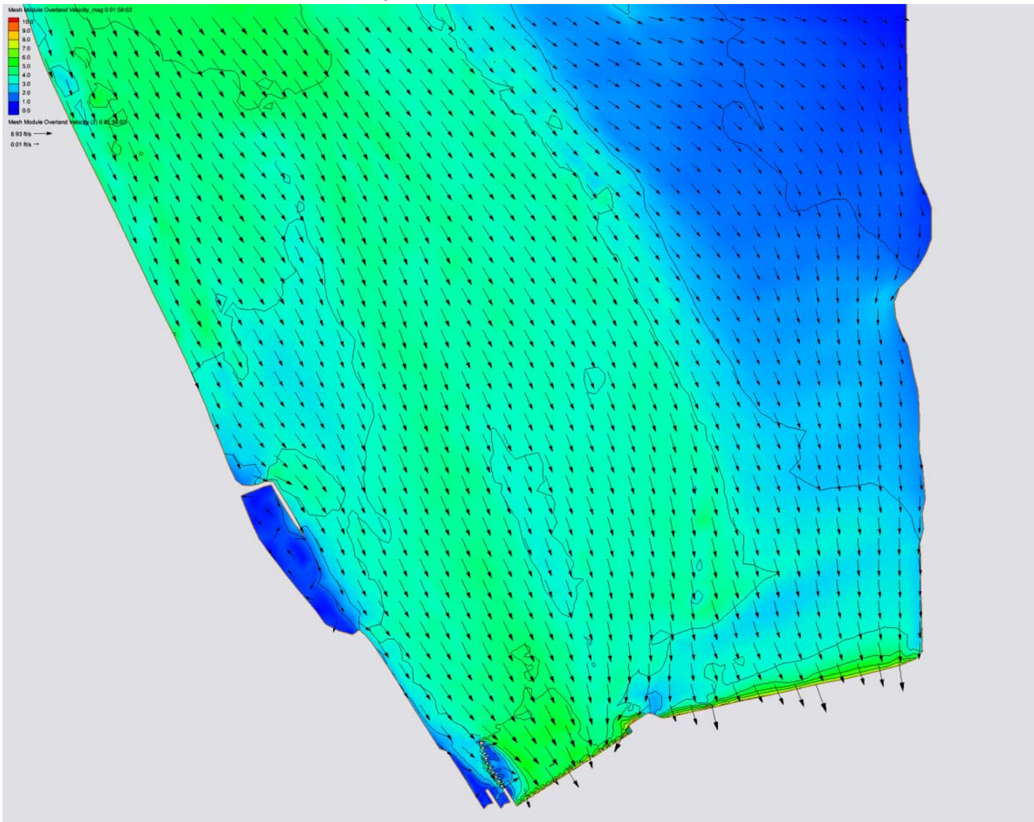
250,000 CFS without Chevrons



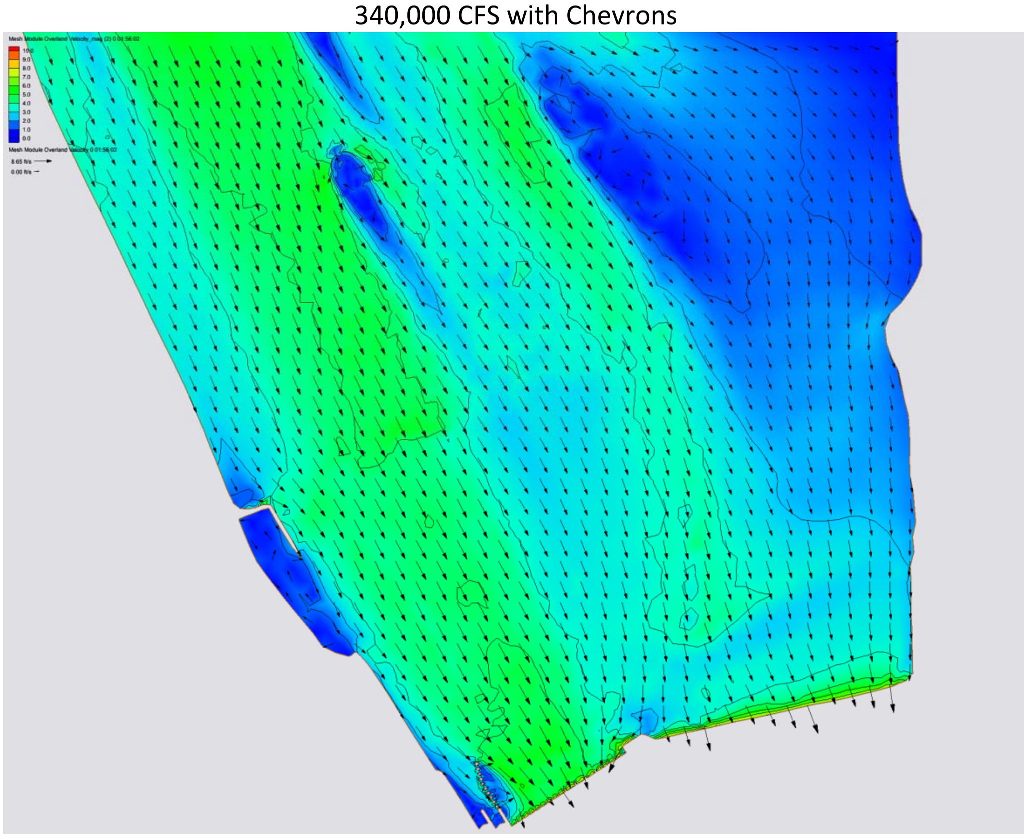
250,000 CFS with Chevrons



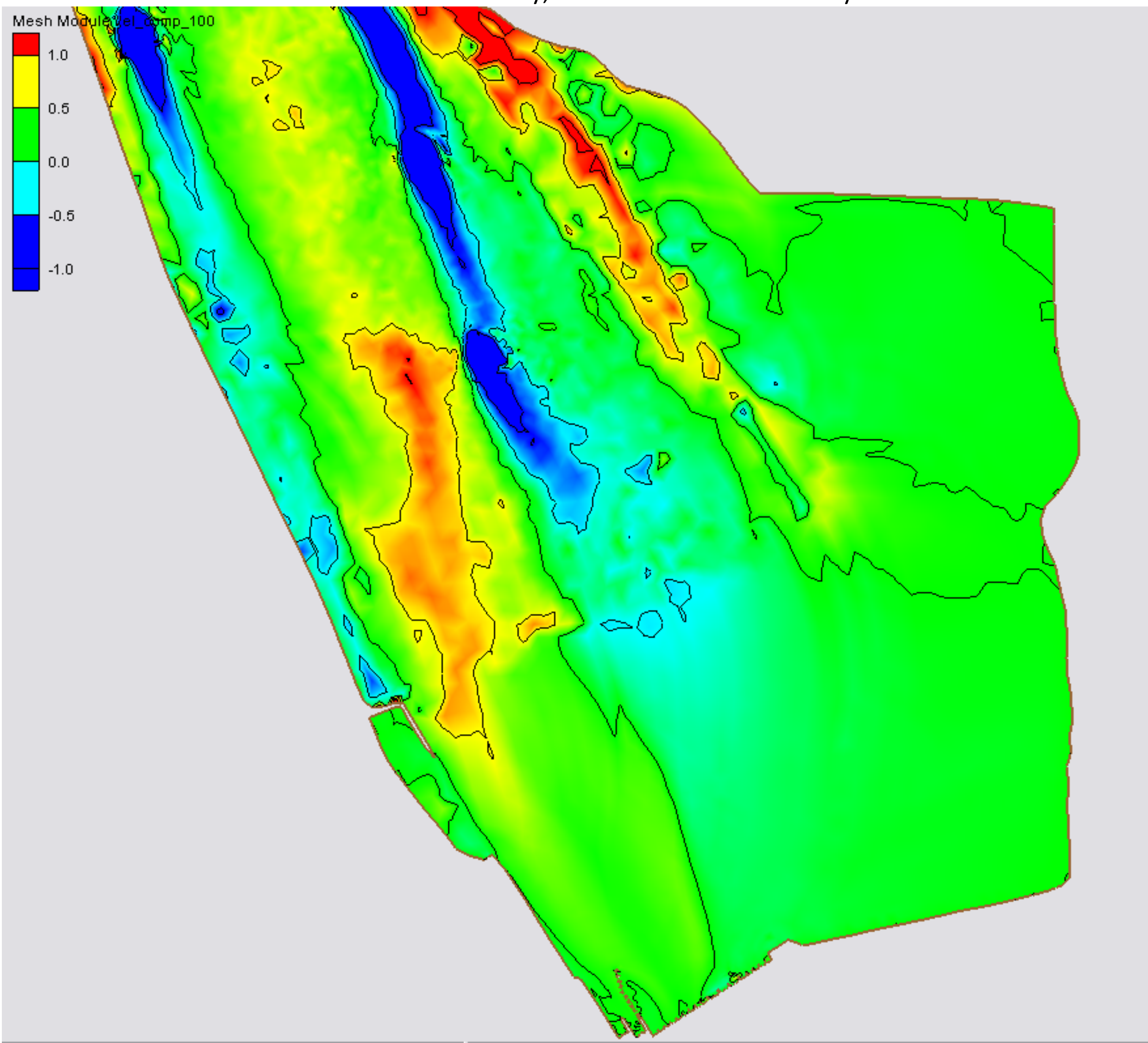
340,000 CFS without Chevrons



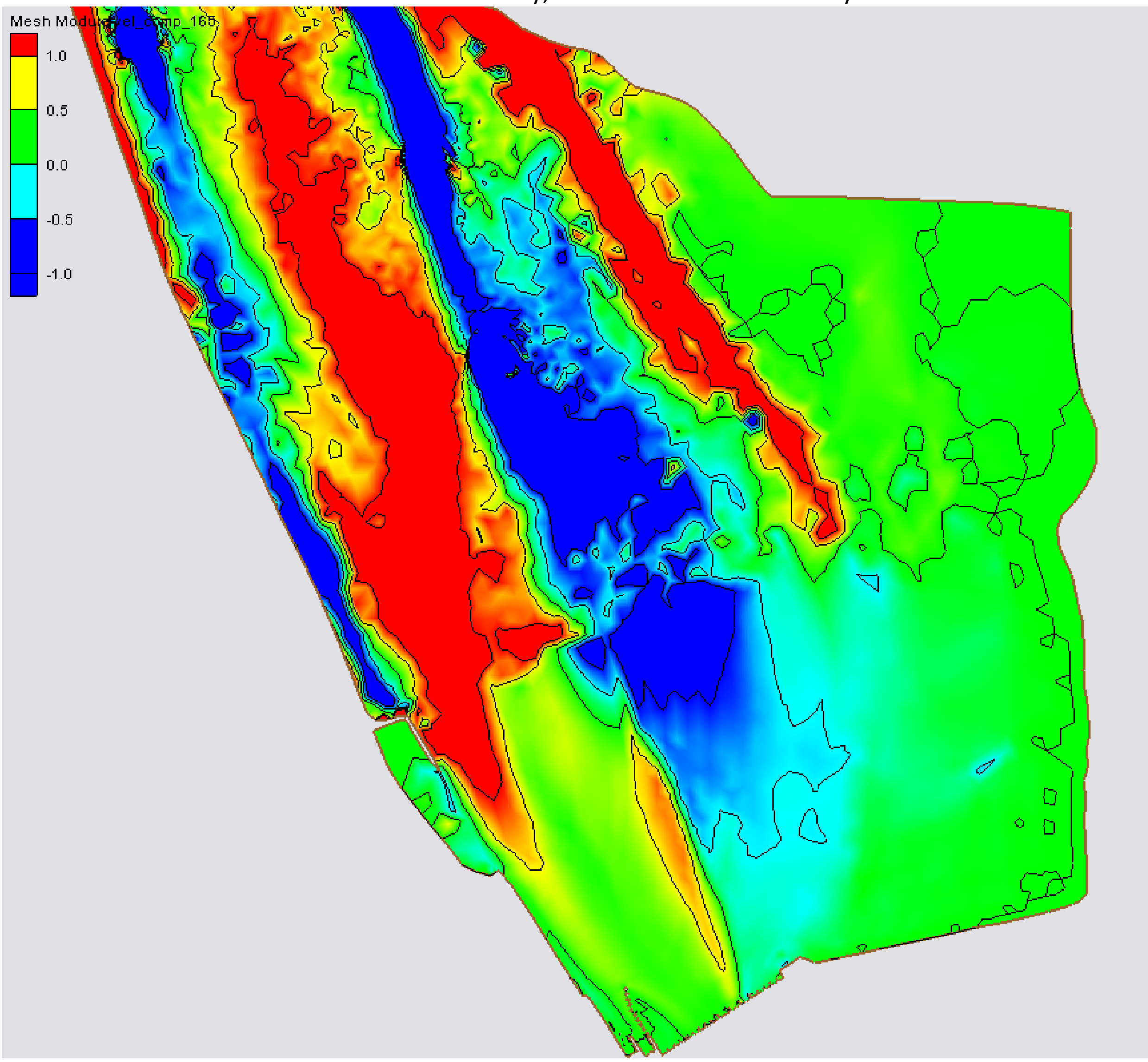
340,000 CFS with Chevrons



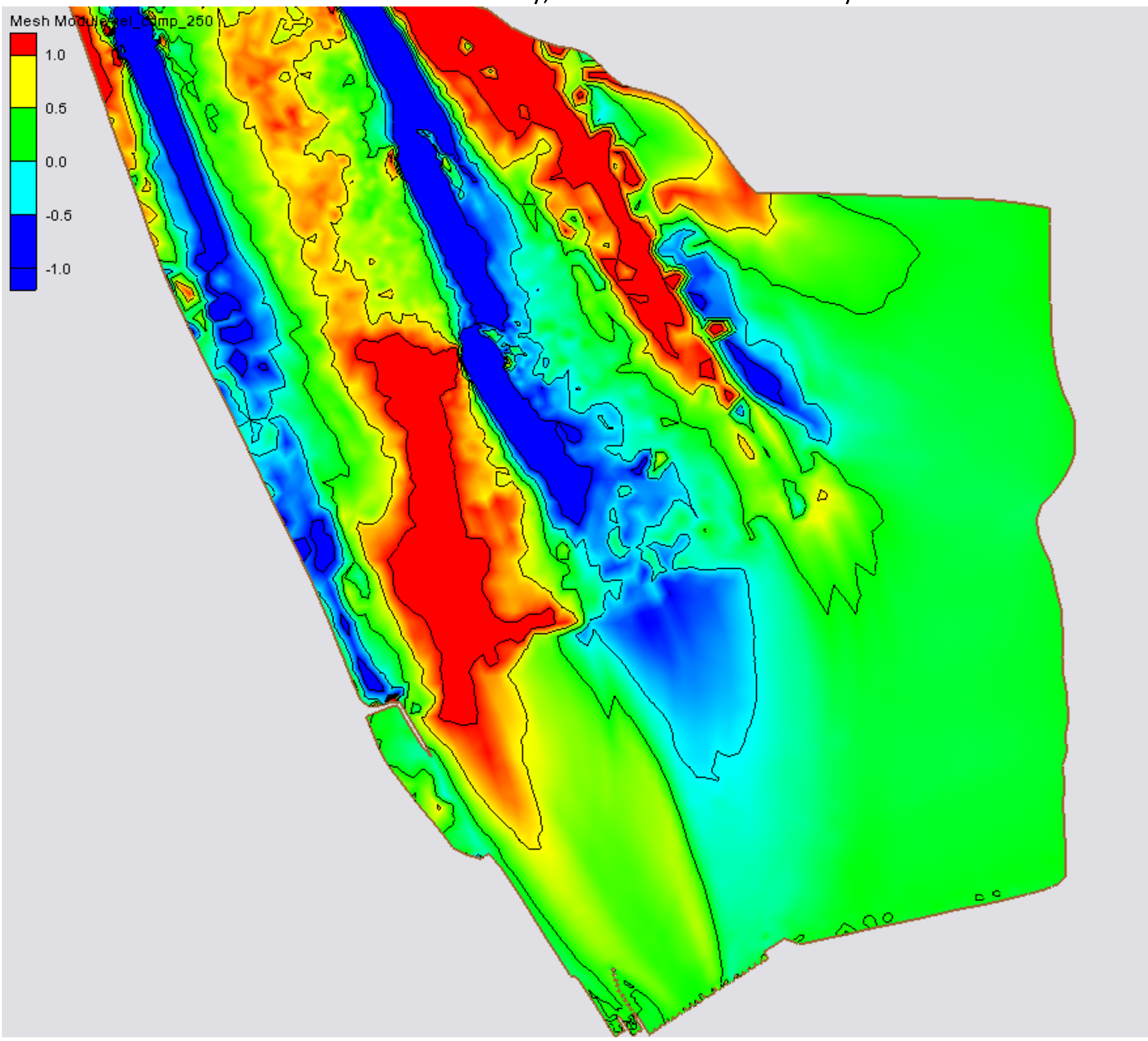
Velocity Comparison 100,000 CFS
Red – increase in velocity, Blue – Decrease in Velocity



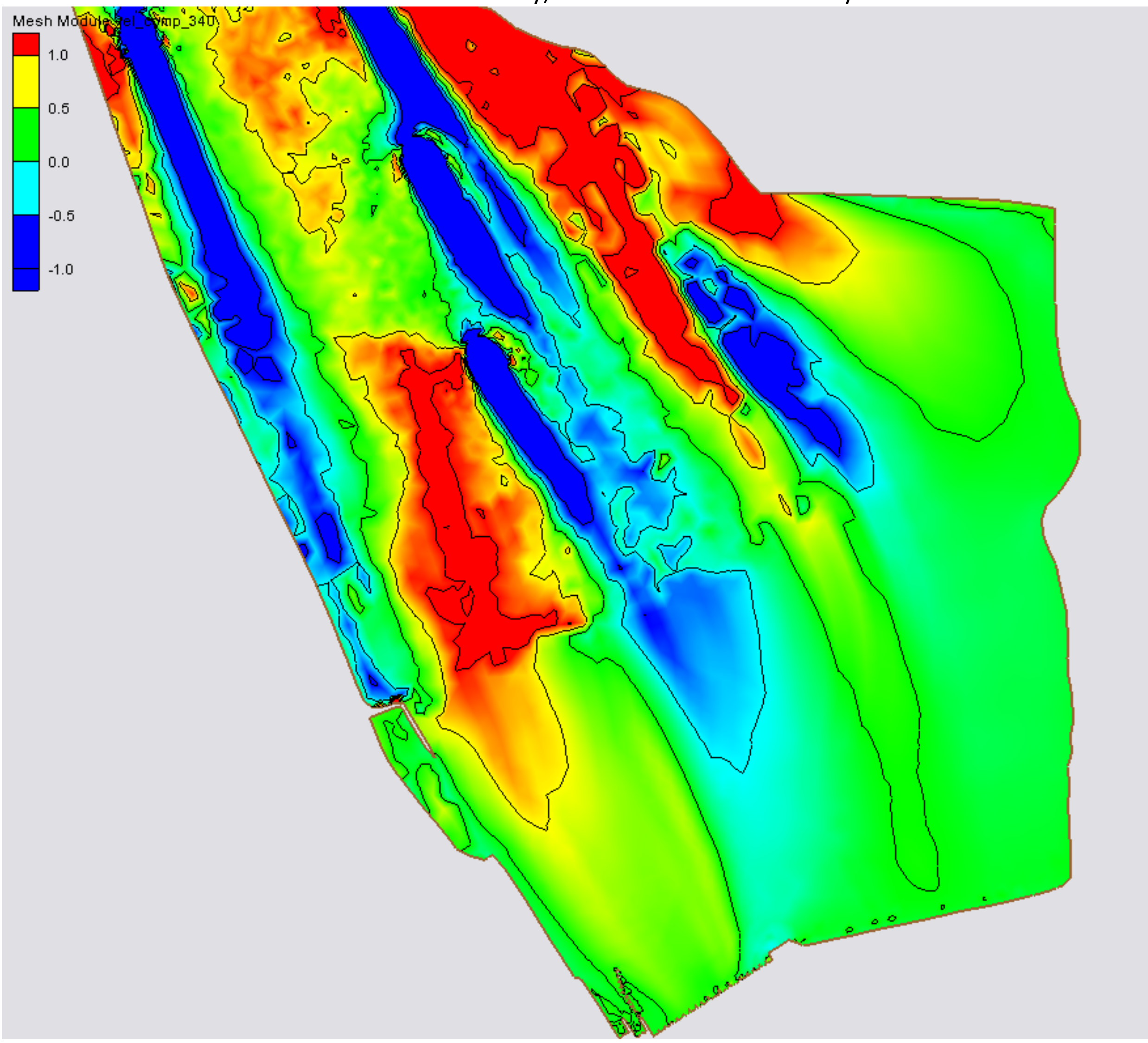
Velocity Difference 165,000 CFS
Red – increase in velocity, Blue – Decrease in Velocity



Velocity Difference 250,000 CFS
Red – increase in velocity, Blue – Decrease in Velocity



Velocity Difference 340,000 CFS
Red – increase in velocity, Blue – Decrease in Velocity



C.3 Conclusion

After analyzing the flow visualization and 2-D numerical modeling results, they continue to verify the results of the velocity readings collected from the HSR model study. All of the studies performed to evaluate the effects of the proposed structures show that they do not worsen the existing outdraft and that they ultimately provide a safer navigation channel by straightening the alignment and the approach to the upstream side of Lock 25.

APPENDIX D. PHASED CONSTRUCTION APPROACH

D.1 Introduction

Prior to the phased construction study, it was thought that the proposed chevrons and revetment could not be completed in a phased approach. This meant that all of the estimated $3.6 million funding for rock placement was required prior to any work starting. As a result, additional testing was done using the HSR model to determine if there were any detrimental impacts to the study area using this approach and which structures to build first.

The amount of structures to test per phase was based on the average Operations and Maintenance (O&M) dollars the Upper River Dike and Revetment Program had received in FY10, 11, and 12. The average O&M dollars received over three years was $1,150,000. Using $1.15 million as the annual budget cut off, it was determined there would be 5 phases or years of construction to complete the proposed chevrons and revetments. The phased approach tested is outlined in the table below.

YEAR	PHASE	CONSTRUCTION	COSTS	TOTAL COSTS	REMAINING UPPER D&R FUNDS TO BE SPENT ON O&M
FY12	1	Chevron 243.7L	$180,000	$400,000	$750,000
		Revetments 243.6L	$220,000		
FY13	2	Chevron 243.3L	$850,000	$850,000	$200,000
FY14	3	Chevron 243.5R	$850,000	$850,000	$200,000
FY15	4	Chevron 243.1L	$780,000	$780,000	$370,000
FY16	5	Chevron 242.8L	$750,000	$750,000	$400,000

Table 1: Phased Construction Approach

D.2 Analysis

The testing began after confirmation that the model was in calibration. Phase 1 included the lead chevron at RM 243.7L and revetments at RM 243.6L. There was not a significant change in the overall base test bathymetry, but locally there was increased depth. The bathymetry results can be seen on Plate D-1.

Phase 2 included the next chevron along the LDB at RM 243.3. The depth and width of the navigation channel increased through RM 243.0. The secondary flow near Batchtown was more evident and a long bar had begun to form behind the chevrons. The bathymetry results can be seen on Plate D-2.

In Phase 3, chevron 243.5R was introduced. The width of the navigation channel at a reasonable depth increased just past RM 243.0. The alignment of the navigation channel started to straighten towards the lock. There was also a slight change in depths near the RDB due to the split flow around the RDB chevron. The bathymetry results can be seen on Plate D-3.

Phase 4 included the next chevron along the LDB at RM 243.1. The deposition in the navigation channel was cleared out and depths increased. The effect of the split flow from the LDB chevrons could be seen in the continuous line of depth near Batchtown. The bar behind the chevrons had extended to the stump field. The bathymetry results can be seen on Plate D-4.

In the last Phase (5), the final chevron was introduced at RM 242.8L. These bathymetry results show the navigation channel at a much straighter alignment than the previous channel, the deposition was significantly reduced, and there were no detrimental effects to the lock approach.

D.3 Conclusion

After testing the 5 year phased construction approach in the LD 25 HSR model, it was determined that it is indeed a viable option. The ability of the structures to locally enhance the channel and not negatively affect the lock approach in phased construction is vital. This increases the chances that the funding needed to construct the LD 25 chevrons and revetments will be acquired and on a much shorter timeline. This is beneficial to navigation since the study area undergoes annual channel maintenance dredging and there have been several groundings in this reach over the last four years due to alignment and outdraft issues.

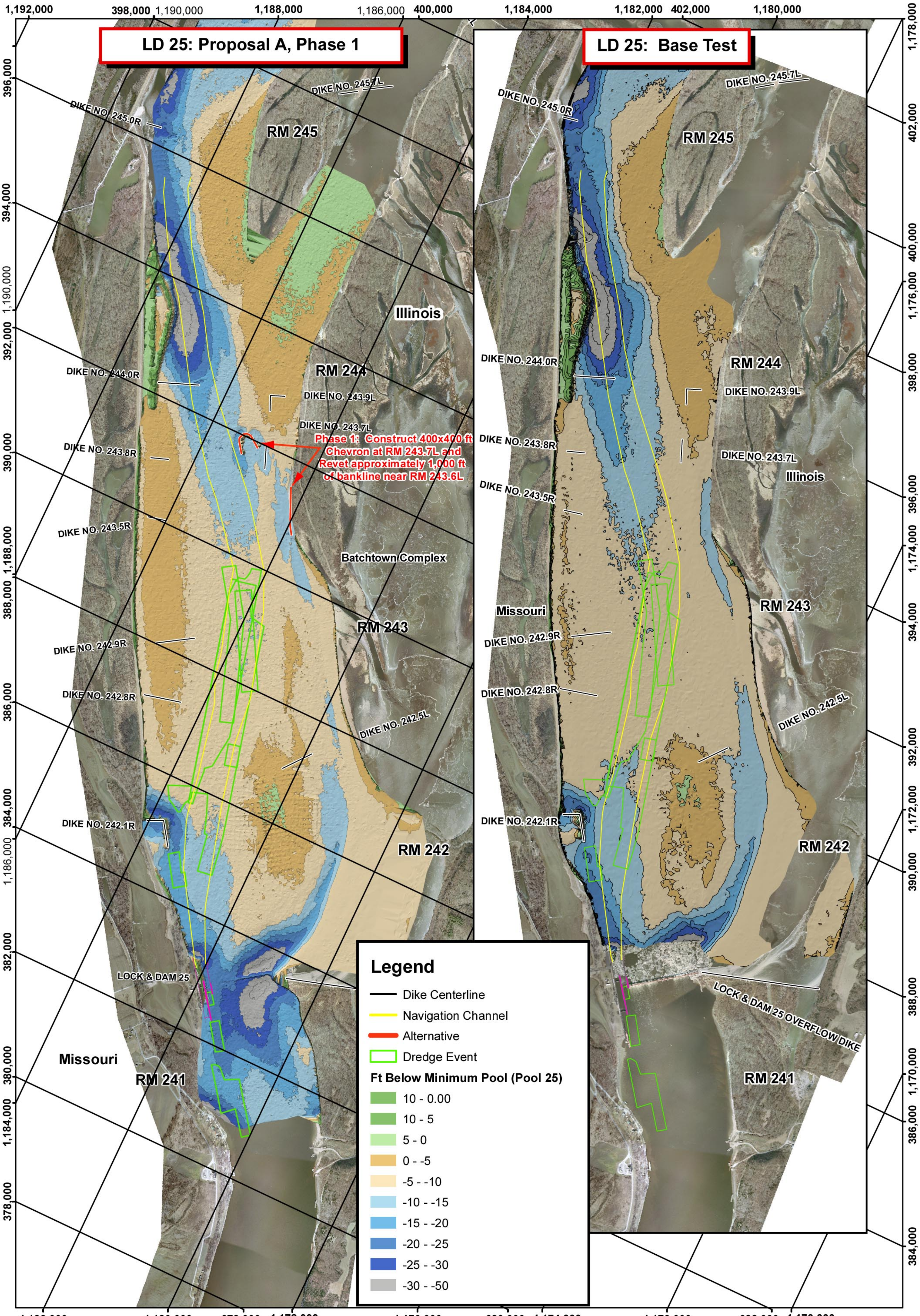


PLATE NUMBER D-1

0 1,000 2,000 4,000 6,000 Feet

Proposal A, Phase 1
Bathymetry Results
2005 AERIAL PHOTOGRAPH

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

Upper Mississippi River Basin
St. Louis District
Lock and Dam 25
HSR Model

DESIGNED BY: A COX	SURVEY DATE: 02/23/2011
DRAWN BY: A COX	REVIEWED BY: J BROWN, P.E. / CHECKED BY: E BRAUER, P.E.
SUBMITTED: A COX	APPROVED: R DAVINROY, P.E.
FILE NAME: . . . LD25/Plates	PLOT DATE: 03/10/2011

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St. Louis District

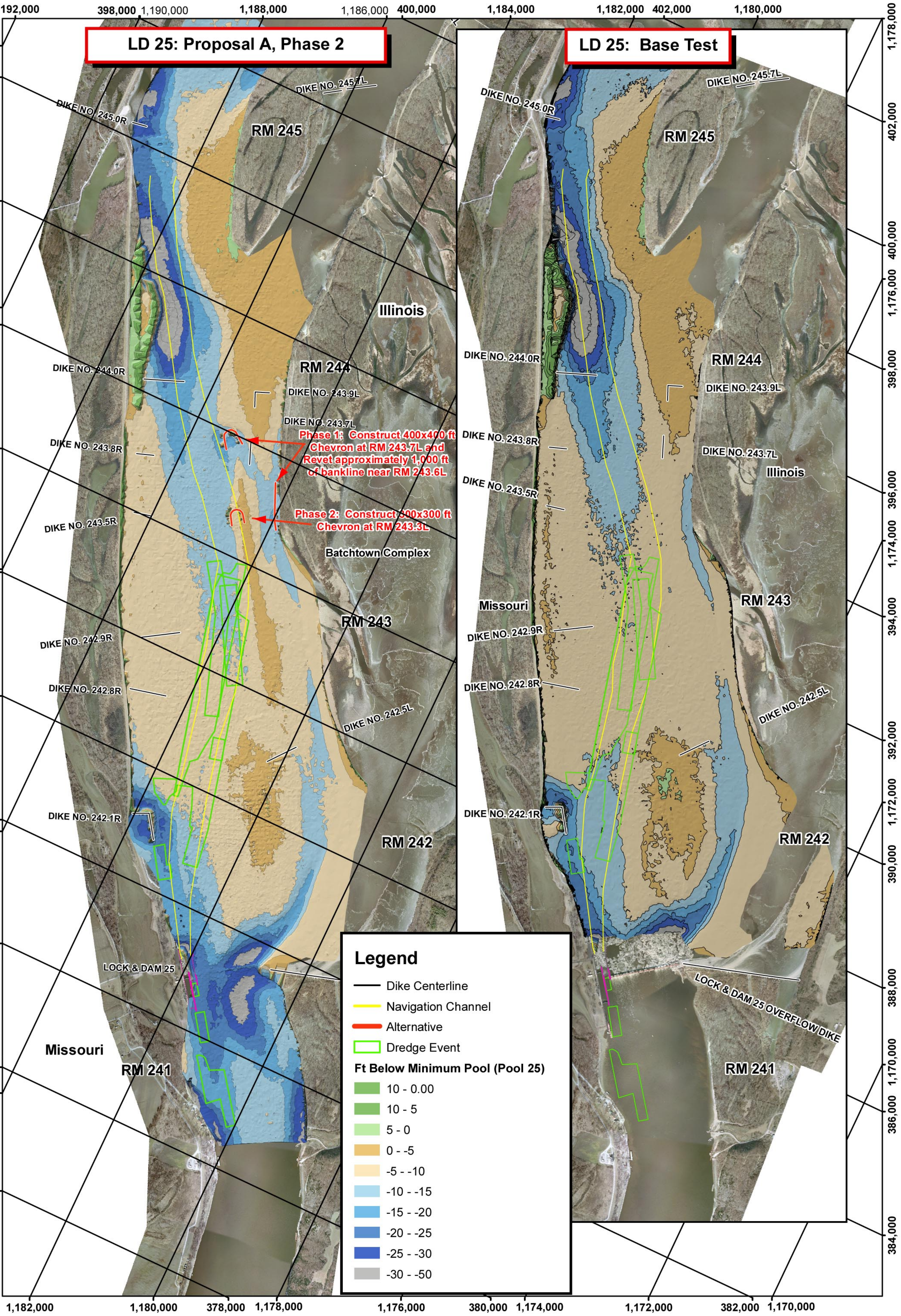

PLATE NUMBER

D-2

0 1,000 2,000 4,000 6,000
Feet

Proposal A, Phase 2
Bathymetry Results
2005 AERIAL PHOTOGRAPH

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ST. LOUIS, MISSOURI

DESIGNED BY:		SURVEY DATE:
A COX		02/25/2011
DRAWN BY:	REVIEWED BY:	CHECKED BY:
A COX	J BROWN, P.E.	E BRAUER, P.E.
SUBMITTED:	APPROVED:	
A COX	R DAVINROY, P.E.	
FILE NAME:	PLOT DATE:	
. . . LD25/Plates	03/10/2011	

Upper Mississippi River Basin
St. Louis District
Lock and Dam 25
HSR Model

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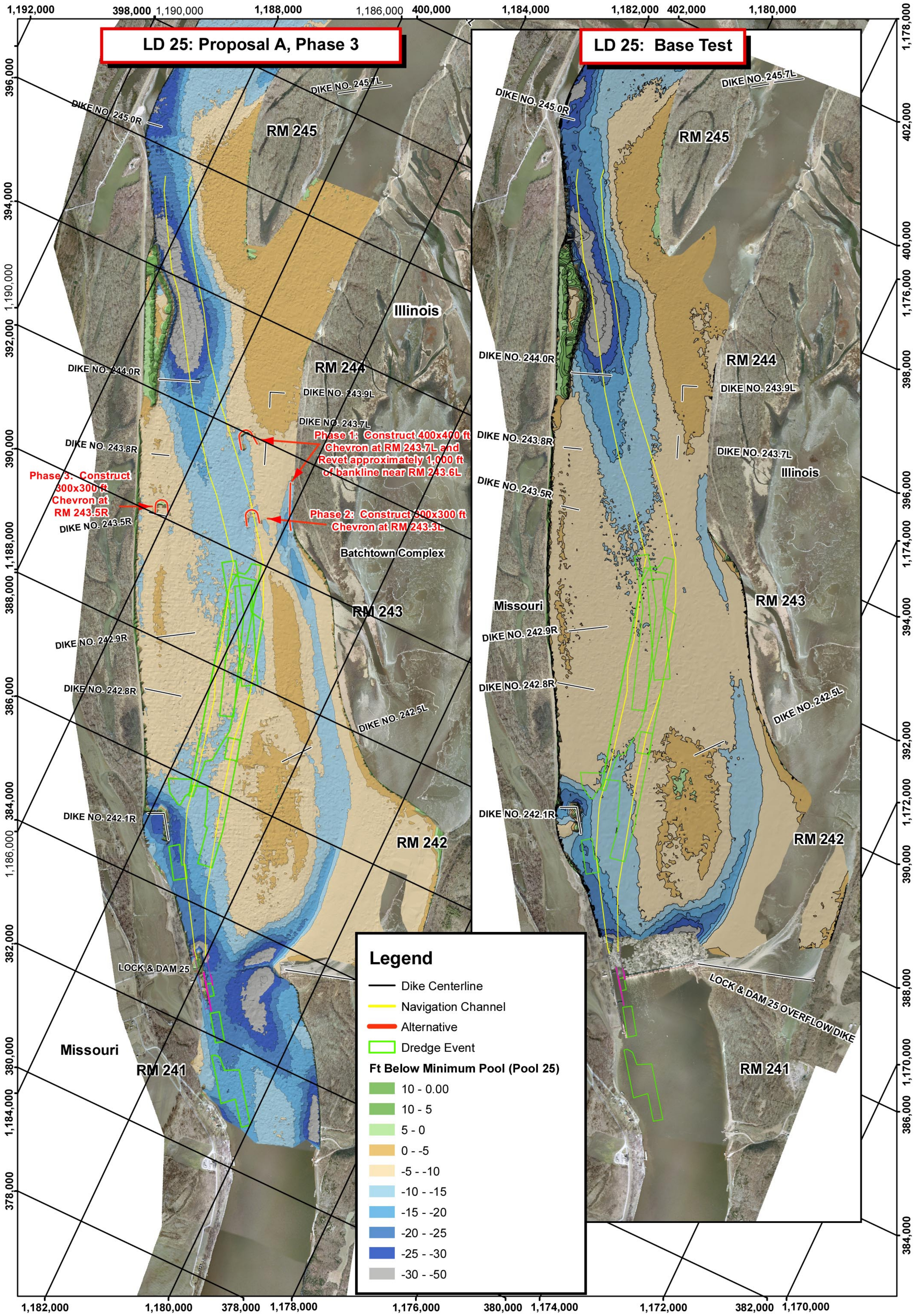

PLATE NUMBER	D-3

0 1,000 2,000 4,000 6,000
Feet

Proposal A, Phase 3
Bathymetry Results
2005 AERIAL PHOTOGRAPH

U.S. ARMY ENGINEER DIVISION CORPS OF ENGINEERS ST. LOUIS, MISSOURI	DESIGNED BY: A COX		SURVEY DATE: 03/02/2011
	DRAWN BY: A COX	REVIEWED BY: J BROWN, P.E.	CHECKED BY: E BRAUER, P.E.
Upper Mississippi River Basin St. Louis District Lock and Dam 25 HSR Model	SUBMITTED: A COX		APPROVED: R DAVINROY, P.E.
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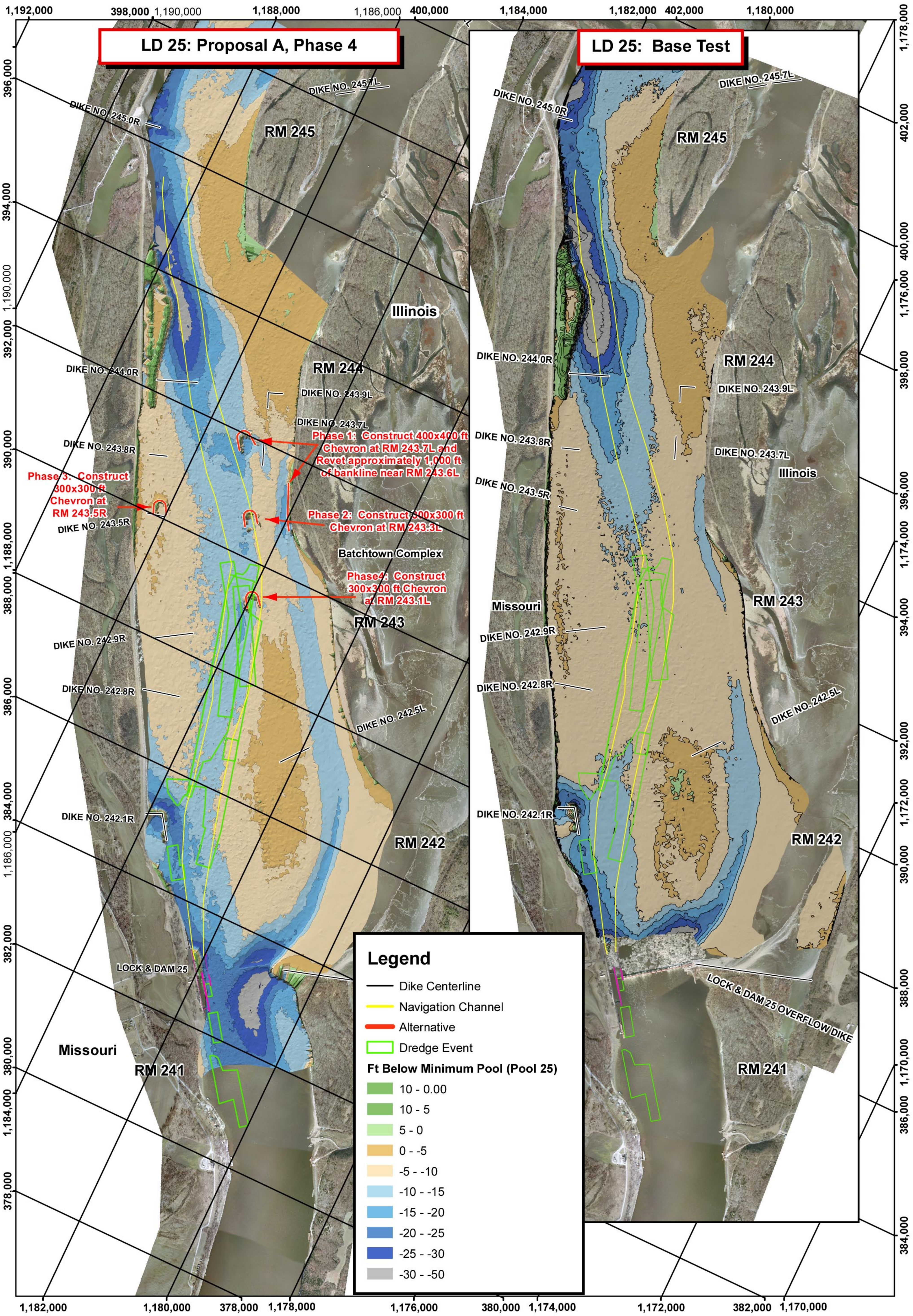

PLATE NUMBER D-4

0 1,000 2,000 4,000 6,000
Feet

Proposal A, Phase 4
Bathymetry Results
2005 AERIAL PHOTOGRAPH

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Upper Mississippi River Basin
St. Louis District
Lock and Dam 25
HSR Model

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SUBMITTED: A COX	APPROVED: R DAVINROY, P.E.	
FILE NAME: . . . LD25/Plates	PLOT DATE: 03/10/2011	

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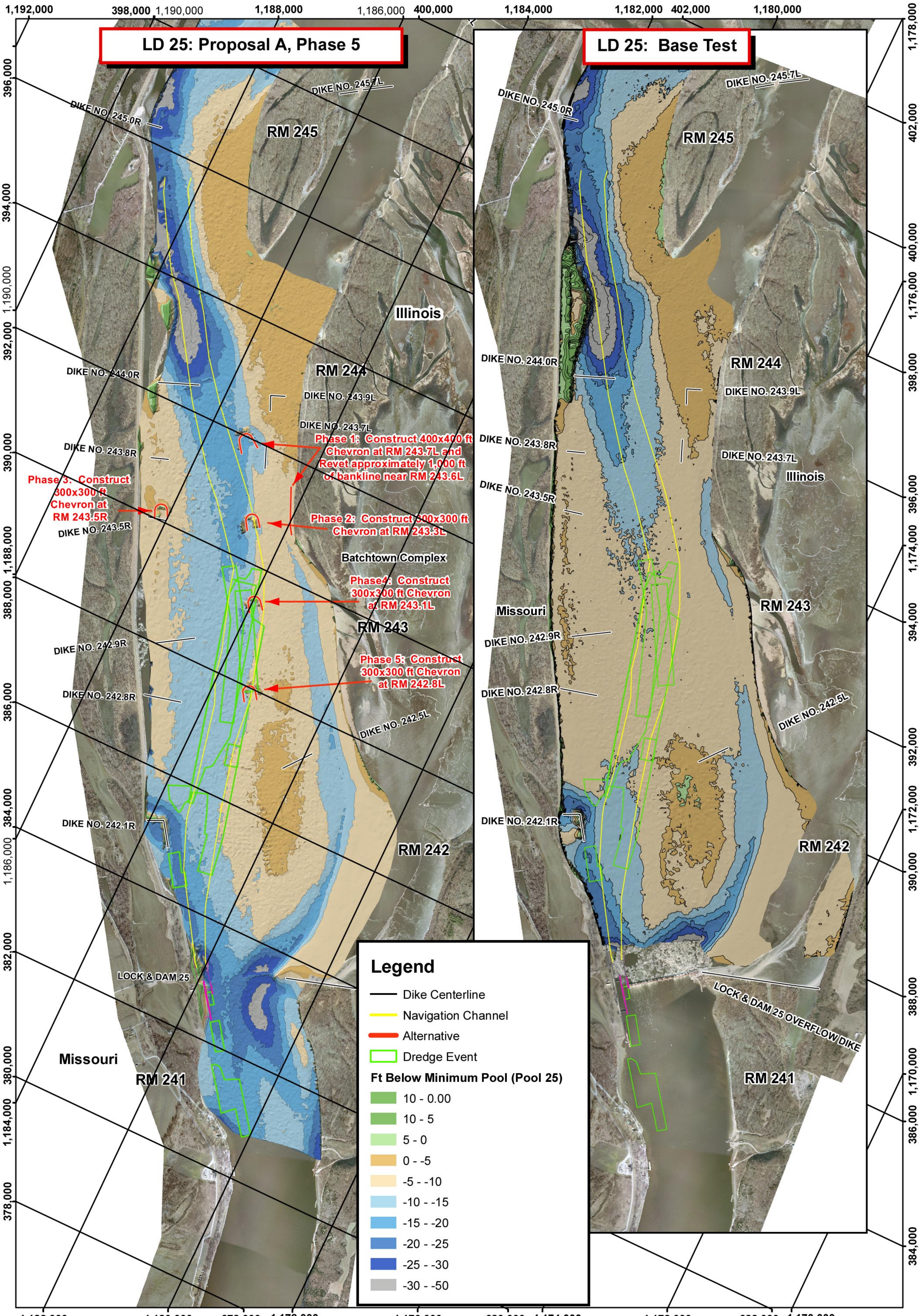

PLATE NUMBER

D-5

Proposal A, Phase 5
Bathymetry Results

2005 AERIAL PHOTOGRAPH

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Upper Mississippi River Basin
St. Louis District
Lock and Dam 25
HSR Model

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SUBMITTED: A COX	APPROVED: R DAVINROY, P.E.	
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