DEVILS ISLAND OFFSET DIKES

PRE and POST-CONSTRUCTION MONITORING COMPLETION REPORT

2009, 2010, & 2012 SURVEY RESULTS

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Open River
Mississippi River
River Miles 57.5 – 60.0

INTRODUCTION

The U.S. Army Corps of Engineers (USACE), St. Louis District's (District) conducted pre- and post-construction biotic (fish) and abiotic (water quality) sampling, along with post-construction sediment, bathymetry, and velocity surveys to compare the fish assemblages and the physical habitat before and after construction of 7 offset dikes located near Mississippi River Mile (57.5 – 60.0R; Exhibit 1).

Under the American Recovery and Reinvestment Act (2010) the offset dikes were constructed in 2011 to reduce sandbar formation on the left descending bank and create a more self-sustaining navigation channel. The purpose of this monitoring study is to compare the fish assemblage pre- and post construction of these innovative structures, and assess the physical changes that have occurred since construction. This study provides information necessary to our understanding of the effects of offset dikes, to assist in decision making, and to inform design of future river training structures elsewhere in the Mississippi River.

This report provides a summary of data collected from two pre-construction fish samples (summer 2009 and spring 2010), and two post-construction fish samples (spring and summer 2012), as well as bathymetry (March 2012), Acoustic Doppler Current Profiler (ADCP) velocity (March 2012), and sediment (August 2012).

METHODS

Study Location

The survey site (Mississippi River Mile 60.0 to 57.5) is in Cape Girardeau County, Missouri; 5 miles upstream from Cape Girardeau, MO. The survey site is along the right descending bank in the dike field which connects to the islands forming Schenimann Chute.

Sampling Dates

During pre-construction sampling, fish assemblage and water quality sampling occurred during the spring (August 12-13, 2009) and summer (March 9-10, 2010). Post-construction sampling occurred during the spring (May 31, 2012) and summer (July 25, 2012).

Fish Sampling

Fish sampling procedures are modified from those used by the Upper Mississippi River Restoration Environmental Management Program (UMRR-EMP) Long Term Resource Monitoring Program (Gutreuter et. al. 1995). A multi-method approach was used to increase the likelihood of sampling the entire fish community in the survey area (Sheehan and Rasmussen 1993). A total of 14 separate electrofishing runs and 12 trawling runs were performed for one year pre- and one year post-construction. Sampling was completed when water levels were below +18 ft at the Cape Girardeau gage; the elevation when the dikes are overtopped. All fish were measured and species and length recorded.

Daytime electrofishing (DC pulse rate of 120; 60 Hz frequency) transects were established during the pre-construction surveys (Exhibit 1). These transects followed the bank and navigation side of the sand bars that had formed below each dike. Post-construction surveys followed these same transects.

An 8 foot mini-Missouri trawl (Herzog et al. 2009), constructed of 19.05 mm inner mesh unit enclosed by a 4.76 mm outer mesh was attached to the bow of the boat with approximately 75 foot towlines was used. Trawling followed the same transects used for electrofishing.

Water quality data was collected at the mid-point of each dike, on the day of but prior to, fish sampling in that area. A HydroLab unit was used to collect pH, conductivity (µS/cm) water temperature (°C), and dissolved oxygen (mg/L) at the surface of the water column (approximately 1-2 feet). Water velocity was also recorded at the mid-point of the transects. Turbidity was recorded using a secchi disk.

Bathymetry, Velocity, and Sediment Surveys

To characterize the river bottom, post-construction bathymetric data were gathered using both channel cross-section (single-beam) and multiple transducer sweep (multi-beam) surveys. The single beam survey followed pre-existing survey transects that incorporate overlapping transects to validate data by comparing adjacent soundings from different transects. Utilizing pre-existing transects also allows for comparison between surveys collected on different dates. These surveys used a boat mounted acoustic echo sounder to measure depth, a differential GPS to provide accurate position, and a computer to time-tag and record the depth and position data. All components were configured prior to the survey to reflect the survey vessel, sensor type, and survey area. The Acoustic Doppler Current Profiler (ADCP) was mounted to the same survey vessel and collected with the multi-beam data.

Sediment samples were collected post-construction by ponar dredge in transects around five dikes, three of which had extensions (dikes 60.2, 59.8, 59.0, 58.3, and 58.2). Sediments were classified into fines, sand, gravel or cobble. The latter three were assigned a size class of fine/small, medium, or coarse/large.

RESULTS

Bathymetry, Velocity, and Sediment Surveys (Exhibit 2 – 4a-c)

Deep holes have formed off the tips of each dike and to a lesser extent where the dikes tie in to the bank (Exhibit 2a-b). Sandbars have formed downstream of several dikes towards the bank.

Based on the ADCP velocities (Exhibit 3), the Mississippi River thalweg directly adjacent to the dike tips was high (4.4 – 5.0 ft/sec). Additionally, velocities of up to 4.0 ft/sec were observed on the upstream side of the first dike within the field. Velocities slow, but were approximately 2.0 ft/sec within the outer portion of the dike field. The dike tips create circular eddies below them that sometimes reach the bank. In most cases, water continues to flow along the bank, though velocities approach zero directly below the dike adjacent to the bank.

There is a wide variety of substrates within the sediment surveys. Dike 60.2, the most upstream surveyed, had large gravel in the two transects adjacent to the dike, the next transect downstream was fine sand and the last transect was medium gravel (Exhibit 4a). The next three dikes surveyed had offset dikes constructed. Dike 59.8 has a deposition zone of fines along the bank below the dike (Exhibit 4a-c). As the sample proceeds toward the thalweg the sediments transition to medium sand and then a mixture of sand, gravel, and small cobble. Sediments behind Dike 59.0 and 58.3 are similar to 59.8 but the sediment is more clearly defined into zones. On either side of the offset, where currents are swift, there is gravel and cobble, directly behind the offset there is a deposition zone of fine and medium sand. Dike 58.3 also has gravel and cobble along the bank. Dike 58.2, which does not have an offset, has some fine gravel and small cobble upstream and in the first transect downstream along the thalweg (Exhibit 4c). All other areas have fines, fine sand and medium sand. During pre-construction fish samples, trawls below the most downstream dikes, 58.2, 58.3 and 58.7, contained gravel. Moving upstream substrate transitioned to silt on the inside transects of the middle dikes and sand on outside and behind the upper dikes.

Water quality parameters varied with season. Turbidity and temperature were lower in spring and higher in summer, while pH and dissolved oxygen followed the opposite trend (Table 1).

Table 1. Mean of water quality parameters measured pre- and post-construction within the Offset Dike (RM 57.5 – 60.0R). "NR" stands for Not Recorded.

Parameter	Pre-Construction		Post-Construction	
	August 2009	March 2010	May 2012	July 2012
Temperature (°C)	NR	NR	25.8	30.6
pH	NR	7.9	NR	7.5
Specific Conductivity (µS cm^{-1})	NR	607	390	389
Dissolved Oxygen (mg L^{-1})	NR	10.6	7.48	6.87
Turbidity (secchi reading in mm)	375	NR	251	389
water velocity (mph)	1.0	NR	0.65	1.42
Water surface elevation (Cape Girardeau gage in ft)	13.81 (12 August 2009)	18.63 (09 March 2010)	15.6 (31 May 2012)	10.2 (25 July 2012)

Fish Sampling

A total of 622 individuals consisting of 28 species representing 10 families were collected during pre-construction over all seasons and gears (Table 2). A total of 1,948 individuals consisting of 30 species representing 12 families were collected post-construction over all seasons and gears (Table 3).

For pre-construction, the most common families (> 10% of total catch) collected included Clupeidae (primarily Gizzard Shad), Sciaenidae (primarily Freshwater Drum), Cyprinidae (primarily Emerald Shiner, Shoal Chub, and Silver Chub), and Ictaluridae (primarily Channel Catfish) (Table 4).

For post-construction, Sciaenidae was the dominant family (Table 4) due to having over 1,000 Freshwater Drum being sampled during the summer using trawls. Silver Chubs were also common with over 350 individuals collected in summer trawls. Species of special note collected during the May 2012 sample, included three juvenile sturgeon (*Scaphirhynchus* spp.) and one juvenile paddlefish. These individuals were collected and returned to river between dike 59.0R and 59.5R.

CONCLUSIONS

Bathymetric and sediment survey results suggest the offset dikes may aide in the persistence of gravel within the dike field. The gaps between the offset and original dike concentrate flow creating scour and preventing fine sediment deposition. Pre-construction trawling found gravel below the lower dikes but sand and fine sediment behind more upstream dikes. Post-construction sediment surveys indicate that the concentrated flow around the upper dike extensions may have scoured out additional gravel.

Overall, the pre-construction and post-construction had similar fish assemblages. Fewer fish were captured in pre-construction samples than post-construction samples. The lower abundance of pre-construction versus post-construction is likely reflective of environmental conditions as river levels were lower during post-construction samples. In terms of physical habitat, the offset dikes have created unique flow patterns providing a more diverse habitat including deep holes, gravel, and sandbars. Preliminary results, while limited, do not suggest that offset dikes negatively impact fish communities, which was a concern posed initially by natural resource agencies. Additional physical and biological monitoring of these structures would provide further information needed to more fully assess how fish are using these river training structures.

Table 2. Pre-construction total fish count by family and species collected by gear and season

	Electrofishing			Trawling			Total Over All Gears & Seasons
Family & Species Name	Spring	Summer	Total	Spring	Summer	Total	
Catostomidae	**13**	**10**	23			0	23
Bigmouth Buffalo	1	1	2			0	2
Black Buffalo		2	2			0	2
River Carpsucker	6		6			0	6
Smallmouth Buffalo	6	7	13			0	13
Centrarchidae			0		**6**	6	6
Bluegill			0		2	2	2
Orange Spotted Sunfish			0		3	3	3
Warmouth Sunfish			0		1	1	1
Clupeidae	**19**	**232**	251			3	254
Gizzard Shad	19	232	251		3	3	254
Cyprinidae	**4**	**21**	25	**7**	**49**	56	81
Channel Shiner			0		5	5	5
Common Carp	3	4	7			0	7
Emerald Shiner		15	15			0	15
Grass Carp	1		1			0	1
River Shiner		1	1		1	1	2
Shoal Chub			0	7	30	37	37
Silver Carp		1	1			0	1
Silver Chub			0		13	13	13
Hiodontidae	**4**	**4**	4		**1**	1	5
Goldeye	4	4	4		1	1	5
Ictaluridae		**8**	8	**2**	**68**	70	78
Blue Catfish			0		8	8	8
Channel Catfish		8	8		60	60	68
Flathead Catfish			0	1		1	1
Madtom spp.			0	1		1	1
Lepisosteidae		**29**	29		**2**	2	31
Longnose Gar		5	5			0	5
Shortnose Gar		24	24		2	2	26
Moronidae	**1**	**14**	15			0	15
White Bass		14	14			0	14
Yellow Bass	1		1			0	1
Percidae			0		**2**	2	2
River Darter			0		1	1	1
Sauger			0		1	1	1
Sciaenidae	**2**	**5**	7	**1**	**119**	120	127
Freshwater Drum	2	5	7	1	119	120	127
Grand Total	**39**	**323**	**362**	**10**	**250**	**260**	**622**

Table 3. Post-construction total fish count by family and species collected by gear and season

	Electrofishing			Trawling			Total Over All Gears & Seasons
Family & Species Name	Spring	Summer	Total	Spring	Summer	Total	
Acipenseridae				**3**	**1**	**4**	**4**
Shovelnose Sturgeon					1	1	1
Sturgeon sp.				3		3	3
Catostomidae	**3**	**5**	**8**		**8**	**8**	**16**
Bigmouth Buffalo	2		2				2
Black Buffalo	1	3	4		1	1	5
Buffalo sp.					1	1	1
River Carpsucker		1	1		6	6	7
Smallmouth Buffalo		1	1				1
Centrarchidae		**1**	**1**				**1**
Largemouth Bass		1	1				1
Clupeidae	**1**	**9**	**10**				**10**
Gizzard Shad	1	8	9				9
Threadfin Shad		1	1				1
Cyprinidae	**4**	**18**	**22**	**4**	**512**	**516**	**538**
Bighead Carp		1	1				1
Channel Shiner				1	63	64	64
Cyprinid sp.					1	1	1
Emerald Shiner					19	19	19
Grass Carp	1		1				1
Red Shiner					3	3	3
River Shiner				1		1	1
Shoal Chub				2	1	3	3
Sicklefin Chub					39	39	39
Silver Carp	3	17	20				20
Silver Chub					386	386	386
Hiodontidae	**3**	**6**	**9**	**95**	**10**	**105**	**114**
Goldeye	3	6	9	95	10	105	114
Ictaluridae				**2**	**75**	**77**	**77**
Blue Catfish					12	12	12
Channel Catfish				2	63	65	65
Lepisosteidae	**19**	**12**	**31**		**6**	**6**	**37**
Longnose Gar	8	3	11				11
Shortnose Gar	11	9	20		6	6	26
Moronidae	**1**		**1**	**9**		**9**	**10**
White Bass	1		1	9		9	10
Percidae				**1**		**1**	**1**
Sauger				1		1	1

Table 3 continued

	Electrofishing			Trawling			Total Over All Gears & Seasons
Family & Species Name	**Spring**	**Summer**	**Total**	**Spring**	**Summer**	**Total**	
Polyodontidae				**1**		**1**	**1**
Paddlefish				1		1	1
Sciaenidae	**1**	**4**	**5**	**9**	**1125**	**1134**	**1139**
Freshwater Drum	1	4	**5**	9	1125	1134	1139
Grand Total	**32**	**55**	**87**	**124**	**1737**	**1861**	**1948**

Table 4. Comparison of pre- and post-construction percent of total catch by family and gear over all seasons. Dominant families (>10% of total catch) are bolded and shaded gray.

Family	Electrofishing				Trawling			
	Pre		Post		Pre		Post	
	Total Count	% of Total Catch	Total Count	% of Total Catch	Total Count	% of Total Catch	Total Count	% of Total Catch
Acipenseridae (sturgeon)	0	0.00	0	0.00	0	0.00	4	0.21
Catostomidae (suckers)	23	6.35	8	9.20	0	0.00	8	0.43
Centrarchidae (sunfish)	0	0.00	1	1.15	6	2.31	0	0.00
Clupeidae (herring)	**251**	**69.34**	**10**	**11.49**	3	1.15	0	0.00
Cyprinidae (minnows)	25	6.91	**22**	**25.29**	**56**	**21.54**	**516**	**27.73**
Hiodontidae (mooneyes)	4	1.10	**9**	**10.34**	1	0.38	105	5.64
Ictaluridae (catfish)	8	2.21	0	0.00	70	**26.92**	77	4.14
Lepisosteidae (gars)	29	8.01	**31**	**35.63**	2	0.77	6	0.32
Moronidae (temperate basses)	15	4.14	1	1.15	0	0.00	9	0.48
Percidae (perch)	0	0.00	0	0.00	2	0.77	1	0.05
Polyodontidae (paddlefish)	0	0.00	0	0.00	0	0.00	1	0.05
Sciaenidae (drums)	7	1.93	5	5.75	**120**	**46.15**	**1134**	**60.93**
TOTAL	**362**	**100.00**	**87**	**100.00**	**260**	**100.00**	**1861**	**100.00**

LITERATURE CITED

Gutreuter, S., R. Burkhardt, and K. Lubinski. 1995. Long Term Resource Monitoring Program Procedures: Fish Monitoring. National Biological Service, Environmental Management Technical Center, Onalaska, Wisconsin, July 1995. LTRMP 95-P002-1. 42pp. + Appendixes A-J.

Herzog, D.P., D.E. Ostendorf, R.A Hrabik, and V.A. Barko. 2009. The mini-Missouri trawl: a useful methodology for sampling small-bodied fishes in small and large river systems. Journal of Freshwater Ecology 24: 103-108.

Pflieger, W.L. 1997. The Fishes of Missouri. Revised edition. Conservation Commission of the State of Missouri. Missouri Department of Conservation, Jefferson City. 342 pp.

Sheehan, R.J. and J.L. Rasmussen. 1993. Large rivers, p. 445-468. *In*: C.C. Kohler and W.A. Hubert (eds.). *Inland Fisheries Management in North America.* American Fisheries Society, Bethesda.

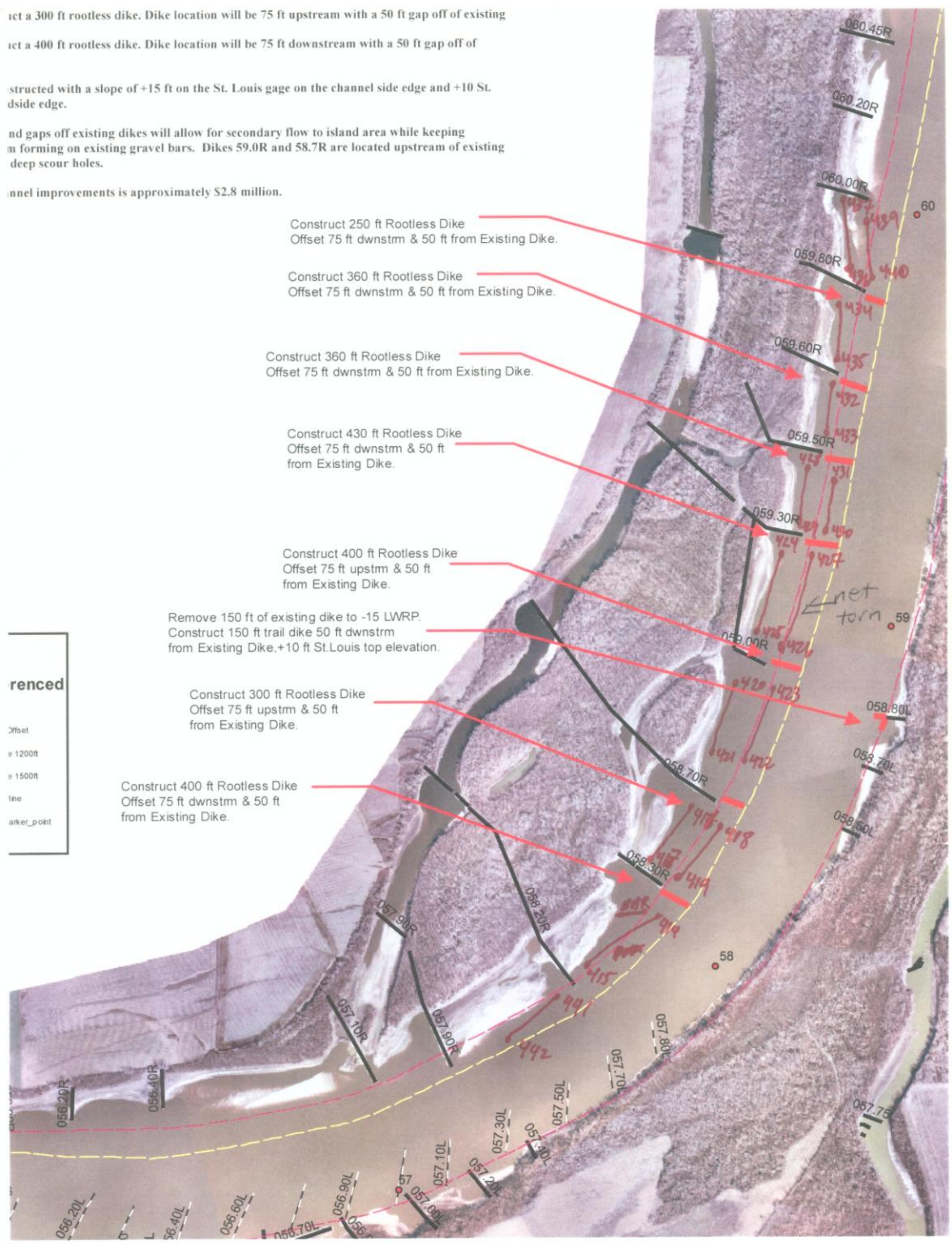

Exhibit 1. The existing dikes and offset rootless dike extensions, and transects for the pre and post-construction fish survey along the right descending bank of the Mississippi River MRM 57.5 – 60.0.

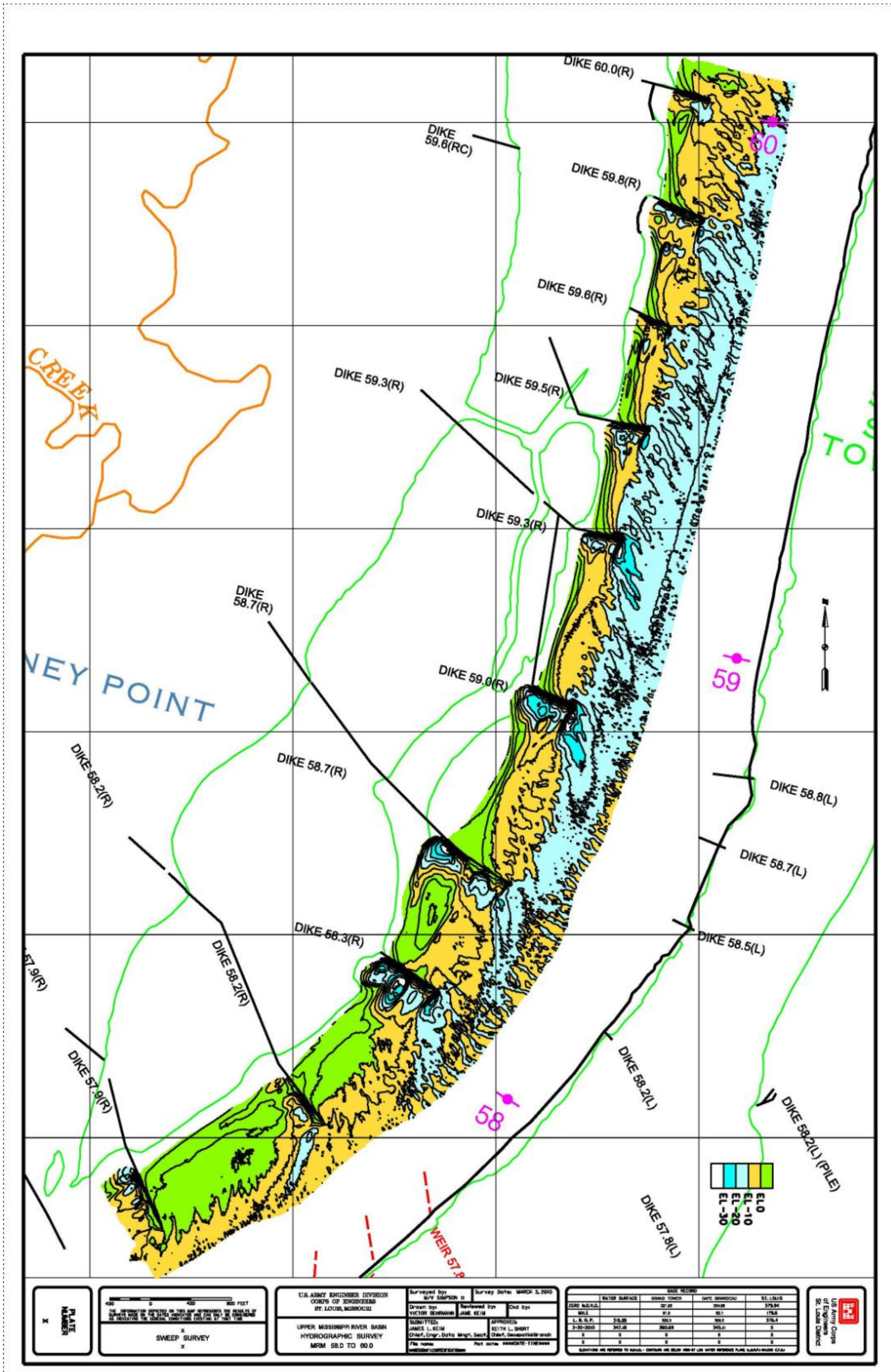

Exhibit 2a. Pre-construction multibeam bathymetric data collected on 30 March 2010. Elevations are in feet low water reference plane (LWRP).

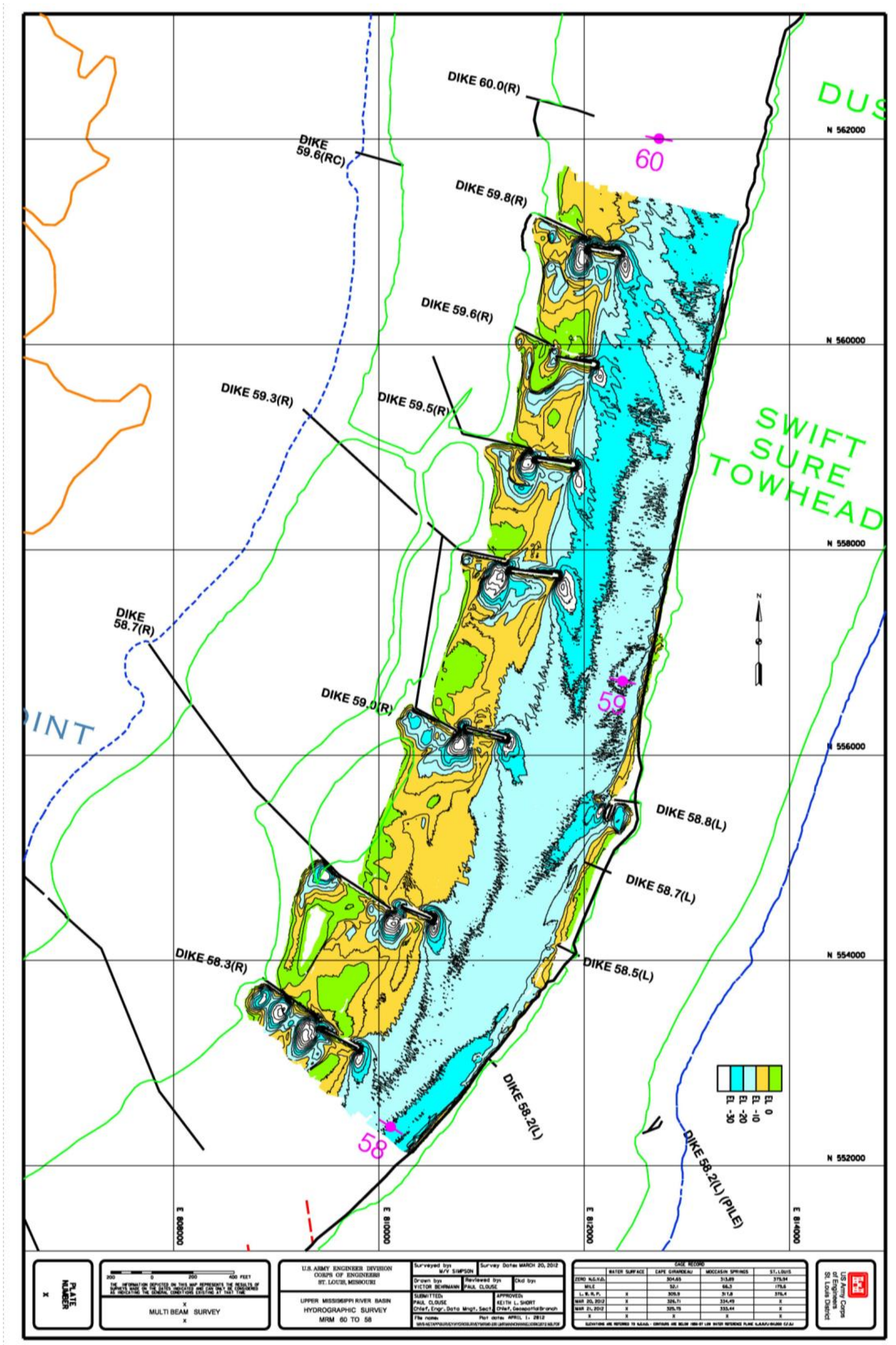

Exhibit 2b. Post-construction multibeam bathymetric data collected on 20 March 2012 to include the thalweg, original dikes and rootless dike extensions. Elevations are in feet low water reference plane (LWRP).

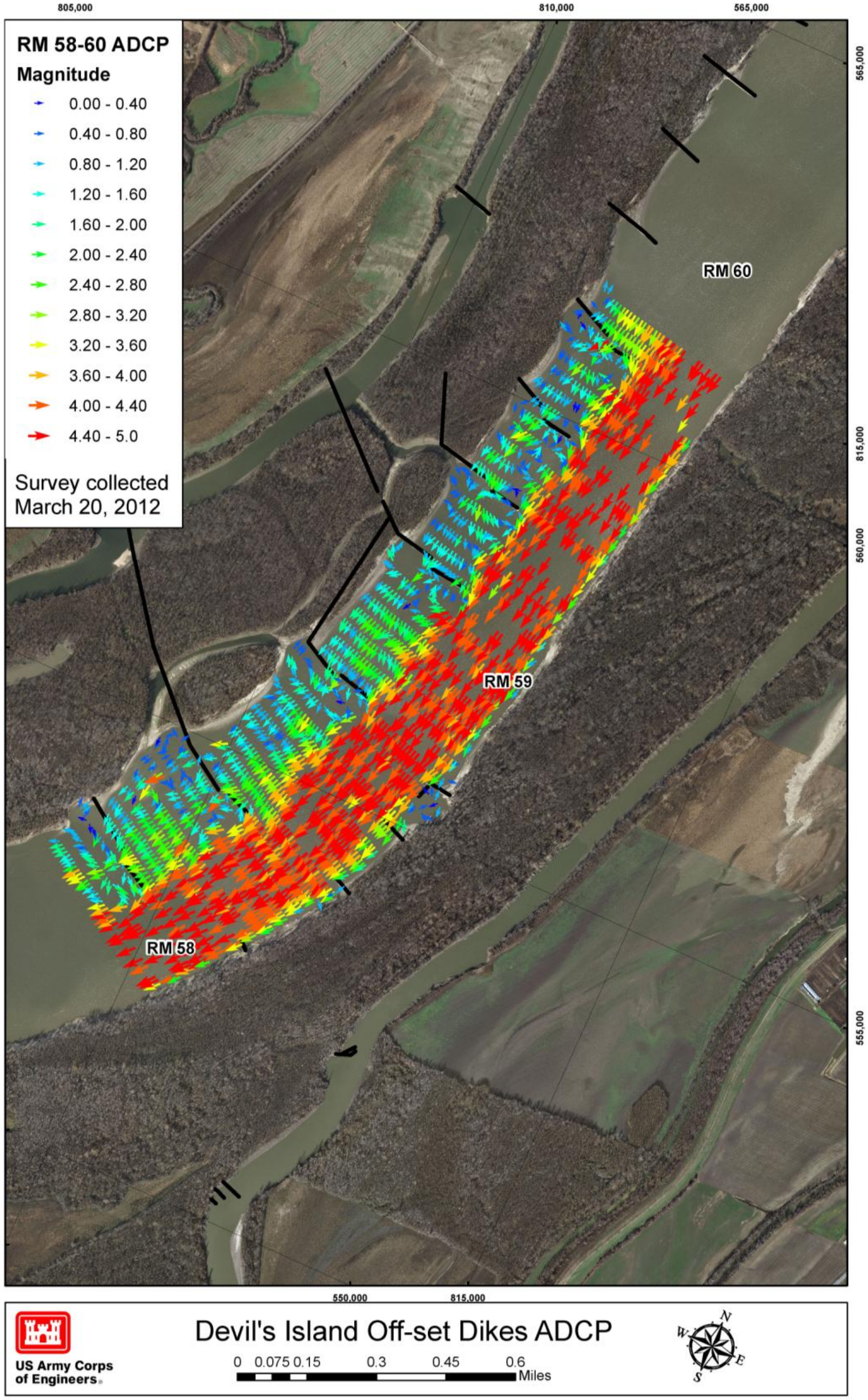

Exhibit 3. Acoustic Doppler Current Profile (ADCP) data (ft./sec) collected on 20 March 2012 of the river current around the dike extensions.

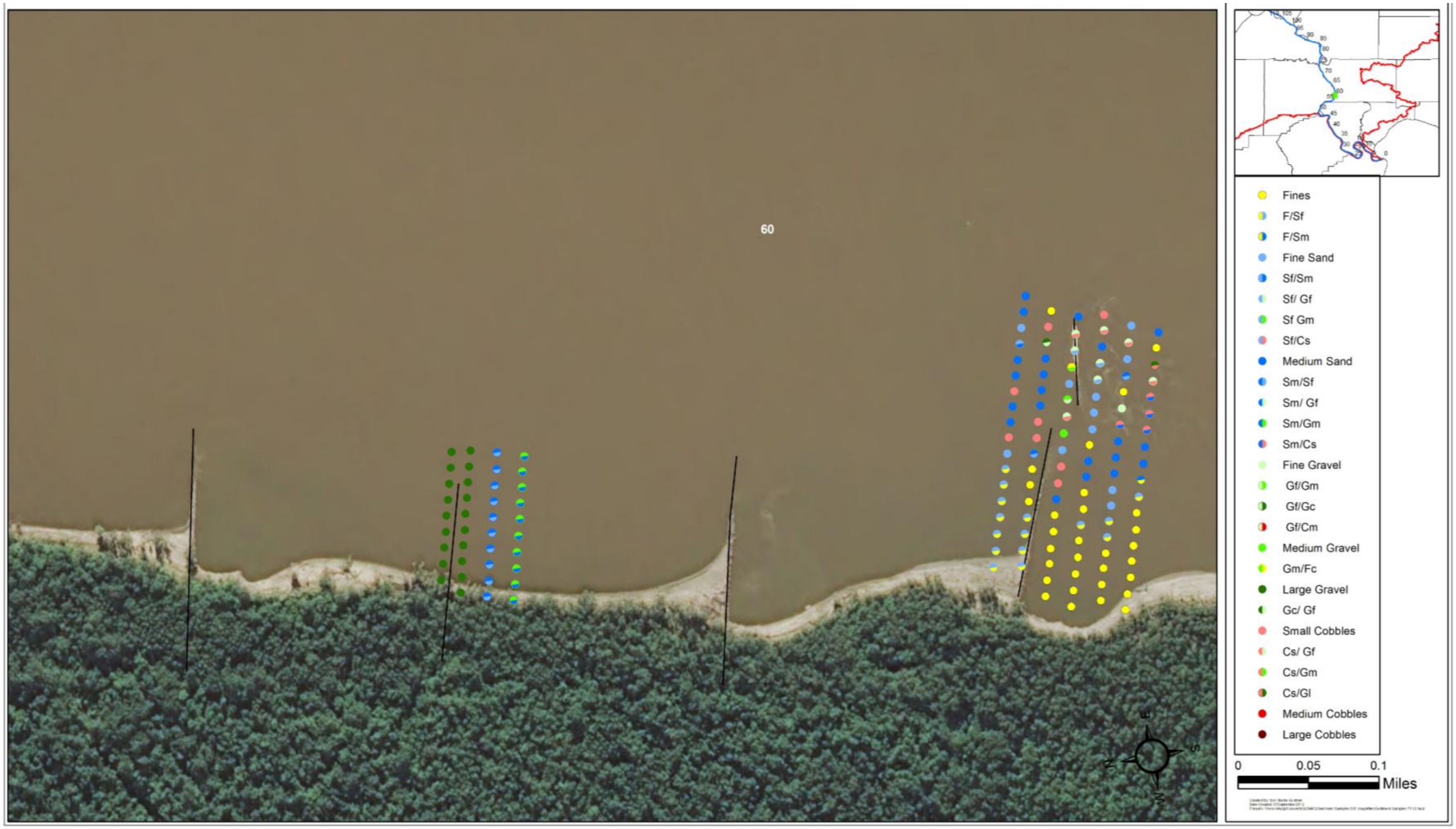

Exhibit 4a. Sediment survey conducted on August 19-20, 2012 around Dikes 60.2 and 59.8. First letter of abbreviations indicate F – fines, S – sand, G – gravel, C – cobble classified into different size classes (2nd letter) f – fine, s-small, m – medium, c – coarse, and l - large.

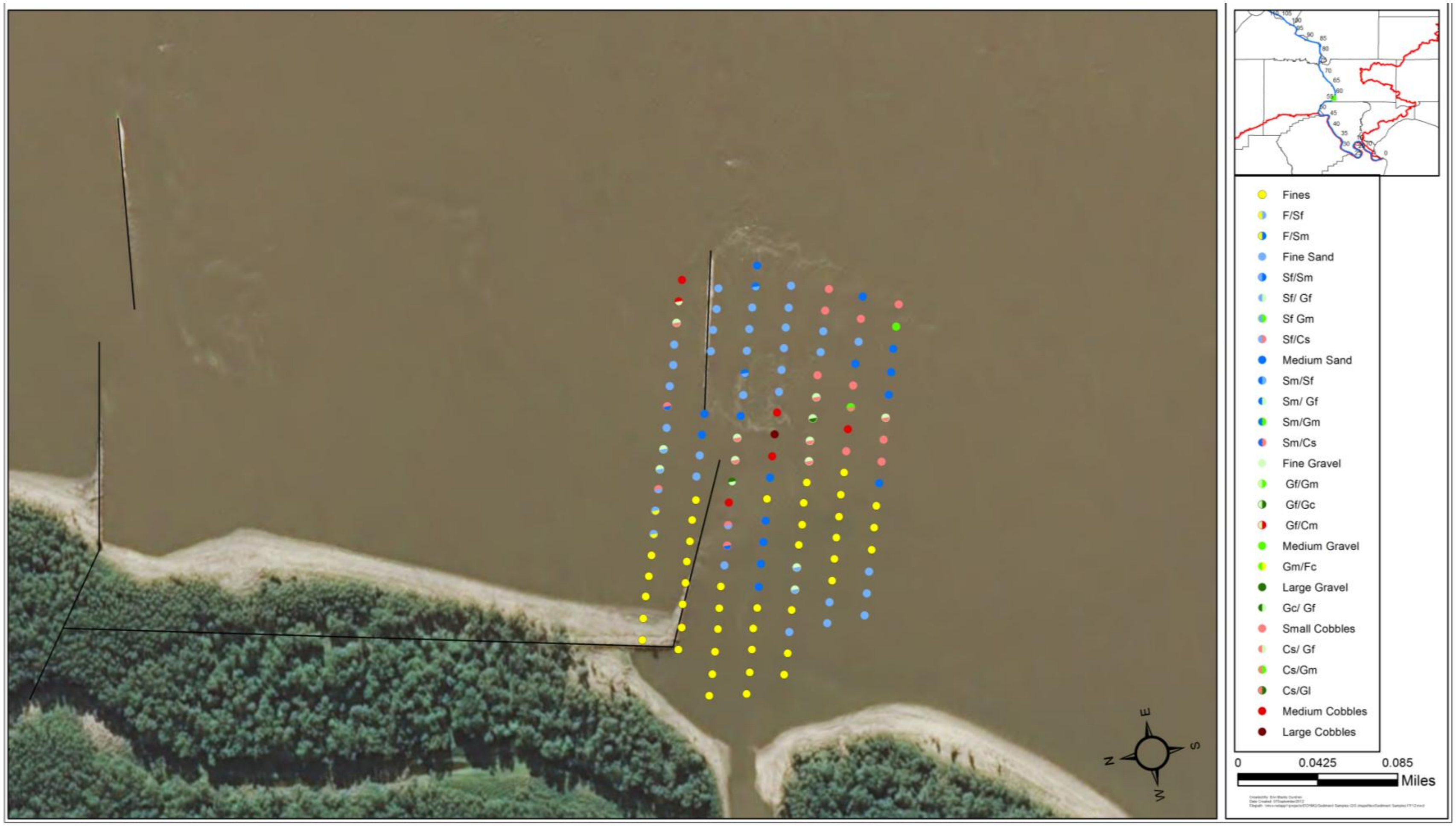

Exhibit 4b. Sediment survey conducted on August 19-20, 2012 around Dike 59.0. First letter of abbreviations indicate F – fines, S – sand, G – gravel, C – cobble classified into different size classes (2nd letter) f – fine, s-small, m – medium, c – coarse, and l -large.

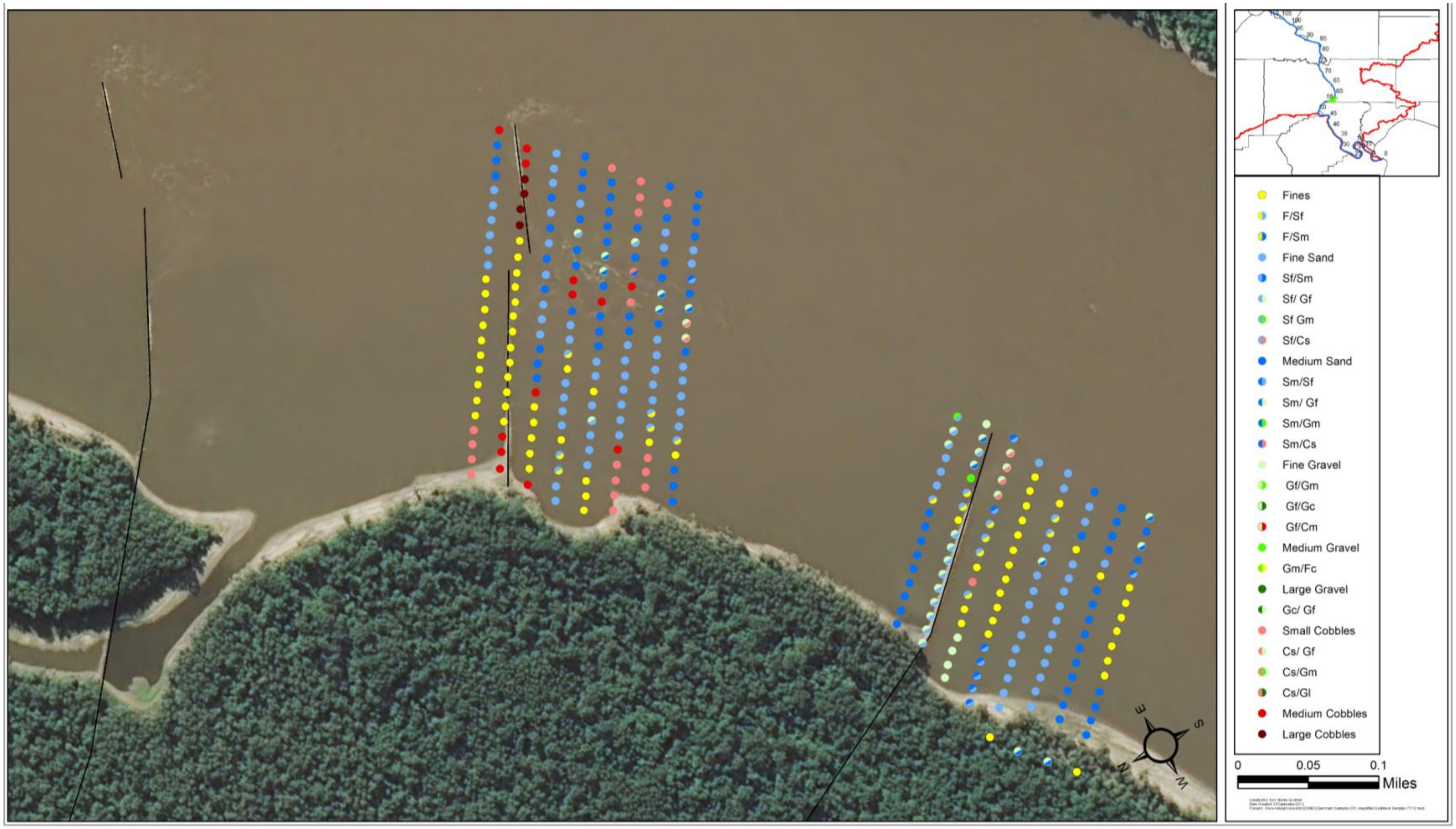

Exhibit 4c. Sediment survey conducted on August 19-20, 2012 around Dikes 58.3 and 58.2. First letter of abbreviations indicate F – fines, S – sand, G – gravel, C – cobble classified into different size classes (2nd letter) f – fine, s-small, m – medium, c – coarse, and l – large.