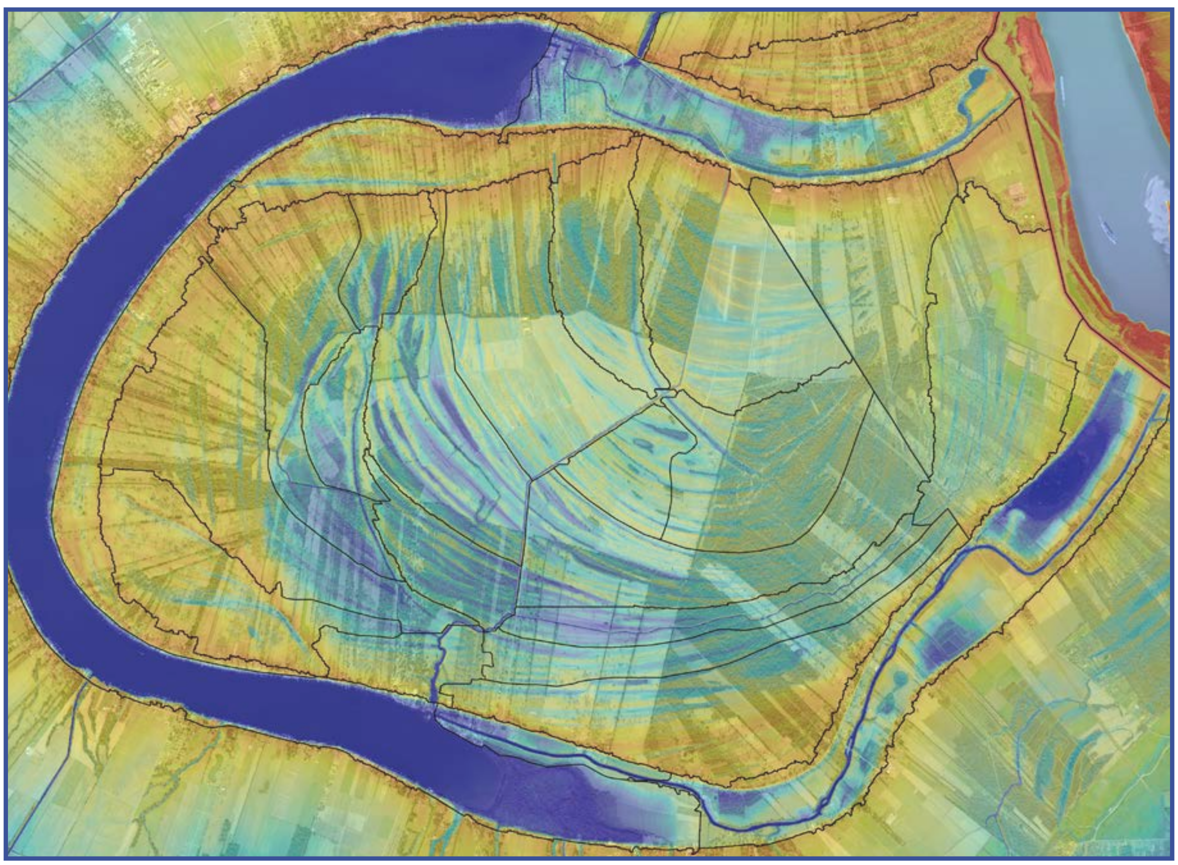
False River Watershed Study:
Discharge Bayou and the Chenal Drainage Network Assessment

Report detailing data collection and modeling effort for the
False River Watershed, prepared for the Department of
Natural Resources and False River Watershed Coalition,
by C.H. Fenstermaker & Associates, LLC.



July 3, 2013

The False River Watershed Study was prepared for the Louisiana Department of Natural Resources and the False River Watershed Council by C.H. Fenstermaker & Associates, LLC.

False River is a 3,000-acre oxbow lake formed from the Mississippi River in Pointe Coupee Parish with a watershed of approximately 37,000 acres. Fisheries, vegetative habitat, and overall water quality have been in decline since the 1980s. The Louisiana Department of Natural Resources, the False River Watershed Council, Chustz Surveying, and local residents teamed with the Water Resources group at C.H. Fenstermaker and Associates to collect hydrologic data, analyze the existing drainage system of The Island, and recommend channel hydromodifications to reduce sediment transport into False River.

Fenstermaker collected data over a six-month period beginning October 2012, developed an existing conditions model, and evaluated several alternatives. This report details the data collection and modeling effort.

False River
Watershed Council

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INTRODUCTION

GEOLOGIC BACKGROUND

Oxbow lakes are typically formed as rivers laterally migrate due to outer bank erosion and sediment deposition on the inner bank. Over time, the meander neck narrows eventually disconnecting the abandoned meander loop. Oxbow lakes form when the abandoned meander loop is completely isolated from the main channel as shown in *Figure* 1 (BBC, 2013; Tetra Tech, 2003).

The fate of an oxbow river lake is determined by the behavior of the main river channel. The oxbow lake may gradually fill with sediment and transform into marsh or swamp if:

- the river channel remains close to the oxbow;
- there is a connection between the water bodies; and
- the oxbow receives water and sediment from the river during high water periods.

However, if the main river channel and oxbow lake are minimally connected (through levees, large distances, etc.), the oxbow lake may remain a deep water body for a greater period of time (Saucier, 1994). The Mississippi River levees removed the connection to False River, and it no longer receives flow during high water events. False River is predisposed to remain a deep water body assuming no other large sediment inputs are available.

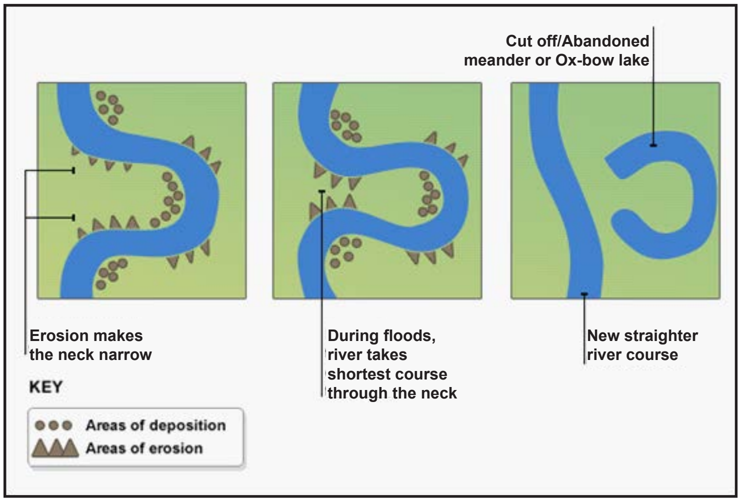


Figure 1 - Illustration describing the progression from a river meander to an oxbow lake (BBC, 2013).

Figure 2 - The Island Channels

Figure 3 - False River Island (the Island)

DESCRIPTION OF REGION/STUDY AREA

The False River watershed encompasses approximately 57 square miles of southeastern Louisiana. Formed in 1722 from an abandoned meander loop of the Mississippi River, False River was completely isolated from riverine flow when the US Army Corps of Engineers (USACE) constructed Mississippi River levees in the 1930s. Presently, False River is a 3,060 acre oxbow lake (dependent on water level) in Pointe Coupee Parish near New Roads, Louisiana (Ensminger, 1999). The watershed is bordered by the Mississippi River on the north and east and False River to the south and west. Primary tributaries providing inflow to False River include Patin Dyke Slough/M-2 Canal, False Bayou, Discharge Bayou/M-1 Canal, and the Chenal (*Figure* 2). For the purpose of this report, references to M-1 Canal include Discharge Bayou. Bayou Sere and the Lighthouse Canal are the only outflow channels for the lake. In 1948, a spillway was constructed at Lighthouse Canal to control False River water levels. In 1989, the Louisiana Department of Transportation and Development (LDOTD) added three 5x8 feet sluice gates (LDNR and LDWF, 2012).

Typical of Mississippi River oxbow lakes, False River has a steep outer bank and a gradually sloping inner bank (Ensminger, 1999). The lake is deepest in the southwest section near Lighthouse Canal. The shallowest portions of False River are found on the northern and southern extents known as the north and south flats. These shallow regions (typically less than five feet in depth) have a highly organic substrate that is extremely susceptible to sediment resuspension from boat wakes and wind shear (LDNR and LDWF, 2012).

Land east of False River is referred to as the Island. The Island is approximately 22,400 acres bound by the Mississippi River to the east, the Chenal to the south, False River to the west, and False Bayou to the north (*Figure* 3). This land was originally bottomland hardwood and swamp habitat before agricultural and residential development moved in. By 1969, approximately 29 percent of the Island (12,000 acres) was used for agriculture and the M-1 Canal was designed to drain the ridges and swales (LDNR and LDWF, 2012). Island agriculture reached a peak in the 1980s with 75 percent of the land used for crop production. During this time, 50 miles of drainage canals (including the M-1 and M-2 canals) were created or expanded and a sediment basin was constructed along the M-1 Canal to improve drainage (LDNR and LDWF, 2012). Agricultural land use has declined in the recent decades with a 2011 NRC report stating that less than eight percent of the Island is used for cropland (LDNR and LDWF, 2012).

FALSE RIVER

The predisposition for a disconnected oxbow lake to remain a deep water body can be jeopardized by high watershed erosion rates resulting in large volumes of sedimentation during runoff events. Erosion can be broadly classified two ways: natural or accelerated erosion. Natural erosion “results from tectonic uplift, earthquakes, weathering, and chemical decomposition and the long-term action of water, wind, gravity, and ice” (Garcia, 2008). Accelerated erosion is the result of human factors (anthropogenic) and can be accelerated by agricultural activities, urbanization, mining activities, and river regulations (Garcia, 2008).

Agricultural activities are a primary anthropogenic factor initiating erosion in lakes, and the Mississippi Delta is a prime agricultural region due to a hot, humid climate and long growing season. The conditions conducive to prolific crops are responsible for the survival of weeds and pests causing agricultural lands in the region to rely on agrochemical pest control. These agrochemicals are often transported into nearby lakes during runoff events, further reducing water quality (Leonard, 1988). Combined with increased sedimentation due to agriculturally accelerated erosion, many delta oxbow lakes that were historically known for their fish productivity and recreational value are facing challenges with declining water quality and clarity.

Elevated suspended sediment levels can impact the biodiversity of water bodies in many ways. Suspended sediments can increase turbidity levels making it more difficult for light to penetrate the water column. Subsequently, high turbidity levels limit photosynthesis jeopardizing the survival of submerged aquatic vegetation. High turbidity levels also reduce respiratory capacity of aquatic invertebrates and limit the feeding ability of visual predators and filter feeders (Tetra Tech, 2003). As sediment is deposited on the bed of water bodies, habitat complexity is reduced as voids and pools are filled. Sediment deposited on shell beds may cover the substrate used by fish and invertebrates for egg placement and can bury benthic plants and animals (Phillips, 2005). Finally, sediment can transport toxic materials, potential pathogens, and nutrients contaminating waterways.

The False River ecosystem has been in decline for decades, seemingly due to high sediment and nutrient loads. The most recent US Environmental Protection Agency (EPA) Waterbody Report in 2010 declared False River as Impaired for fish and wildlife propagation. High pH levels from unknown sources and the introduction of non-native aquatic plants have been the cause of impairment according to the EPA (US EPA, 2010). Data collected for the Louisiana Department of Environmental Quality (LDEQ) report in 2003 indicated the lake was experiencing organic enrichment (LDEQ, 2003). While these findings are from nearly a decade ago, they are presumed applicable today, as evidences by common algal blooms and a "pea-green" water color. This conclusion also correlates with the 2010 LDEQ findings, as high pH levels are common in waters with algal blooms.

TIMELINE (LDNR AND LDWF, 2012)

- **1948** The Lighthouse Canal is built to control the lake stage.
- **1969** Design survey for the M-1 Canal is started.
- **1977** EPA describes the lake as eutrophic with severely low dissolved oxygen levels in the summer.
- **1981** US Natural Resources Conservation Service (NRCS) completes installation of the M-1 and M-2 Canals and associated sediment basins.
- **1999** Pointe Coupee Police Jury (PCPJ) excavates a large amount of sediment (>10,000 cubic yards) from the sediment basin.
- **2001** USACE proposes the False River Aquatic Ecosystem Restoration Study.
- **2003** USACE estimates that 28,000 tons of sediment is being deposited into False River annually.
- **2006** PCPJ excavates approximately 8,000 to 10,000 cubic yards of sediment from the sediment basin.
- **2010** PCPJ excavates 1,200 to 1,500 cubic yards of sediment from the sediment basin.
- **2011** NRCS estimates that approximately 21,000 tons of sediment is lost to erosion from crop and pasture land in the False River watershed.

SIMILAR CASE STUDIES

MISSISSIPPI OXBOW LAKE WATERSHEDS

In a study led by the USDA Agricultural Research Service National Sedimentation Laboratory, three oxbow lakes in the Mississippi River alluvial plain were monitored for pesticides before and after best management practices (BMPs) were in place. The three year study used an intensive sampling of surface water, shallow ground water, and sediments to understand pesticide contamination of closed-system oxbow lakes in the Mississippi Delta. The oxbow lakes studied include Beasley Lake, Deep Hollow Lake, and Thighman Lake (Cooper, Smith, & Moore, 2003).

The Beasley Lake watershed (Sunflower County, Mississippi) received minimal BMP treatment: grade stabilization, water control structures including slotted-board water control structures (including slotted-inlet pipes, overfall pipes, and culverts), and grass filter strips used along major inlet channels to the lake. An existing large forested wetland area adjoining the lake provided additional natural water treatment. Deep Hollow Lake watershed in Leflore County, Mississippi, received an intensive BMP effort including the placement of winter wheat cover crop and conservation tillage for selected cotton and soybean fields. Herbicide input was reduced through ground breaking weed sensor technology. Additionally, grass filter strips and stiff grass hedges along with slotted-board riser pipes and slotted-inlet pipes were used at critical drainage locations. Thighman Lake watershed in Sunflower County, Mississippi served as a control lake with no initial BMPs.

The study showed lake contamination due to current-use pesticides was reduced using on-field and edge-of-field BMPs, and the forested wetlands and vegetated drainage ditches were highly efficient in neutralizing the pesticides that reached Beasley Lake. The Mississippi Oxbow Lake study demonstrated edge-of-field vegetation ranging from grass buffers to vegetated drainage ditches or forested wetlands provides valuable and inexpensive ways to improve water quality (Cooper, Smith, & Moore, 2003).

MOON LAKE, MISSISSIPPI

In Coahoma County, Mississippi, Moon Lake (a 2,342 acre oxbow lake) struggled with high turbidity levels from runoff of a 57,000 acre watershed (80 percent was agricultural). In the early 1980s, steps were taken to determine the historic decline in fish population and recreational activity as a result of reduced depth, water clarity, and water quality (Tetra Tech, 2003). Feasibility studies in the early 1990s indicated the presence of pesticides and increased sedimentation rates were dramatically reduced by switching to less intensive crop farming (FTN Associates, 1991). Despite this reduction in sedimentation rates, Moon Lake is on Mississippi's 1996 Section 303(d) List of Impaired Water Bodies due to high turbidity levels after storms (FTN Associates, 1991; Cooper, 1989).

As an Impaired Water Body, it was mandated that a Total Maximum Daily Load (TMDL) for Moon Lake be established. Collected data was used with the Generalized Watershed Loading Function (GWLF) model (Haith & Shoemaker, 1987) to establish the lake volume and estimate annual inflows to determine TMDLs. The Brune Method (United States Army Corps of Engineers, 1989) estimated trap efficiency of the lake, and siltation rates were used to estimate the lake's life span under various land management scenarios. A reduction in sediment load was recommended to address the siltation loading (Tetra Tech, Inc, 2003).

TAMPA BAY, FLORIDA

Storm water runoff from Tampa International Airport discharged into drainage canals which conveyed flow to Tampa Bay (Storm Water Solutions, 2013). Over time, these drainage canals became inefficient and were in need of cleaning and grading. The construction team performing this work was required by the State of Florida to keep turbidity values below 31 NTU for discharge entering the Tampa Bay. With turbidity reading as high as 620 NTU, the construction team used sediment bags and biopolymers (liquid biopolymer-2101 & LiquiFloc) to reduce turbidity. These measures appeared to work well with the system due to its relatively low storm water runoff (150 gallons per minute) and short project duration. The construction team continues to monitor the area using YSI data sondes and reports the collected data to the EPA.

CHESAPEAKE BAY

The Chesapeake Bay watershed receives runoff from 64,000 square miles of land including the District of Columbia, New York, Pennsylvania, Maryland, Delaware, Virginia, and West Virginia. The region has seen an alarming increase in sedimentation rates. Timber harvesting, agricultural, and urban land conversion have led to a nearly 500 percent increase in sedimentation since the 1800s (Phillips, 2005). An overabundance of sediment and nutrients carried into the bay cause poor water quality and clarity.

In an effort to reduce the amount of sediment and nutrients deposited in Chesapeake Bay, multiple reservoirs were constructed along the Susquehanna River in the early 1900s. This method has worked well, with the reservoirs effectively trapping and slowly filling with nutrient-laden sediment. This infilling, however, has become a concern of late. Two of the reservoirs are considered full and no longer trap significant quantities of sediment or nutrients. USGS estimates the third reservoir will reach sediment storage capacity within the next 20-25 years (Phillips, 2005). In 2005, the USGS suggests that a reduction in both nutrient and sediment transport is needed, and strategies will have to be implemented to address each problem individually. The primary focus has been placed on preventing sediment runoff to near-shore areas.

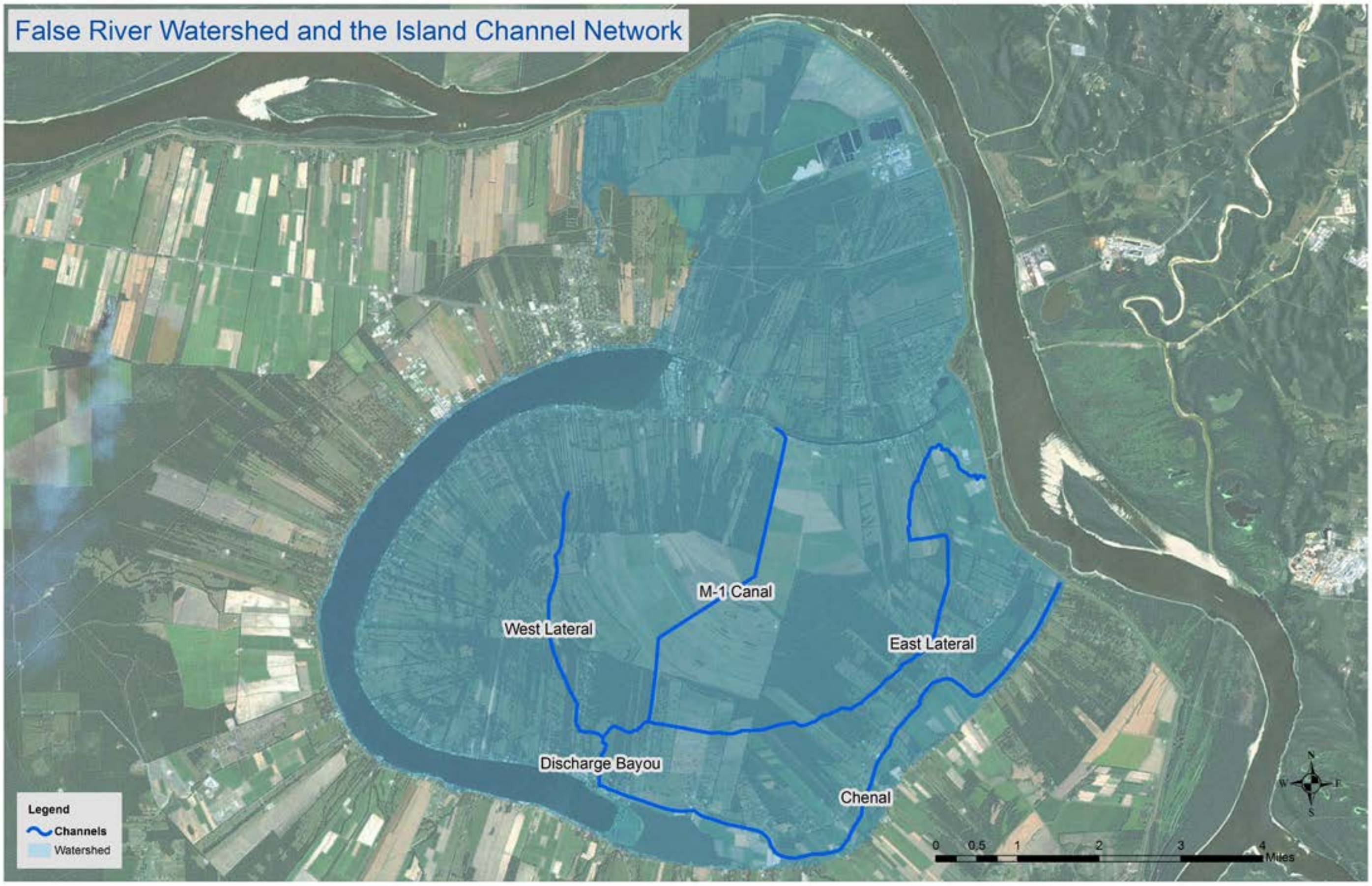


Figure 4 - False River Watershed and the Island Channel Network

METHODS

Approximately 36,500 acres (57.1 square miles) drain into False River through 35 miles of main channels (*Figure* 4). Fenstermaker was tasked with studying the Island of the False River watershed, specifically the Chenal and M-1 Canal. Fenstermaker developed hydrology models using HEC-HMS v.3.5 and hydraulic models in HEC-RAS v.4.1.0. The hydrologic and hydraulic models were used to determine existing channel flow parameters and analyze sediment reduction alternatives using collected water level and turbidity data.

HYDROLOGY MODELS

The HEC-HMS hydrology models were developed by delineating basins, collecting rainfall data, and determining land use. These models produced runoff hydrographs for each basin as shown in *Figure* 5. The hydrographs were representative of three specific storm events: 100-year,

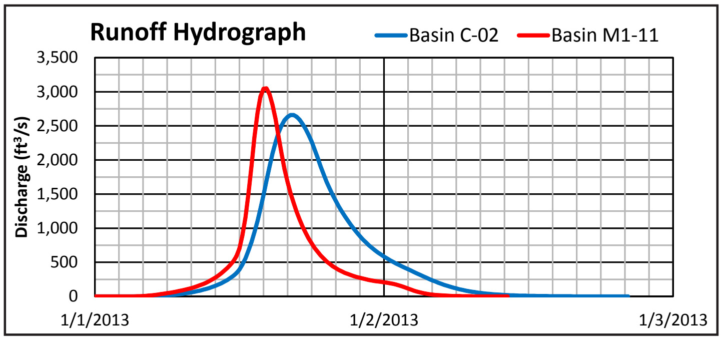


Figure 5 - HEC-HMS Output: Runoff Hydrograph

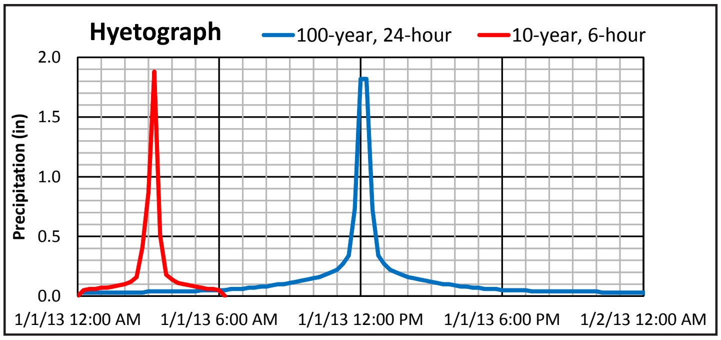


Figure 6 - Runoff Hyetograph

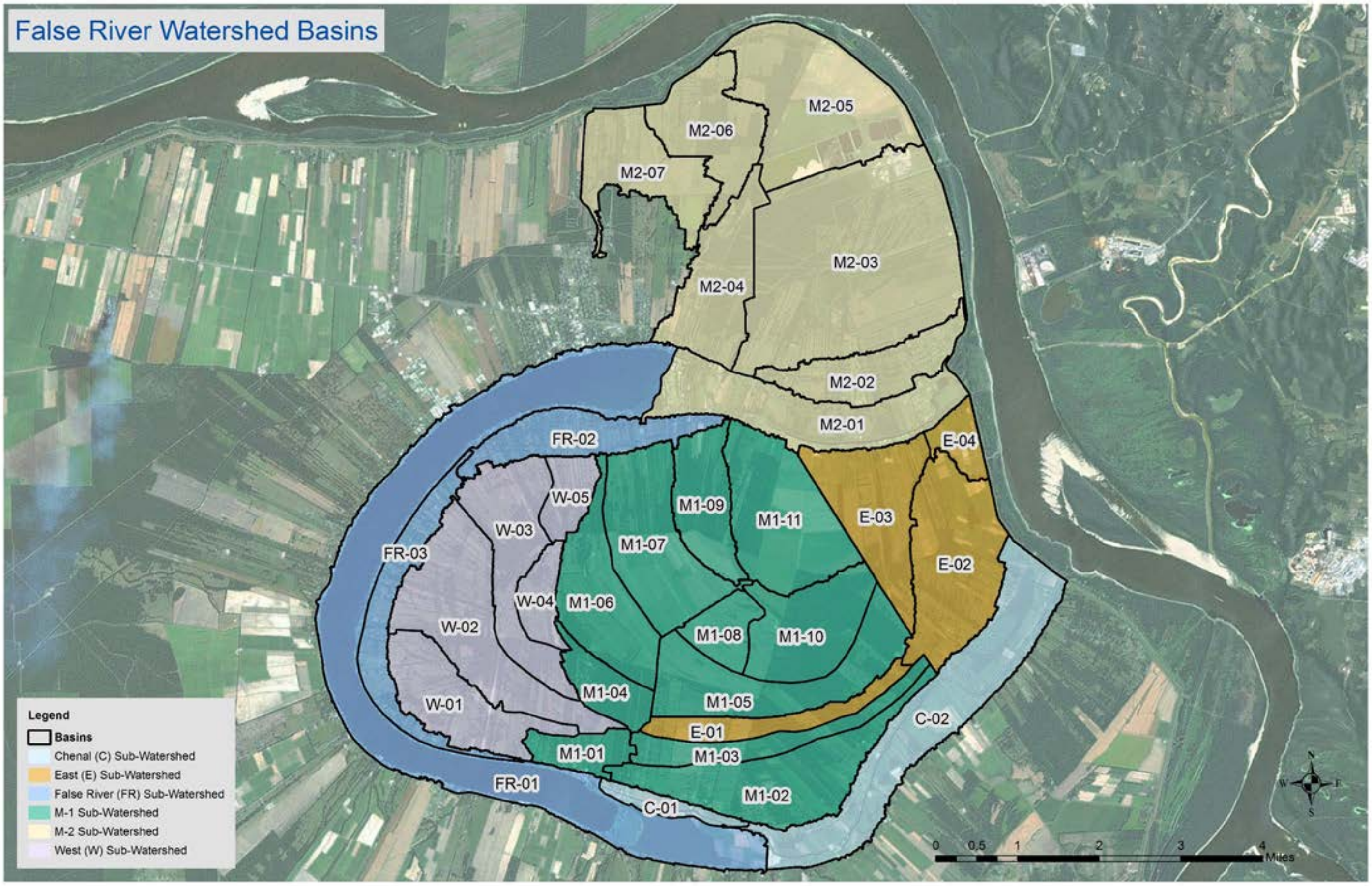


Figure 7 - False River Watershed Basins

Table 1: Sub-Watershed Areas		
Sub-watershed	**Area (acres)**	**Runoff Volume (acre-ft)**
Chenal	2,248	696
East	3,415	1,117
False River	5,879	2,110
M-1	9,886	3,251
M-2	10,803	3,449
West	4,324	1,420

24-hour; 10-year, 6-hour; and December 10, 2012. The 100-year storm event is used by FEMA to delineate flood zones and in south Louisiana this represents a 12.6 inch rainfall over 24 hours. The 10-year storm event represents 5.5 inches of rain over six hours. ON December 10, 2012 approximately 1.5 inches fell over four hours.

For this study, the False River watershed was delineated into six sub-watersheds and 32 basins as shown in *Figure* 7. Table 1 lists sub-watershed areas and runoff volume during a 10-year, 6-hour storm event (5.5 inches over six hours, see *Figure* 6 for the hyetograph). The M-1 and M-2 sub-watersheds show the largest runoff volumes mainly due to their large contributing area compared to the other sub-watersheds, while the Chenal and East sub-watershed show the smallest runoff volumes. Detailed attributes for each basin are located in Appendix B.

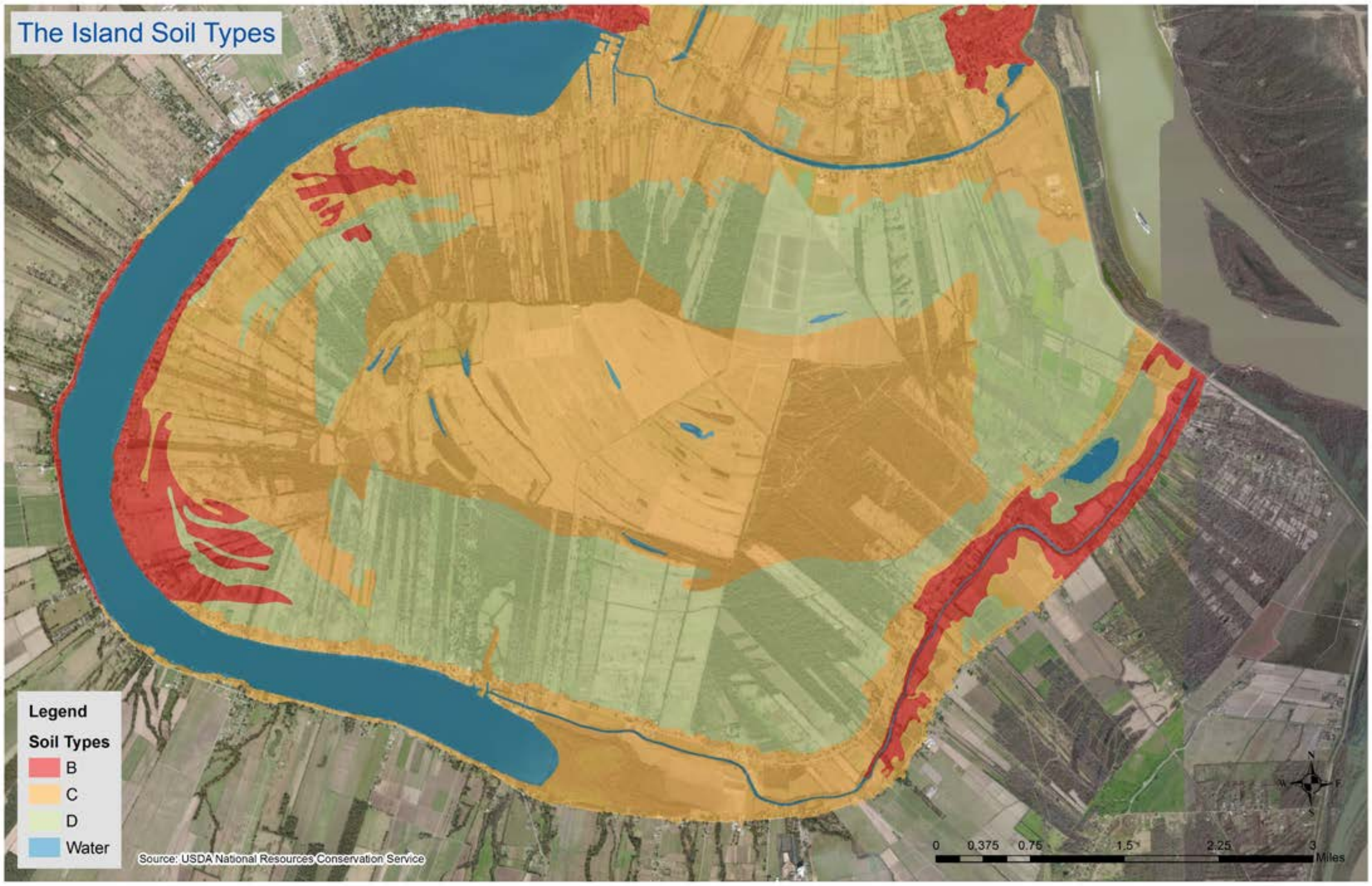


Figure 8 - The Island Soil Types

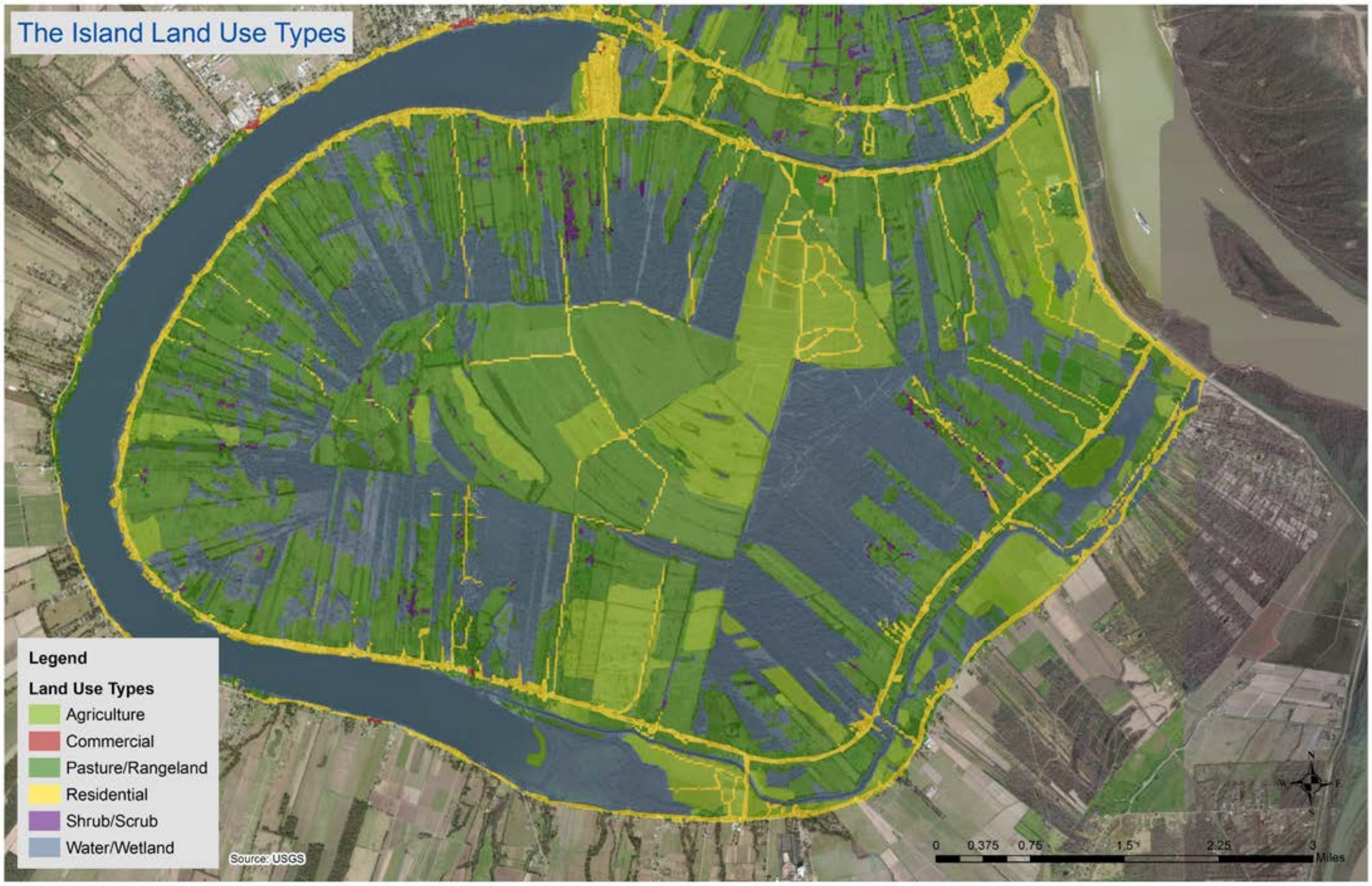


Figure 9 - The Island Land Use Types

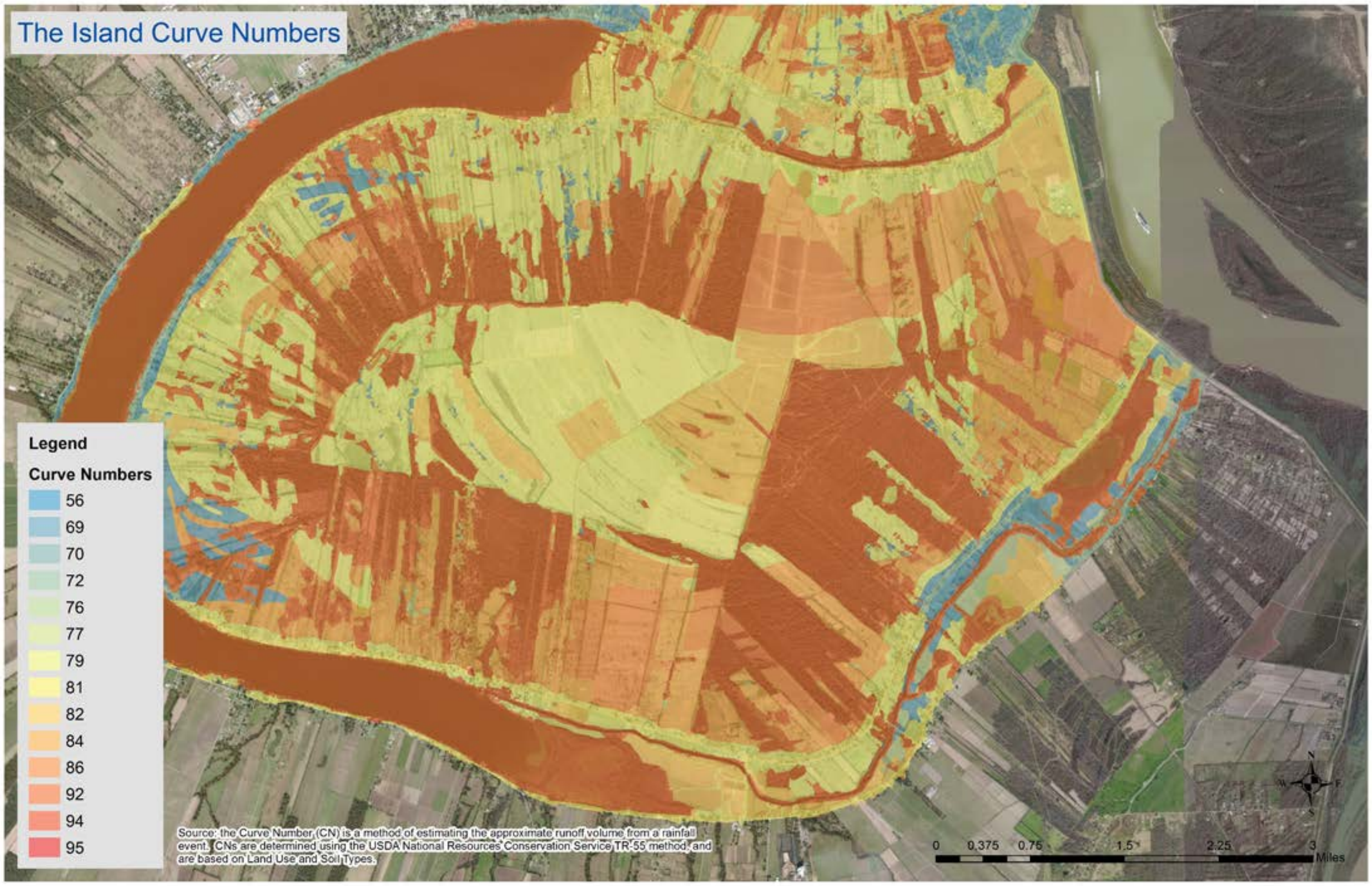


Figure 10 - The Island Curve Numbers

Table 2: Soil Table
Group A: low runoff potential, high infiltration rates even when thoroughly wetted, and consist chiefly of deep, well drained sand or gravel
Group B: moderate infiltration rates when thoroughly wetted and consist chiefly of moderately deep, moderately well drained soils with moderately fine to moderately coarse textures
Group C: low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine texture
Group D: high runoff potential, very low infiltration rates when thoroughly wetted, and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material

Figures 8 through 10 show soil types, land use designations, and Curve Numbers for the False River Island watershed. Approximately 85 percent of the Island is classified as soil types C and D (52 percent and 32 percent, respectively) which typically consist of clays, silts, and loams showing poor infiltration and high runoff potential (USDA NRCS, 2007). See Table 2 for more detailed descriptions of soils. The majority of the land use in the watershed is agricultural and pasture (39 percent and 13 percent) with limited areas of residential and commercial uses (approximately eight percent). The Curve Numbers ranged between 95 and 56 with an average of 82. Curve Number (CN) is a method of estimating the approximate runoff volume from a rainfall event. CN is determined by the USDA National Resources Conservation Service (NRCS) TR-55 Method, which uses land use and soil types to estimate runoff. Overall, the Island watershed shows poor infiltration and high runoff potential coupled with large areas of agriculture and pasture lands.

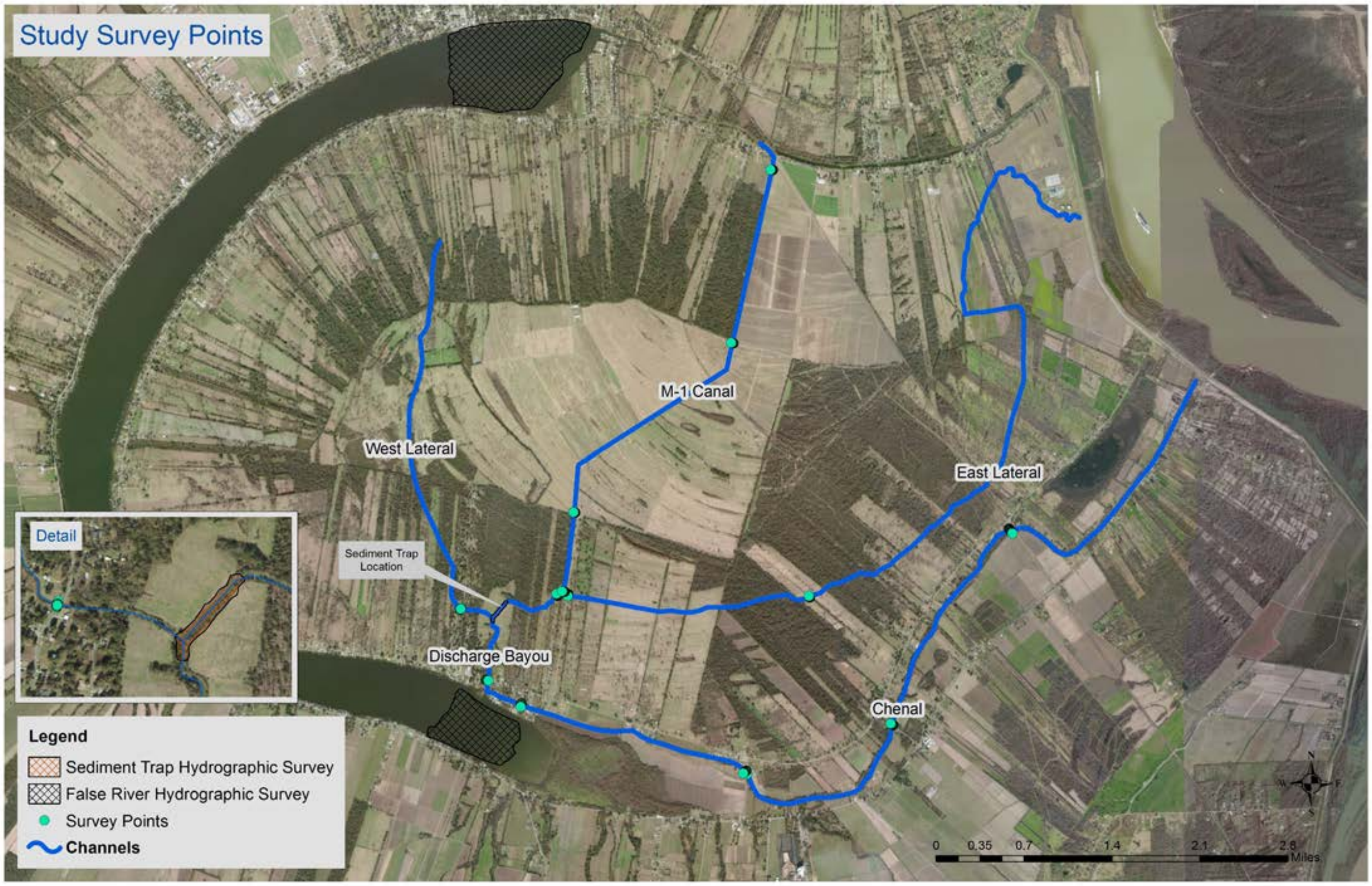


Figure 11 - Study Survey Points

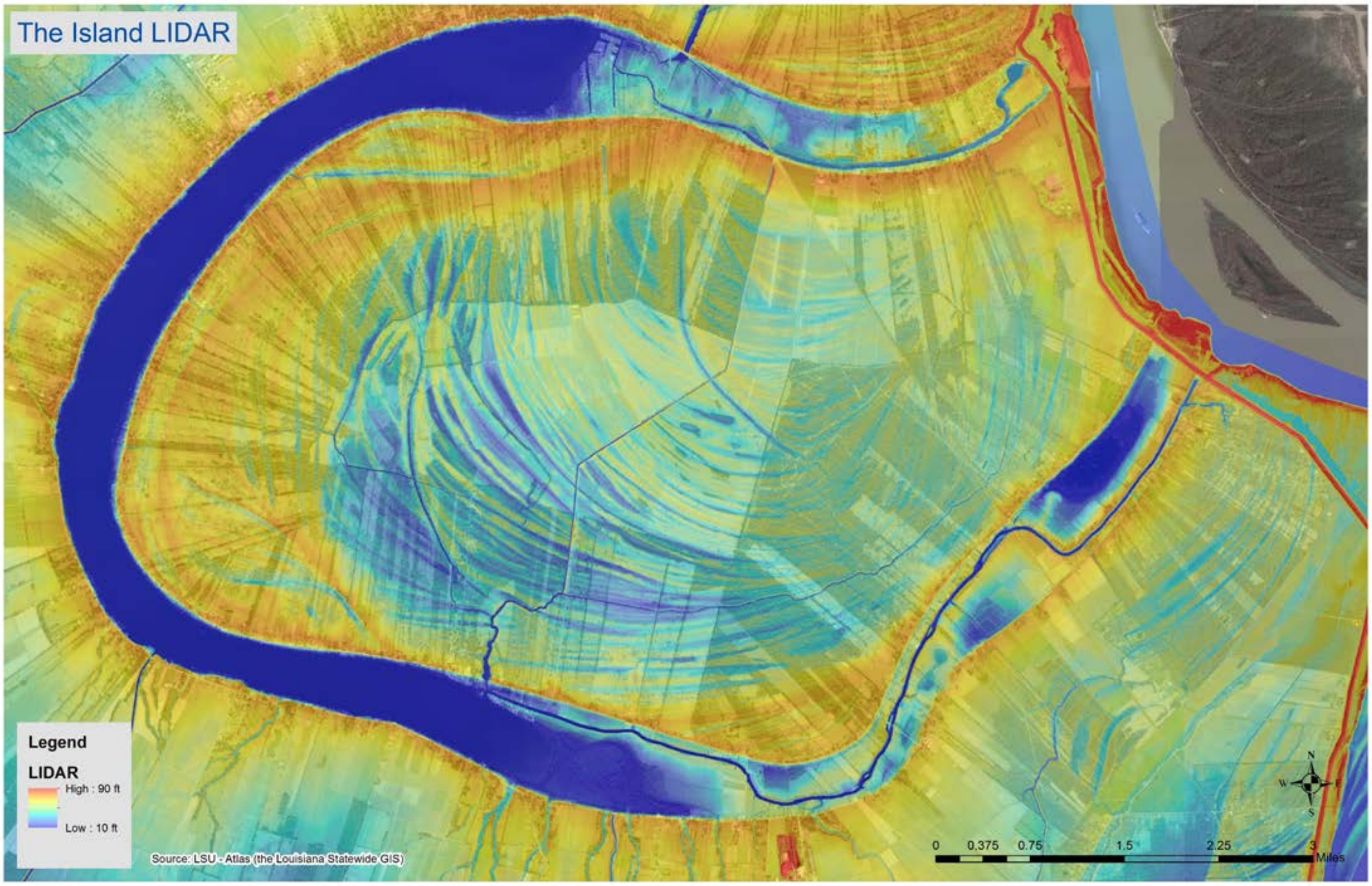


Figure 12 - The Island LIDAR

Figure 13 - The Island Low Lying Areas

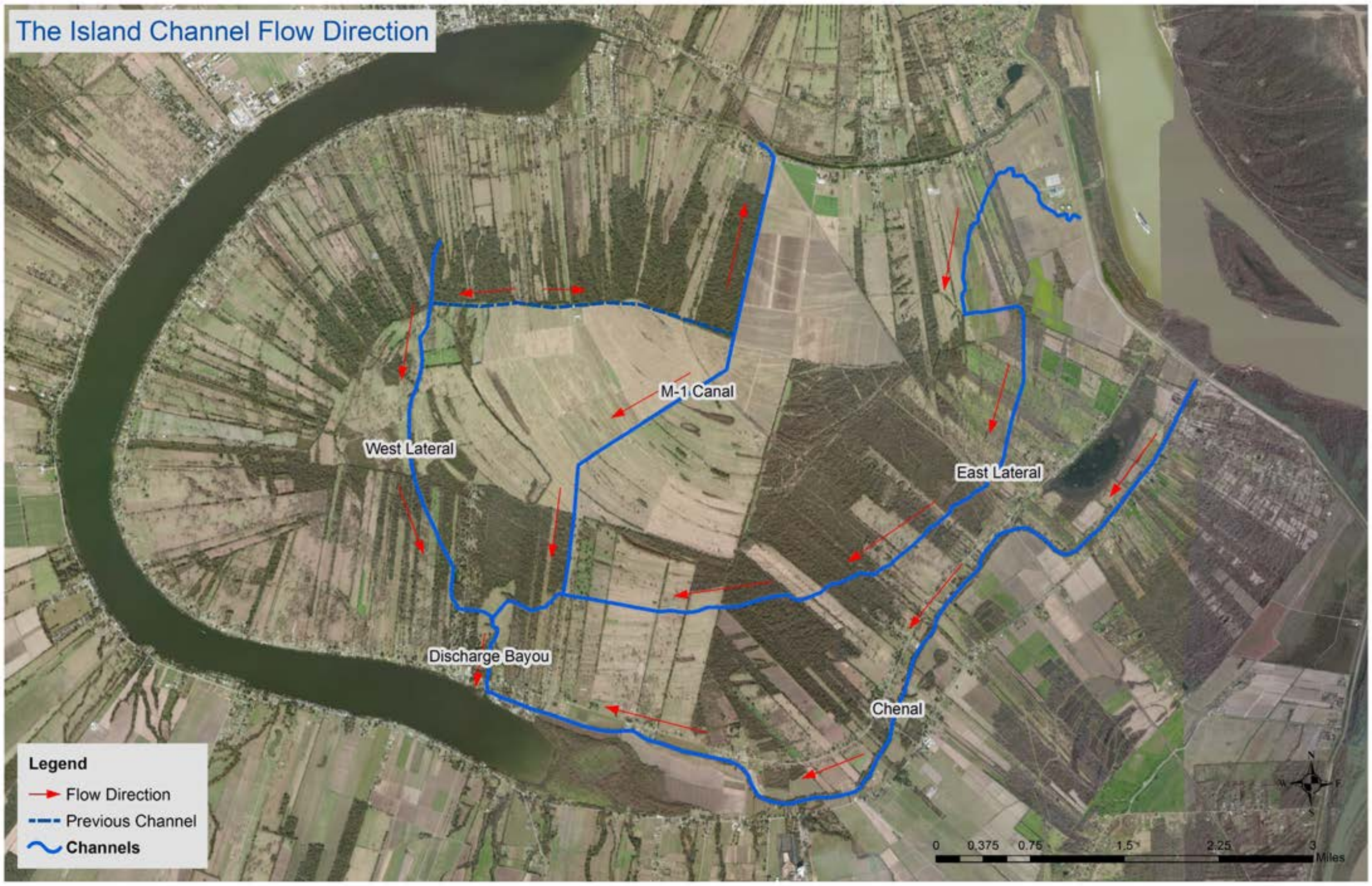


Figure 14 - The Island Channel Flow Direction

HYDRAULIC MODELS

The HEC-RAS hydraulic models were developed using survey data, field visits, and collected water levels. These models replicated water level, discharge, and velocity along the studied Island channels. Discharges from HEC-HMS were linked to HEC-RAS to replicate existing conditions and proposed alternatives.

Chustz Surveying, Inc. provided topographic and bathymetric data along the Chenal, East, M-1 Canal, and West channels in addition to bathymetric data in the north and south flats of False River (*Figure* 11). Light Detection and Ranging (LIDAR) data from LSU Atlas was used to complete the topographic surface (*Figure* 12). The cold colors (blues) represent low-lying areas and the hot colors (reds) are higher ground. As shown in *Figure* 13, approximately 3,500 acres of low-lying area are now drained by the East, M-1 Canal, and West channels. *Figure* 14 shows flow direction along these channels.

The Chenal and M-1 Canal are the two major drainage systems on the Island. The M-1 drains approximately 17,600 acres into False River, and the Chenal drains 2,200 acres. As shown in *Figure* 15, the Chenal is 3.5 miles longer than the M-1, but the slope is much less (5.4×10^{-5} ft/ft compared to 5.3×10^{-4} ft/ft). Surveyed channel dimensions are shown in *Figure* 17. The locations for these surveyed channels are shown in *Figure* 18. The channel area increases and elevation decreases downstream along the M-1 Canal, while the Chenal is relatively constant. The channel slopes and dimensions suggest the M-1 Canal has a higher velocity than the Chenal.

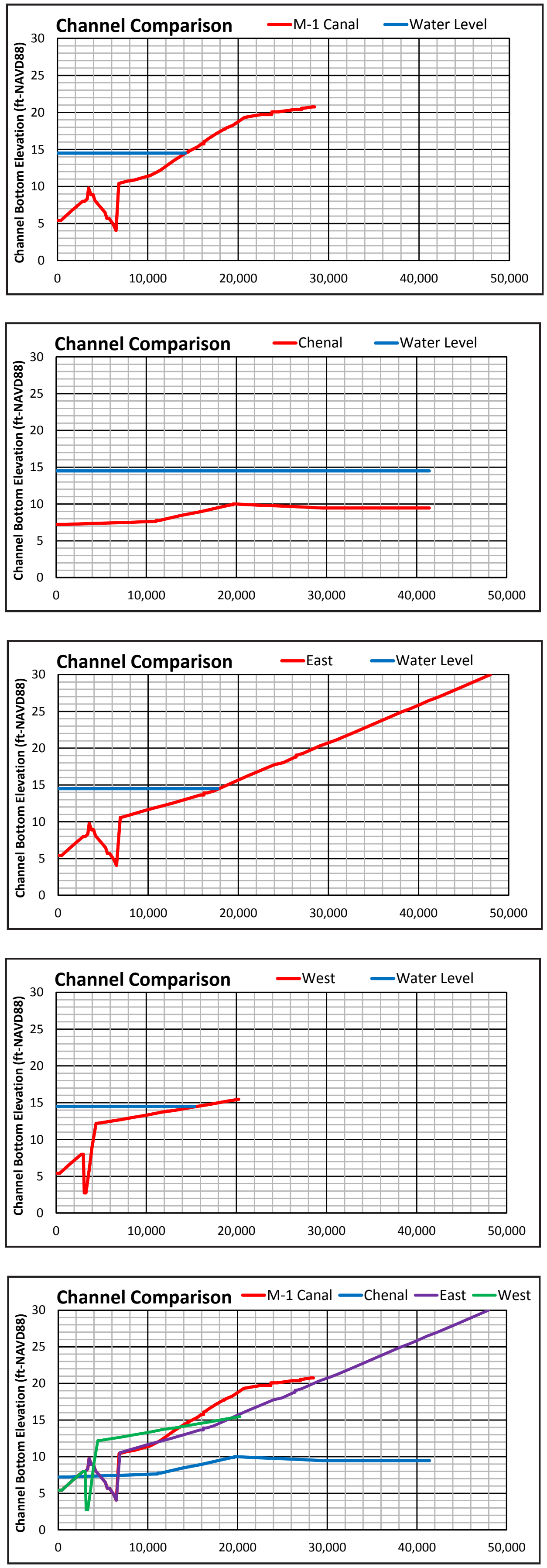


Figure 15 - Channel Comparison

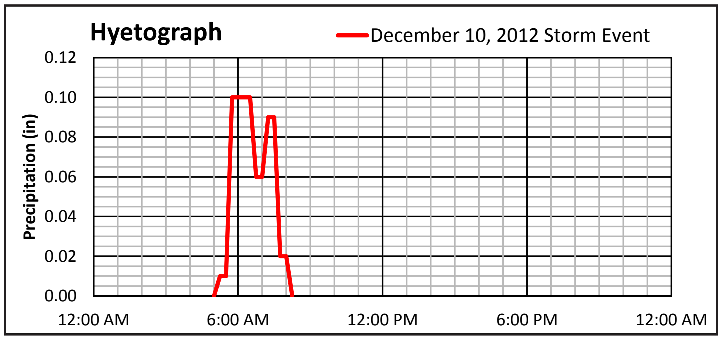


Figure 16 - False River Hyetograph from December 2012

MODEL CALIBRATION AND VALIDATION

The hydrologic and hydraulic models were calibrated using a storm event on December 10, 2012. Over four hours approximately 1.5 inches of rain fell on False River (*Figure* 16). Spatially and temporally varying rainfall data from the National Climatic Data Center and False River water levels from Pointe Coupee Parish were used to calibrate the models. As shown in *Figure* 19, the models accurately replicated existing conditions. See *Figure* 20 for Modeled Water Level Comparison Locations.

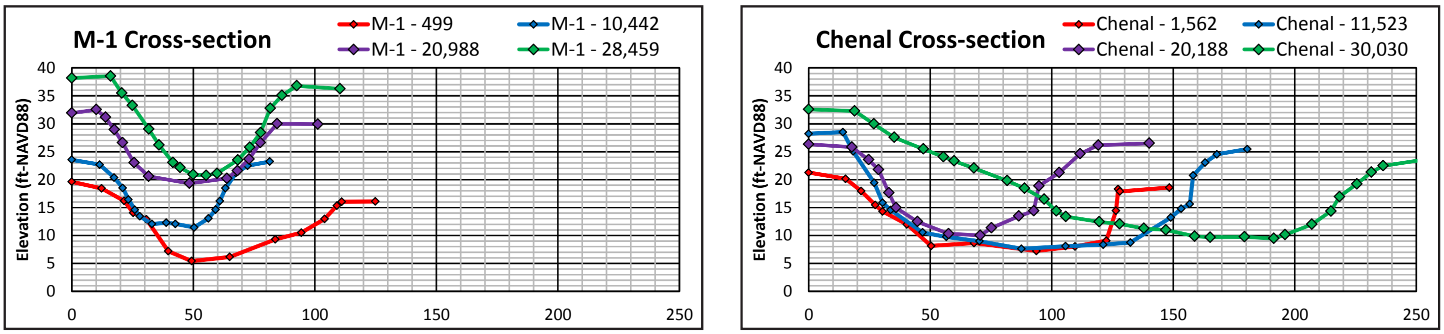


Figure 17 - Channel Cross-sections

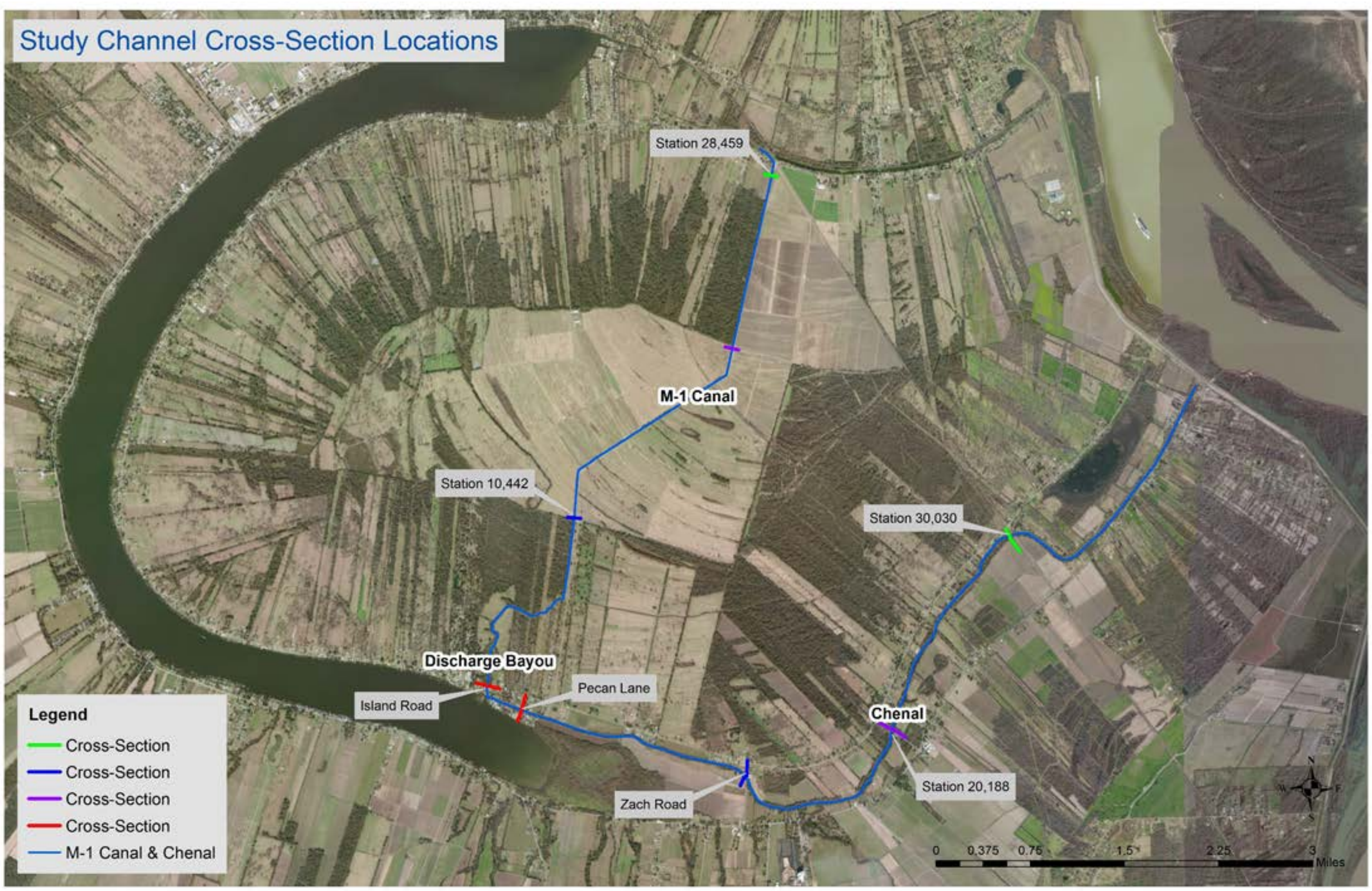


Figure 18 - Channel Cross-section Location Map

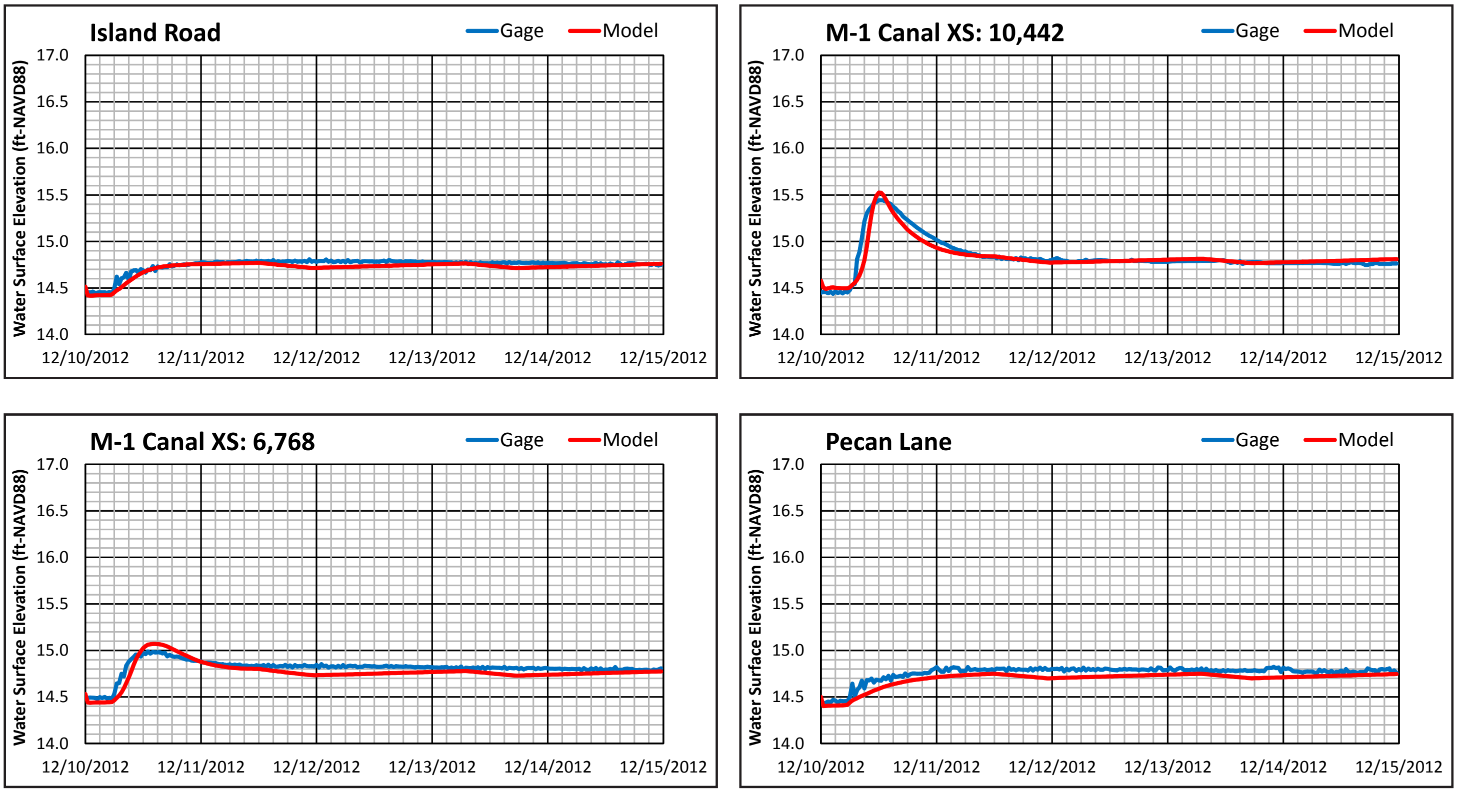


Figure 19 - Calibration Collected and Modeled Water Level Comparisons

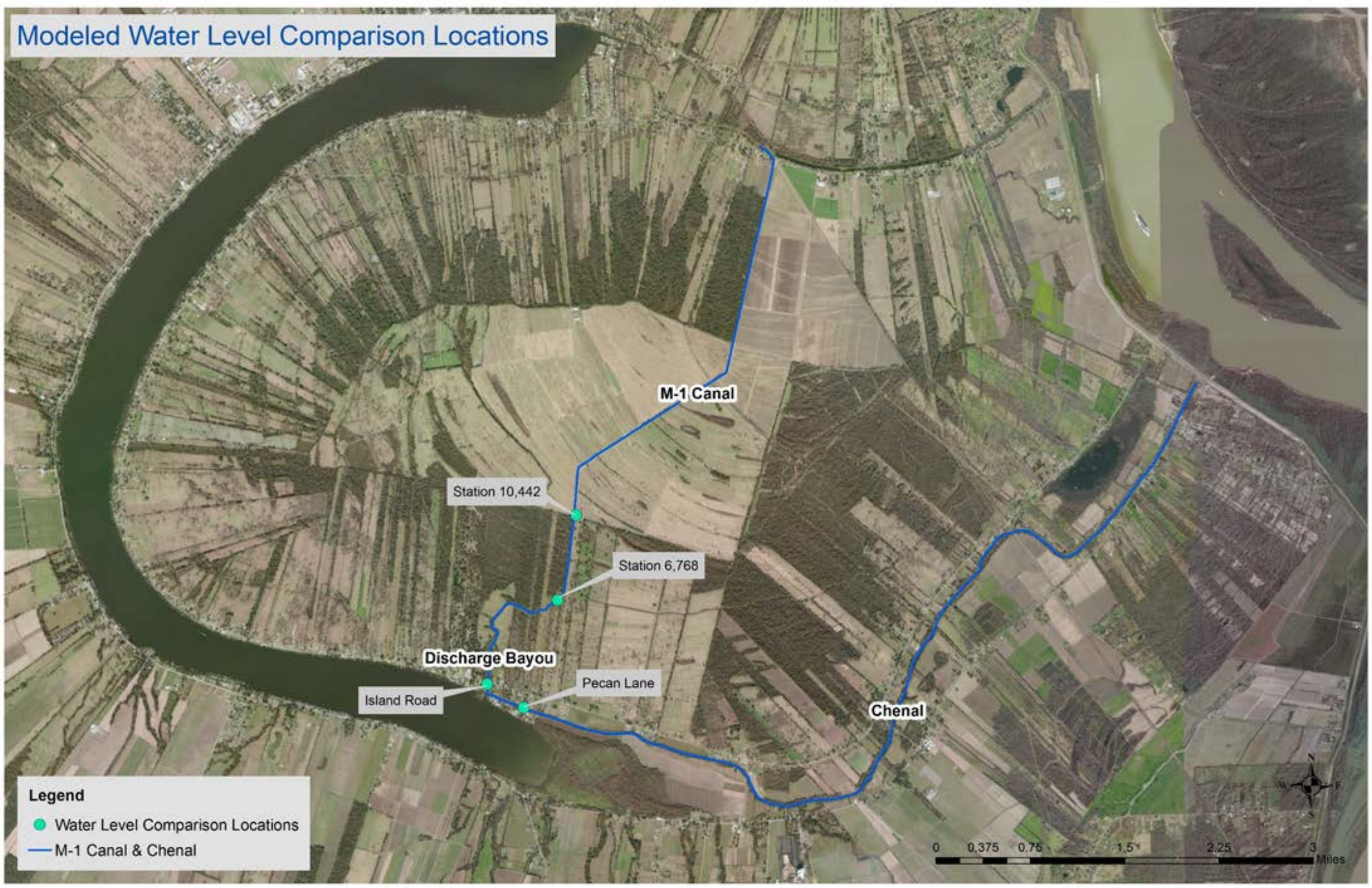


Figure 20 - Modeled Water Level Comparison Locations

DATA COLLECTION

Water level and turbidity data were collected using YSI data sondes, and hand collected water samples were analyzed by the Wetland and Aquatic Biogeochemistry Lab at the Department of Oceanography and Coastal Sciences in the School of Coast and Environment at Louisiana State University (*Figure* 21).

Data sondes collected water level and turbidity data at five locations along the Chenal and M-1 Canal channels (*Figure* 22) on a continuous 30 minute interval. The collection period spanned from October 15, 2012, through April 23, 2013. *Figures* 23 through 26 show processed water level and turbidity readings for each location. Water levels along the M-1 Canal were typically highest at Stations 10,442 and 6,768. Island Road, Pecan Lane, and Zach Road generally showed similar water levels indicating that water levels in the Chenal are dictated by the M-1 Canal and False River water levels. Turbidity values were the lowest along the Chenal. Typically, turbidity along M-1 was highest at Station 10,442 and lowest at Island Road.

Figure 21 - Data Collection Equipment

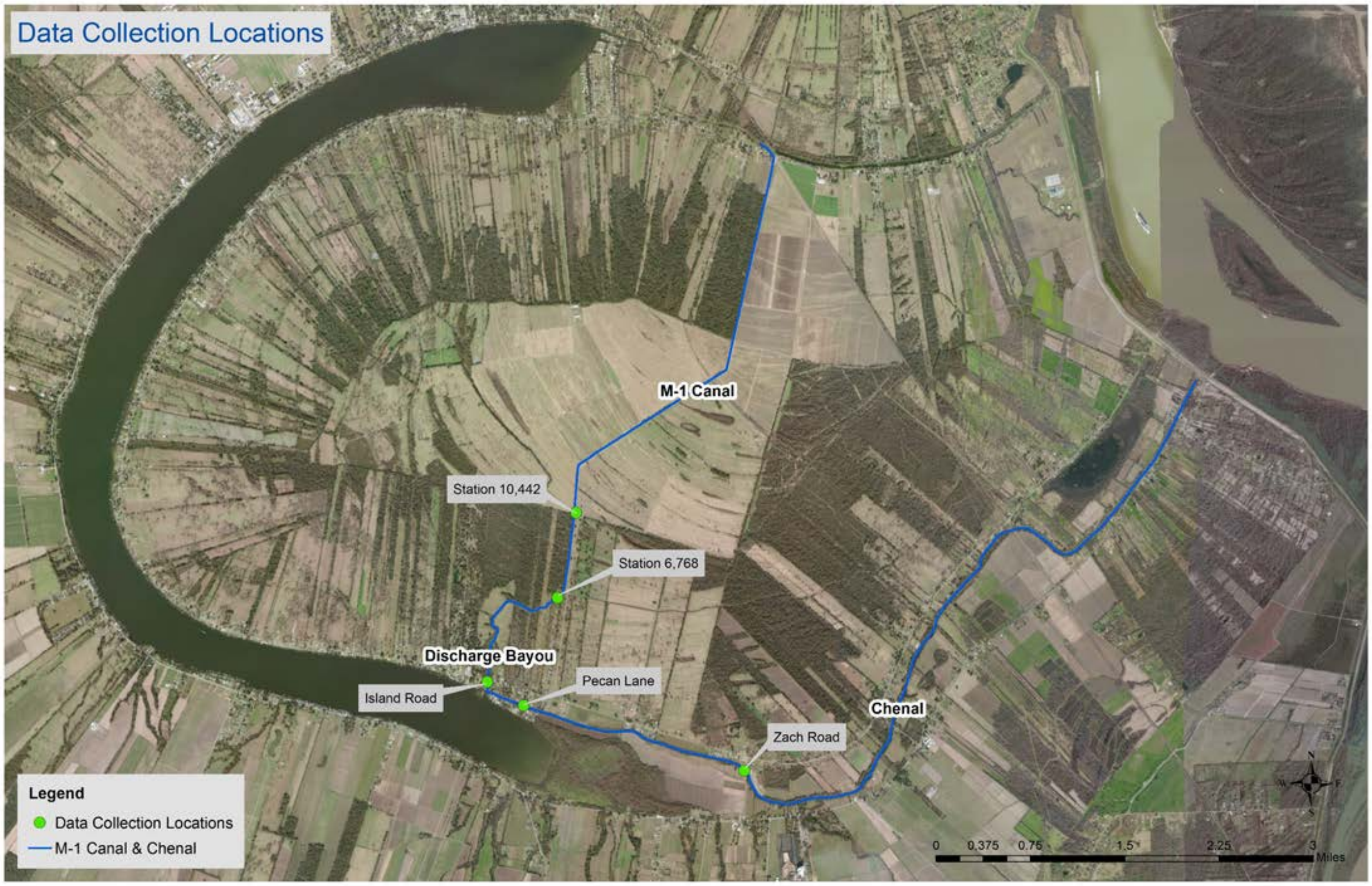


Figure 22 - Data Collection Locations

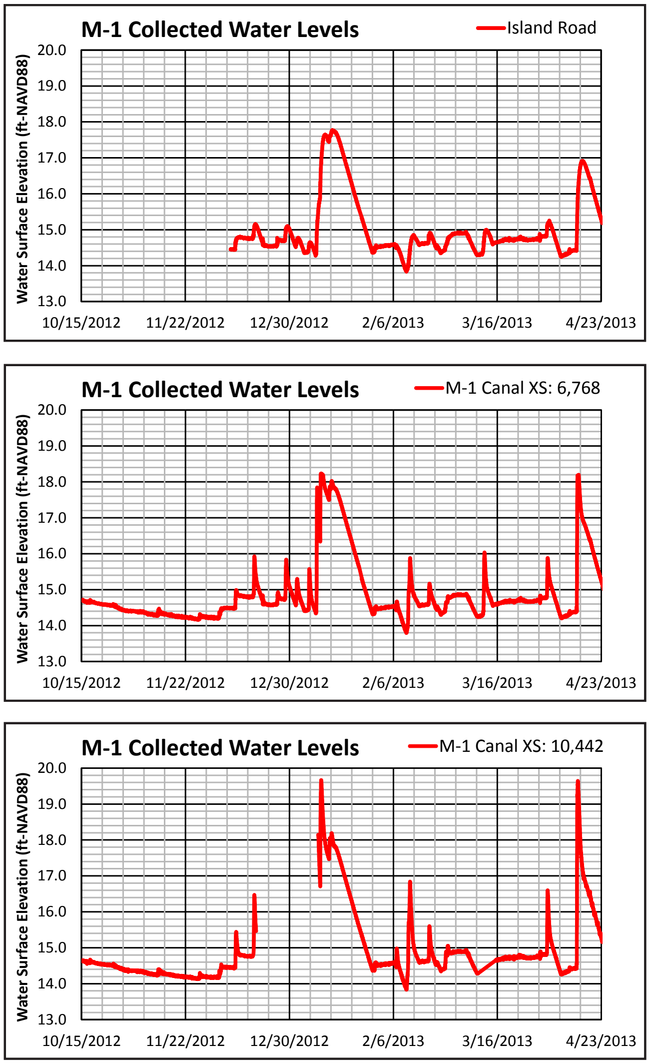


Figure 23 - M-1 Canal Collected Water Level Data

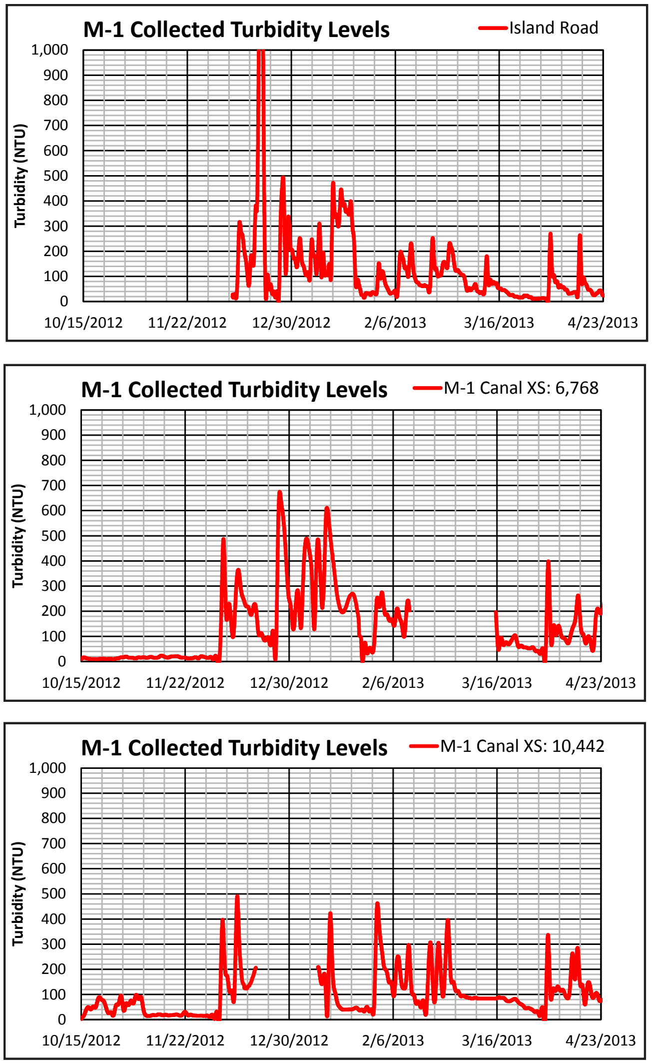


Figure 25- M-1 Canal Collected Turbidity Data

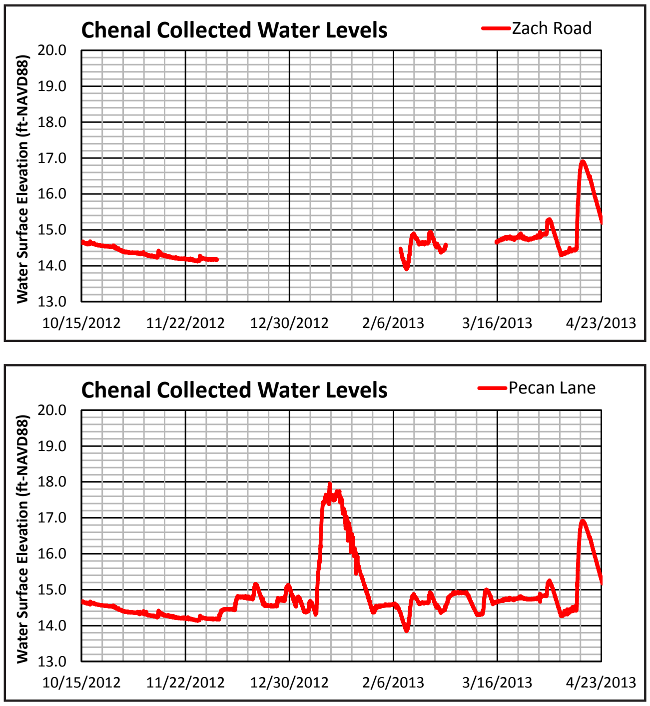


Figure 24 - Chenal Collected Water Level Data

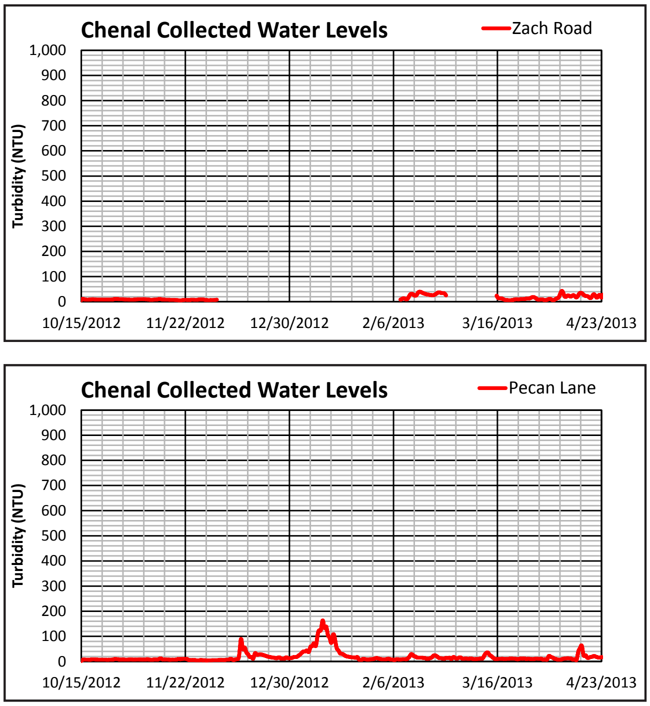


Figure 26 - Chenal Collected Turbidity Data

Table 3: Collected and Processed Data Statistics					
Data Sonde	Location	Water Level (ft-NAVD88)			
		# of Readings	Maximum	Median	Minimum
1	M-1: Island Road	6,418	17.77	14.73	13.83
3	Chenal: Zach Road	5,024	16.91	14.65	13.90
5	M-1 Canal: 10,442	7,513	19.67	14.59	13.83
6	Chenal: Pecan Lane	9,073	17.96	14.62	13.84
7	M-1 Canal: 6,768	9,696	18.24	14.59	13.80

Table 4: Collected and Processed Turbidity Statistics					
Data Sonde	Location	Turbidity (NTU)			
		# of Readings	Maximum	Median	Minimum
1	M-1: Island Road	6,429	1,286	78.4	0
3	Chenal: Zach Road	5,043	42	10	6
5	M-1 Canal: 10,442	7,508	491	77	0
6	Chenal: Pecan Lane	9,110	163	11	2
7	M-1 Canal: 6,768	7,617	675	88	0

As shown in Tables 3 and 4, water levels and turbidity readings were generally highest along the upstream portions of the M-1 Canal. Water levels ranged 5.8 feet at Station 10,442, 4.5 feet at Station 6,768, and 3.9 feet at Island Road. Water level fluctuations along the Chenal are similar to those at Island Road. Turbidity values are generally highest at Station 10,442 and tend to diminish downstream along the M-1 Canal, while turbidity readings along the Chenal are typically lower. The collected data suggests sediment loads along the upstream portions of M-1 Canal are typically highest, and the introduction of less turbid discharge from the East and West channels cause a reduction in turbidity levels. The data also suggests the Chenal's small sub-watershed does not produce large stormwater runoff volumes and the system is dictated by the M-1 Canal.

The relationship between water level and turbidity was variable. Typically turbidity peaked as the water levels increased, however turbidity peaked as the water levels receded on several occasions (*Figure* 27).

This data collection effort spanned six months and may not be representative of long-term water level and turbidity trends along the Chenal and M-1 Canal. Further, False River outlet control keeps water levels elevated along the Chenal and M-1 Canal due to a maximum drawdown rate of two inches per day (GEC Environmental Resources, 2012). The relationship variations between turbidity and water levels could be caused by several sources including land use changes (agricultural tilling, land clearing, shoreline development, etc.) and longer collection periods could refine the turbidity and water level relationship.

DISCHARGE TO TSS RELATIONSHIP

A relationship between discharge and total suspended solids (TSS) was established to estimate the amount of sediment entering False River through the Chenal and M-1 Canal. The following correlations were made to estimate False River sediment loads:

- Collected water level to modeled discharge;
- Collected turbidity to analyzed TSS; and
- Modeled discharge to analyzed TSS.

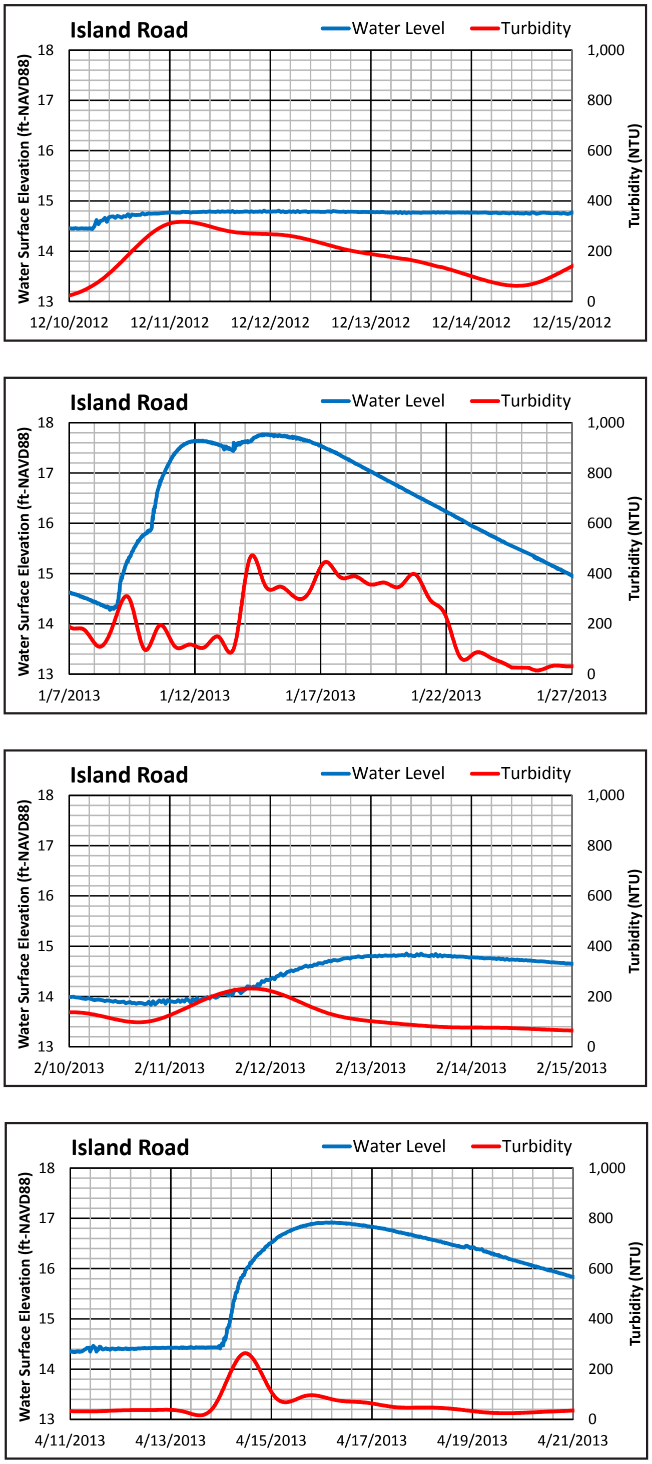


Figure 27 - Water Level - Turbidity Comparison

As previously discussed, False River is outlet controlled which keeps water levels elevated during storm events. This means water levels stayed elevated while discharges receded as shown in *Figure* 28. However, the rising and falling limbs of the Water Level – Discharge Rating Curve were well correlated (*Figures* 29 and 30).

Turbidity data was collected by data sondes placed in the Chenal and M-1 Canal. The TSS analysis was performed by the Wetland and Aquatic Biogeochemistry Lab at the Department of Oceanography and Coastal Sciences in the School of Coast and Environment at Louisiana State University on surface water and depth averaged water samples. Collected turbidity and TSS data from LDNR and LDWF (2012) supplemented data collected by Fenstermaker to complete the correlation. As shown in *Figure* 30, Turbidity and TSS were well correlated.

Once a relationship between Water Level – Discharge and Turbidity – TSS was finalized, discharge could be correlated with TSS. The regression correlations in *Figures* 29 and 31 were used to estimate discharge and TSS based on collected water level and turbidity data. *Figure* 32 shows the discharge to TSS correlation for the entire collection period at Island Road. This correlation is heavily skewed by artificially high water levels with little discharge. To show a more reasonable correlation, discharge and TSS values were collected from the rising limb of water levels for six storm events as shown in *Figure* 33. The storm events occurred December 10-11, 2012, December 28-29, 2012, February 19, 2013, March 10-11, 2013, April 3, 2013, and April 14, 2013. This correlation provides a more realistic view of False River sedimentation rates.

The relationship between discharge and TSS is poorly correlated, but this was expected. LDEQ (2010) showed discharge to turbidity correlations vary from r^2=0.77 to r^2=0.22 with the low coefficients of determination corresponding to channels with reservoirs similar to False River. The Discharge – TSS correlation provides average TSS values for a given discharge allowing for estimation of sediment loads entering False River. A longer collection period would likely improve the Discharge – TSS correlation.

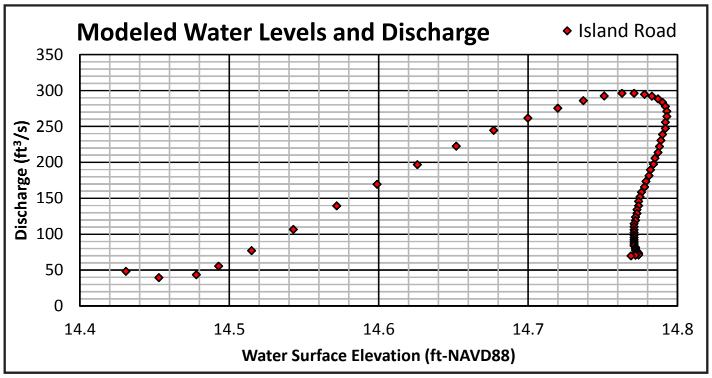


Figure 28 - Water Level - Discharge Rating Curve

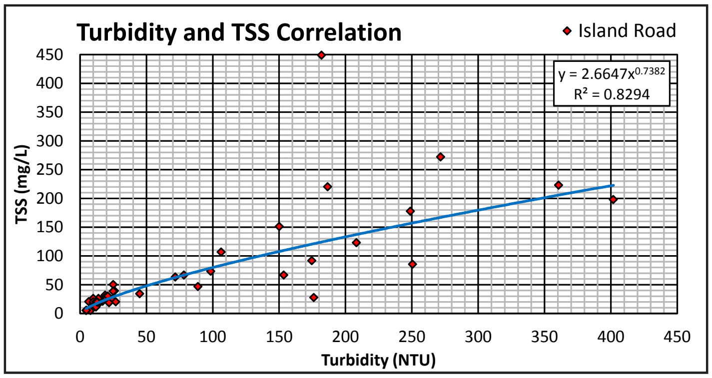


Figure 31 - Turbidity - TSS Relationship

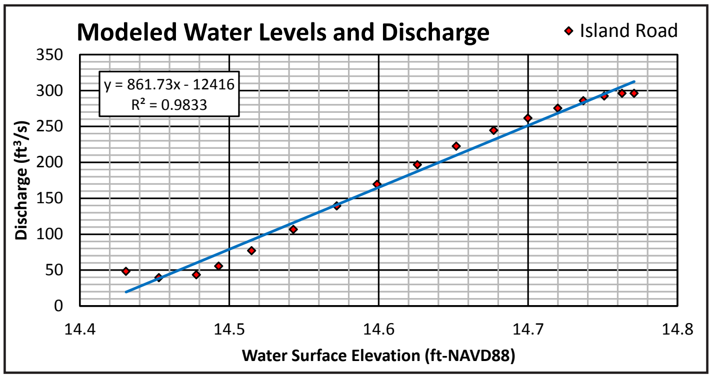


Figure 29 - Water Level - Discharge Rating Curve - Rising Limb

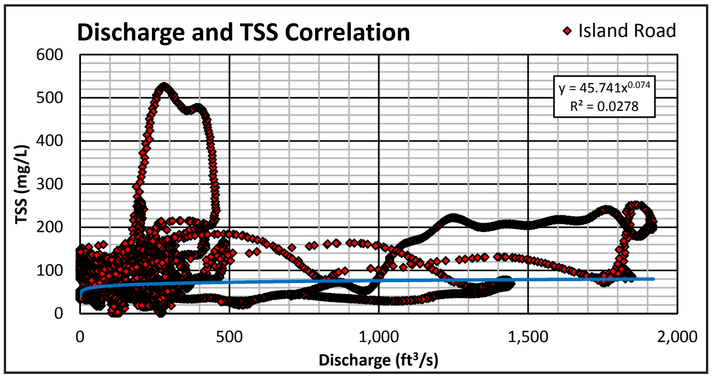


Figure 32 - Discharge - TSS Relationship - Collection Period

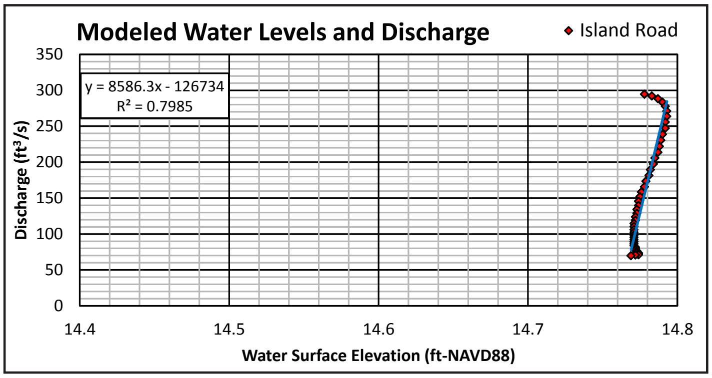


Figure 30 - Water Level - Discharge Rating Curve - Falling Limb

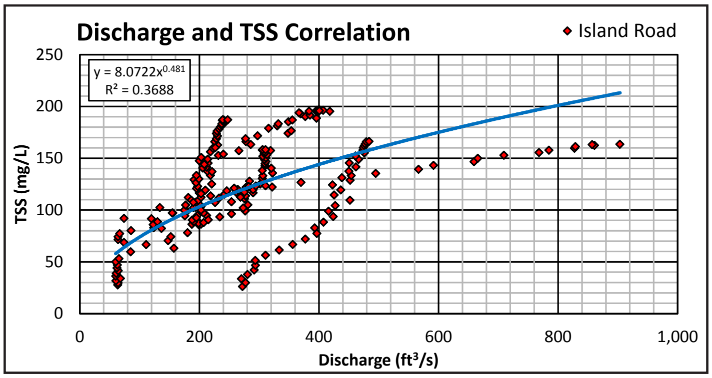


Figure 33 - Discharge - TSS Relationship - Rising Limb of Select Storms

SEDIMENT BASIN EVALUATION

The concept behind a sediment trap is to reduce channel velocities allowing sediment particles to fall out of suspension. Typically, a sediment trap is built by widening and deepening a portion of the channel. The M-1 Canal sediment basin was constructed in the 1980s. The sediment trap has been cleaned three times and each time a significantly smaller volume of sediment is removed. The reduction in sediment volumes is likely due to improved land use practices, reductions in agricultural average, and limited large-particle sediment supply.

Velocities in the M-1 Canal sediment trap during a 10-year, 6-hour storm event peak around 2.0 feet per second (ft/s) as shown in *Figure* 34. This is a reduction of approximately 0.5 ft/s caused by the wider and deeper channel. As previously discussed, the majority of the False River Island watershed soil is clays and silts which have a settling velocity of less than 0.10 ft/s (Table 5). Therefore, the sediment trap effectively collected larger sized sediment (sands, gravel, etc.) and the finer sediments (silts and clays) are able to bypass the sediment trap. *Figure* 35 shows sediment trap location along M-1 Canal.

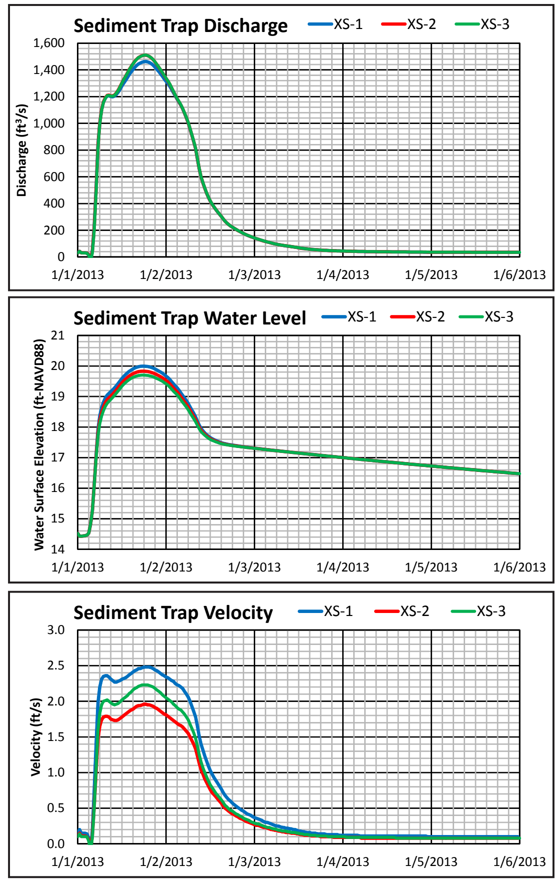


Figure 34 - M-1 Canal Sediment Trap Discharge, Water Levels, and Velocity

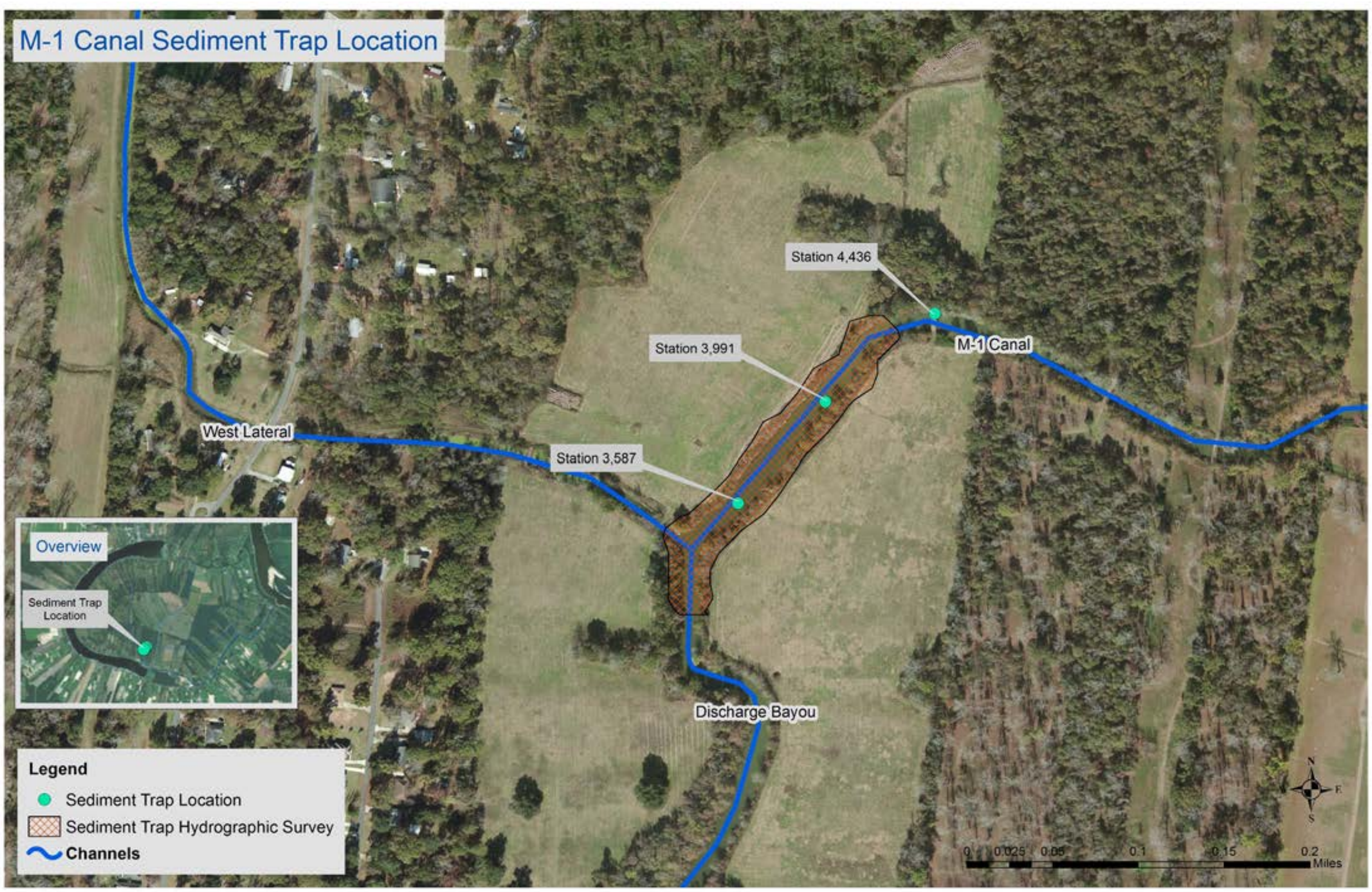


Figure 35 - M-1 Canal Sediment Trap Location

Table 5: Settling Velocity Rate Table (Fifield, 2001)		
Diameter (ft)	Settling Velocity (ft/s)	Particle
3.28E-05	0.00030	Fine Silt
6.56E-05	0.0011	Median Silt
9.84E-05	0.0026	Median Silt
0.00013	0.0046	Coarse Silt
0.00016	0.0071	Coarse Silt
0.00020	0.010	Coarse Silt
0.00023	0.014	Very Fine Sand
0.00026	0.018	Very Fine Sand
0.00030	0.023	Very Fine Sand
0.00033	0.029	Very Fine Sand
0.00036	0.034	Very Fine Sand
0.00039	0.041	Very Fine Sand
0.00043	0.048	Fine Sand
0.00046	0.056	Fine Sand
0.00049	0.064	Fine Sand
0.00052	0.073	Fine Sand
0.00056	0.082	Fine Sand
0.00059	0.092	Fine Sand
0.00062	0.10	Fine Sand
0.00066	0.11	Fine Sand

SEDIMENTATION RATES

Previous studies have estimated the annual sedimentation rate between 21,000 and 28,000 tons annually for the entire watershed. During the six month collection period, approximately 8,000 tons of sediment discharged into the south flats of False River. Assuming this six month period is a representative sample, approximately 16,000 tons of sediment enter False River annually through the Chenal and M-1 Canal. Assuming a specific weight of 105 lb/ft^3, approximately seven acre-feet (305,000 ft^3) of sediment are deposited into the south flats annually. This estimate is only applicable to the six month data collection period and may not represent typical rainfall and sediment amount. This estimate does not account for sedimentation in the north flats.

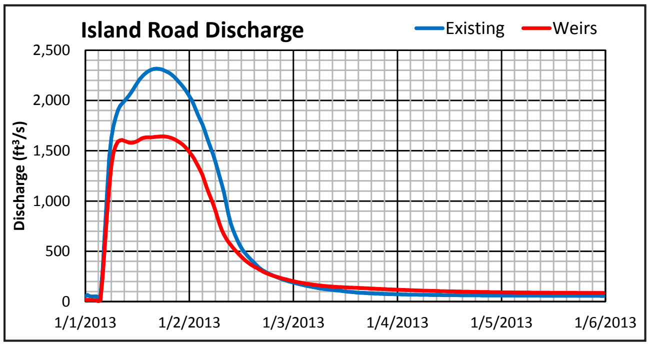
CHANNEL HYDROMODIFICATIONS

The hydrologic and hydraulic models were used to evaluate potential channel hydromodifications aimed at reducing suspended sediments entering False River. As previously discussed, the models output water levels, discharge and velocity along the studied channels. HEC-RAS was not used to explicitly study sediment transport, instead a relationship was determined between discharge and total suspended solids (TSS) to estimate sediment loads. This analysis method analysis assumes:

- Uniform channel velocity for a given time step at a given location. Generally velocity is highest in the center of a channel near the surface (assuming a straight channel). Channel velocities tend to decrease as flow gets closer to the channel bottom and banks. However, for this analysis it was assumed velocity at the channel center is the same as velocity near the channel bottom and banks.

- Sediment loads entering False River are fine sediments (clays and silts) in suspension. Bed load deposition was not investigated. This assumption was deemed reasonable because the majority of False River is fine grained soils and sediment in False River was easily resuspended.

- Suspended sediment load was uniform across the channel for a given time step at a given location. Sediment loads are generally non-uniform throughout the water column dependent on the type and size of available sediment and flow conditions.



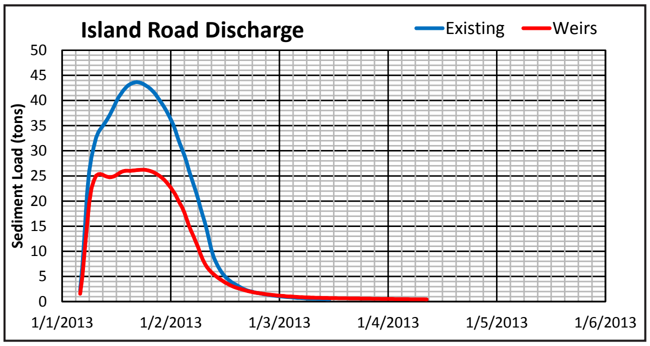


Figure 36 - Weir Sediment Load

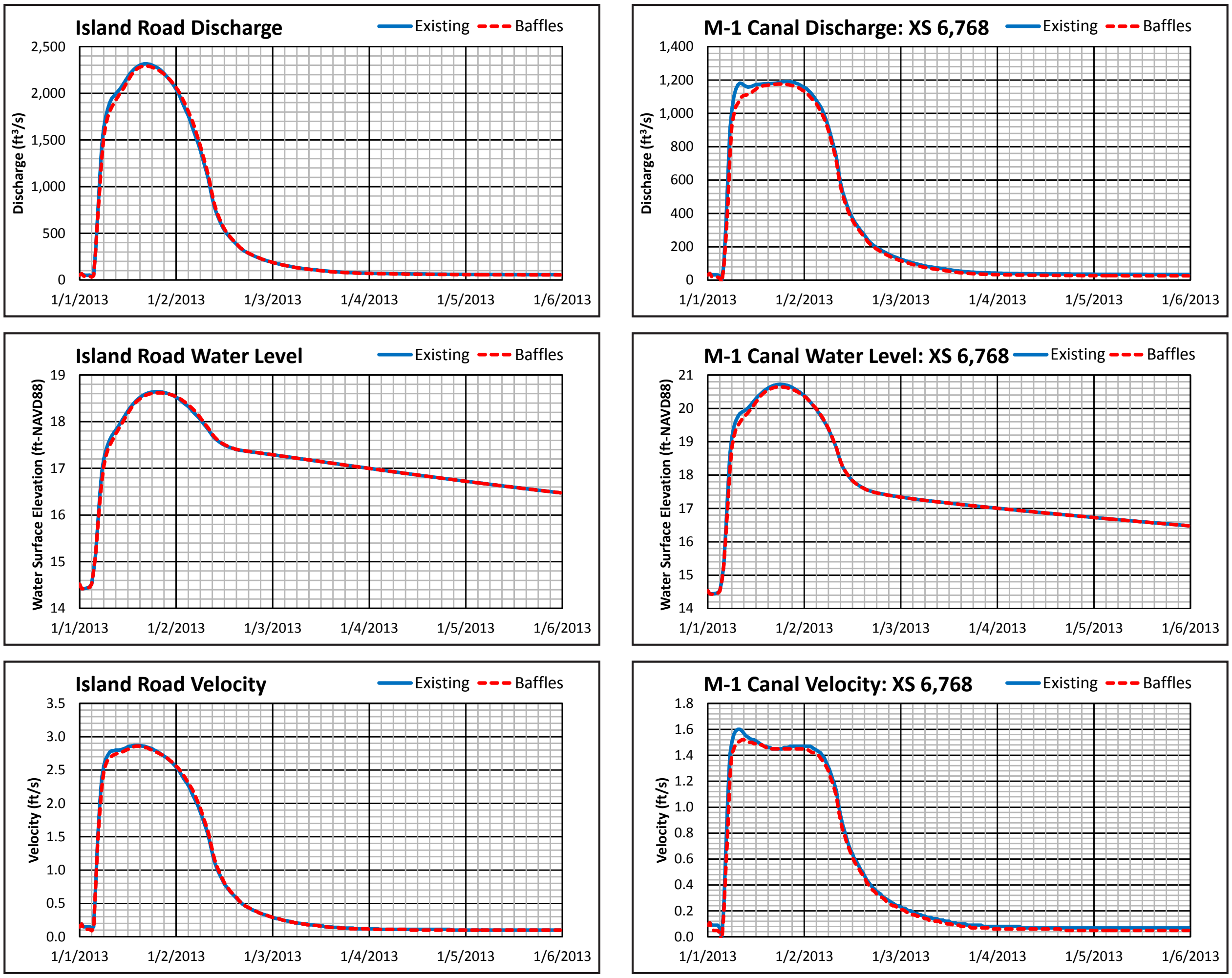


Figure 37 - Baffle Discharge, Water Level, and Velocity

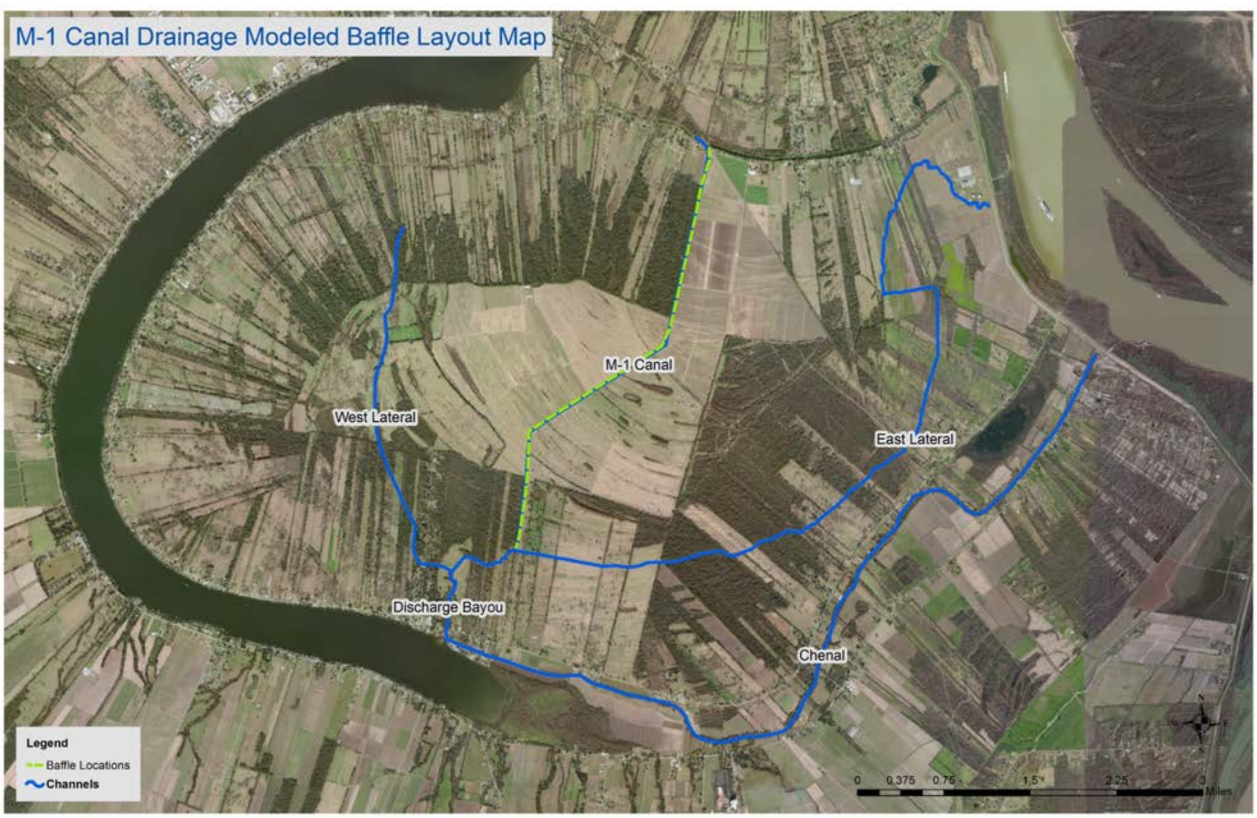


Figure 38 - M-1 Canal Drainage Modeled Baffle Layout Map

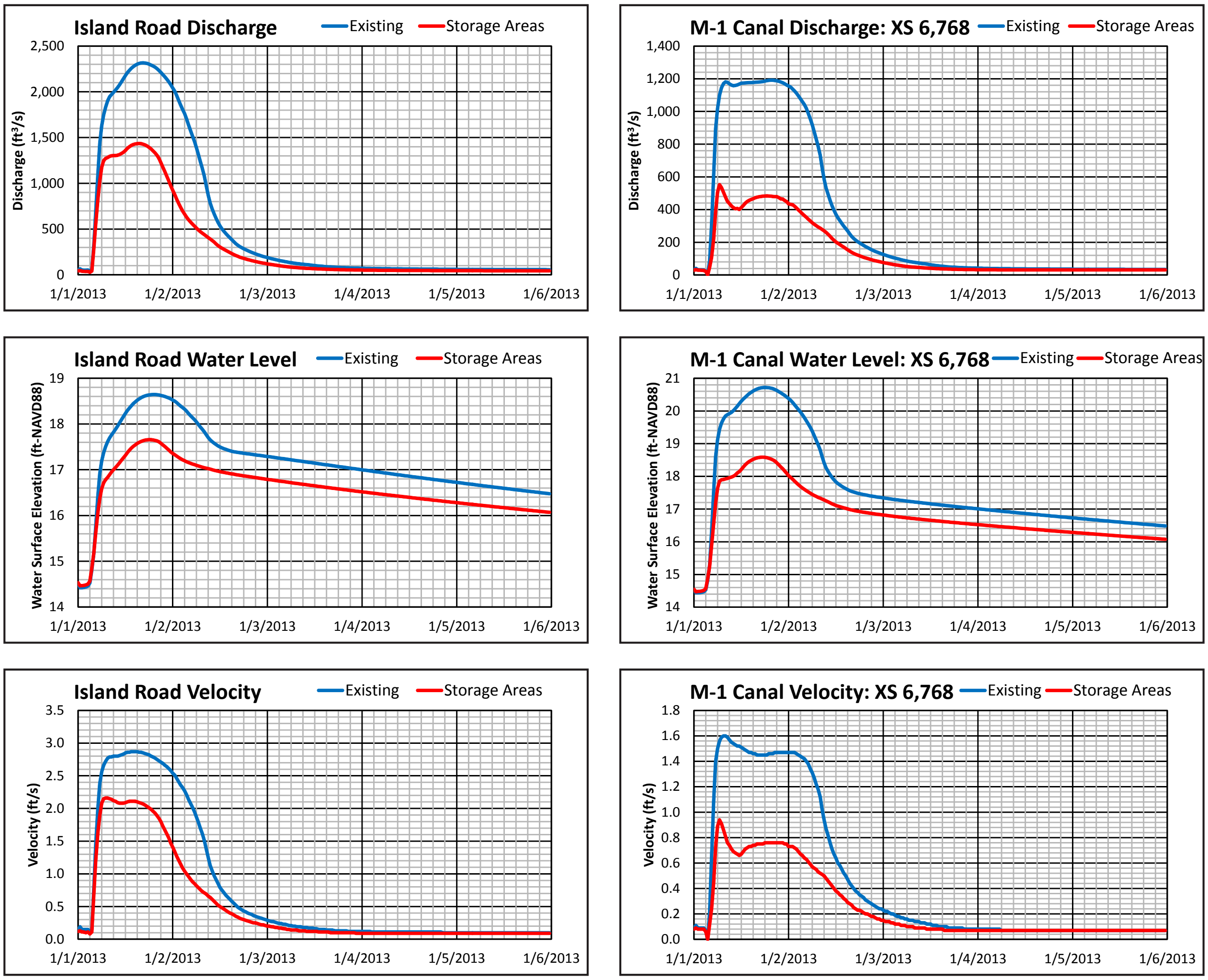


Figure 39 - Storage Area Discharge, Water Level, and Velocity

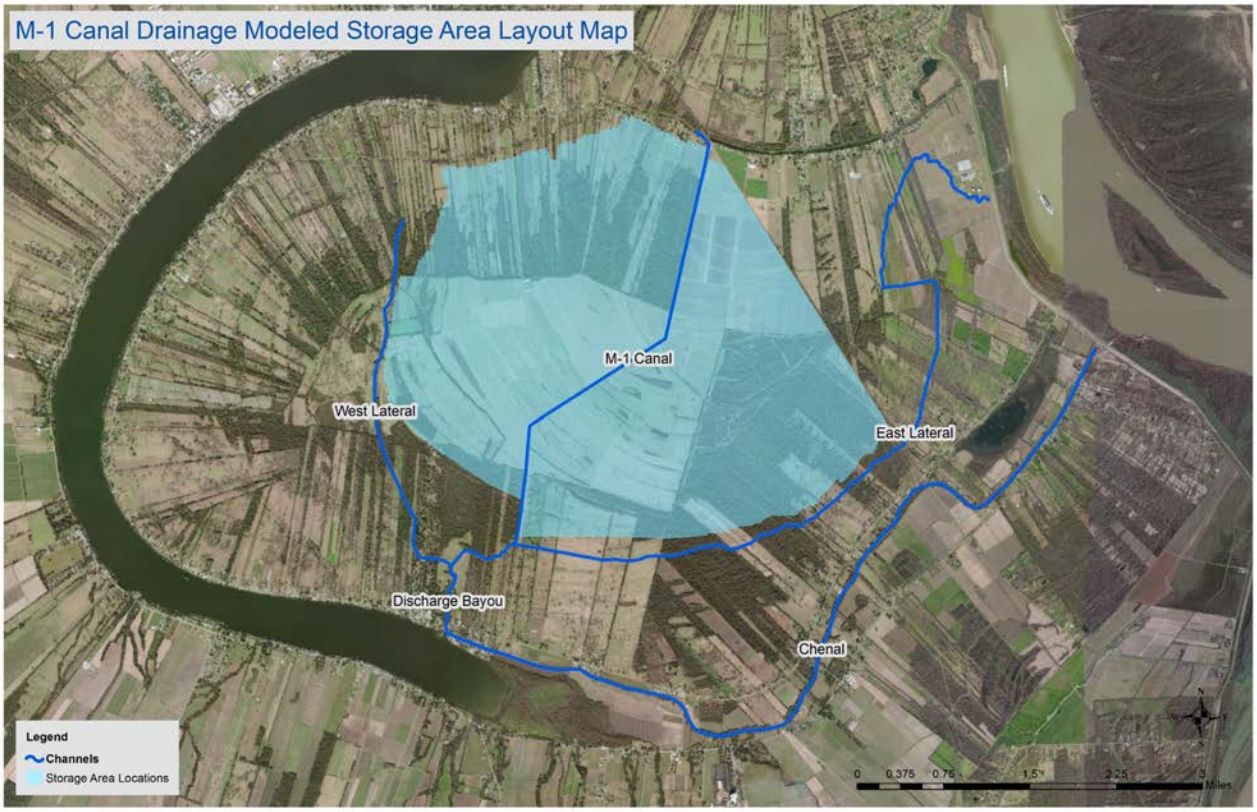


Figure 40 - M-1 Canal Drainage Modeled Storage Area Layout Map

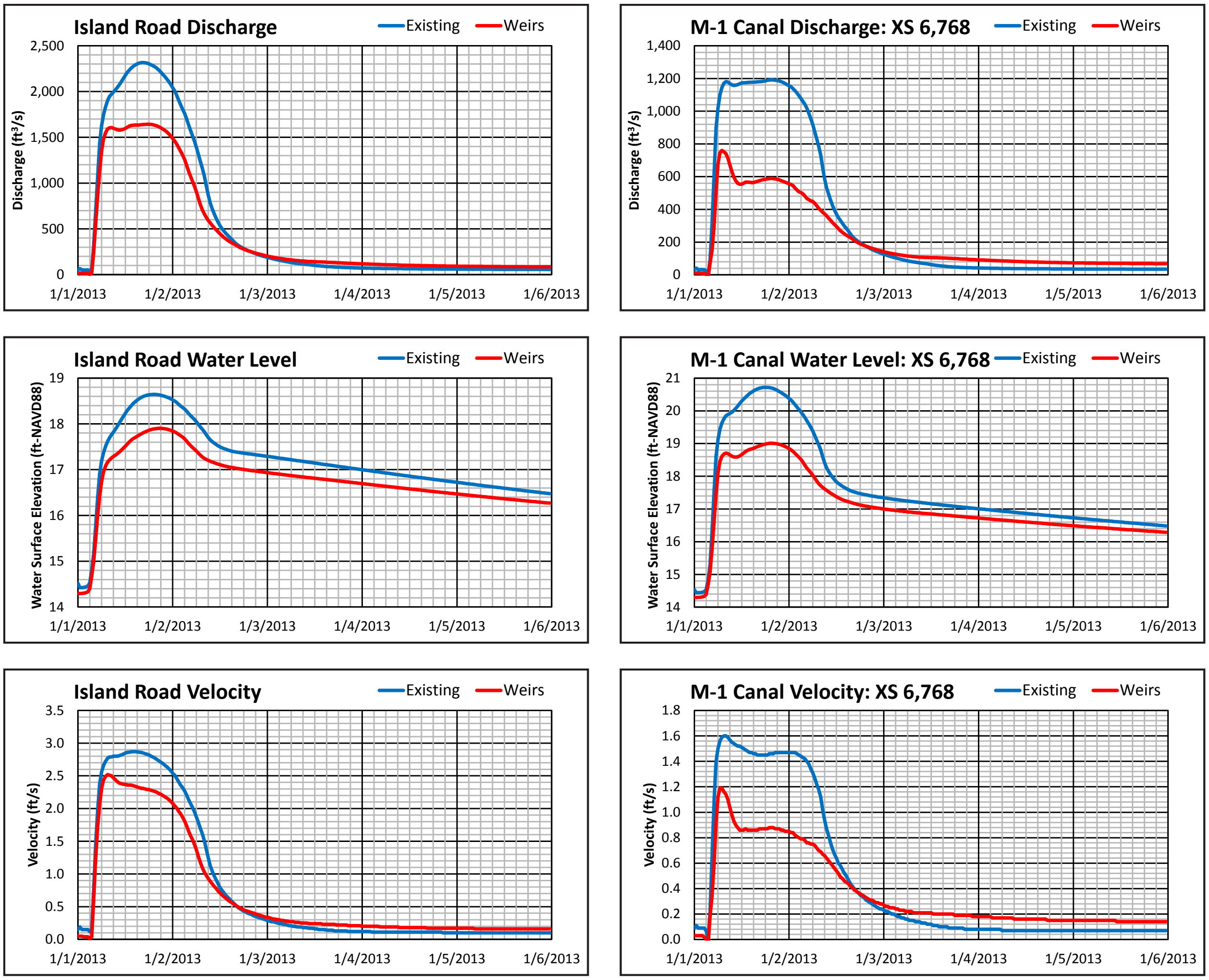


Figure 41 - Weir Discharge, Water Level, and Velocity

Figure 42 - M-1 Canal Drainage Modeled Weir Layout Map

The following six alternatives underwent a conceptual evaluation to determine feasibility and effectiveness. Each alternative was evaluated individually. Combining alternatives may have a greater impact on sediment reduction, but was not quantitatively evaluated as part of this study. Three alternatives were selected for further analysis while the remaining three alternatives were determined unfeasible due to higher cost or lower effectiveness.

- **Channel Realignment**: no further evaluation;
- **Flow Redirection**: no further evaluation;
- **Pumps**: no further evaluation;
- **Baffles**: detailed study;
- **Storage Areas**: detailed study; and
- **Weirs**: detailed study.

Channel realignment was not evaluated in detail due to costs. The concept for this alternative was to increase channel length and sinuosity. The lengthened channel would increase stormwater runoff travel time, and the meander bends would provide losses, all of which would reduce channel velocity. However, in order to have a large impact, miles of new channel would likely have to be constructed on private land.

Flow redirection was not modeled because it did not address the problem reasonably. Two conceptual plans were evaluated to redirect stormwater runoff. One plan looked at routing stormwater runoff from the Chenal and M-1 Canal into the low-lying areas of False Bayou. This plan was rejected due residential structure inundation and lack of capacity. The second plan looked at routing stormwater runoff south into Bayou Sere. This plan was rejected because vessels would not be able to enter the Chenal and M-1 Canal, as well as difficulty of construction.

Pumps were also under consideration to convey stormwater runoff into Bayou Sere or the Mississippi River. The pumps would convey stormwater runoff three to six miles over private land. This plan was eliminated due to maintenance and construction feasibility, permitting issues, and long-term costs.

Three alternatives were examined in detail using numerical models: baffles, storage areas, and weirs. The baffles alternative looked at placing flow impediments within the channel causing a reduction in velocity and an increase in travel time. Storage areas examined development of retention areas to reduce runoff volumes. The weirs alternative analyzed placement of channel weirs to reduce velocity and increase channel storage duration.

Several parameters were examined as part of the alternatives analysis. Discharge, water level, and velocity impacts were analyzed to determine effectiveness of each alternative. Construction feasibility and costs were also examined. The following section describes each alternative in more detail.

BAFFLES

Baffles were added along the East, M-1 Canal, and West channels to reduce channel velocity and limit discharge (*Figure* 38). Approximately half of the channel was blocked off causing stormwater runoff to flow around the obstructions. As shown in *Figure* 37, baffles had a minimal impact on water levels and discharge during a 10-year, 6-hour storm event.

STORAGE AREAS

Storage areas examined converting the Island interior into a retention area (*Figure* 40). This alternative provided the largest reductions in discharge, water levels, and velocity along M-1 Canal near Island Road (*Figure* 39). The 40 percent reduction in discharge is due to increased duration of overland storage. This alternative required filling the M-1 Canal north of the East channel and reconstruction of the Mississippi River swales. This alternative was not recommended due to the high cost of construction.

WEIRS

Weirs were placed along the East, M-1 Canal, and West channels. The weirs were placed on the interior of the Island away from residential property (*Figure* 42). The weirs were used to increase channel storage duration, route stormwater runoff through the old Discharge Bayou channel, and reduce channel velocities. As shown in *Figure* 41, the weirs reduced discharge by approximately 30 percent for the 10-year, 6-hour design storm. The increased channel storage duration would have a greater impact on smaller storm events. The weirs in this study were numerically modeled in the locations shown in *Figure* 42. These locations are approximate, however if these weir locations are placed in alternate locations, it may affect the discharge reduction and may require further analysis.

Table 6: Approximate Cost Estimates for Weir Alternative							
Weir	River	Approx. Station	Weir Materials	Mobilization (25%)	Contingency (30%)	Design & Inspection (6%)	Total
1	East Lateral	9,500	$50,000	$15,000	$15,000	$5,000	$85,000
2	M-1 Canal	27,300	$10,000	$5,000	$5,000	$1,000	$21,000
3	M-1 Canal	24,000	$40,000	$10,000	$10,000	$4,000	$64,000
4	M-1 Canal	16,500	$60,000	$15,000	$20,000	$6,000	$101,000
5	M-1 Canal	10,460	$90,000	$25,000	$30,000	$8,000	$153,000
6	West Lateral	9,200	$60,000	$15,000	$20,000	$6,000	$101,000
Total			**$310,000**	**$85,000**	**$100,000**	**$30,000**	**$525,000**

RECOMMENDATIONS

Weirs were selected as the primary recommended alternative due to effectiveness, constructability, and costs. Construction of weirs does not require overly complex methods or materials, and long-term maintenance is not typically burdensome. In addition to increasing stormwater runoff, these weirs were developed to be a permeable filter. As shown in *Figure* 44, the weirs would fill the channel with a rectangular notch to pass large flows. The weirs were envisioned to be 20 to 30 feet long with vegetation planted on the upstream and downstream sides. Additionally, baffles could fill portions of the channel allowing runoff to flow on one side. The baffles are intended to be 10 to 15 feet long, vegetated on all sides.

The addition of baffles, storage areas, and riparian buffers would provide added sediment reduction. Baffles and storage areas can be placed along the channel as determined appropriately to achieve the design results.

The weir-only alternative showed a peak discharge decrease of nearly 30 percent during a 10-year, 6-hour storm event (*Figure* 36). Using the discharge to TSS relationship developed previously, the recommended weir alternative reduces sedimentation from approximately 2,000 tons to 1,300 tons during this storm event. Placement of a riparian buffer or vegetative filter strip would further reduce sedimentation rates.

Several areas along the Chenal are subject to increased sedimentation due to land clearing and agriculture land stormwater runoff. The Chenal does not produce large amounts of stormwater runoff, and the sediments typically deposit near their entry into the channel. The sediment deposits cause localized shoaling which can block vessels and aquatic species from freely moving through the system. This sedimentation issue can be effectively addressed on a case by case basis using floating silt/turbidity barrier, vegetative filters, and spot dredging.

Weir placement determined effectiveness of discharge reduction. The weirs were overtopped and showed minimal discharge reduction when placed farther downstream. Placing multiple weirs on the upstream portions of the East, M-1 Canal, and West channels provided the most benefit. Weirs were not effective on the Chenal.

A cost estimate for the weir-only alternative is provided in Table 6. This cost estimate assumes a weir top width of 10 feet, side slopes at 2:1, and a rip-rap cost of $166 per cubic yard. This also assumes the weirs would be designed and built by private consultants and contractors. This cost could be reduced if Parish resources are used during construction.

Riparian buffers are highly recommended along the Chenal and M-1 Canal. The 100 foot easement on both

Figure 43 - *Panicum virgatum*

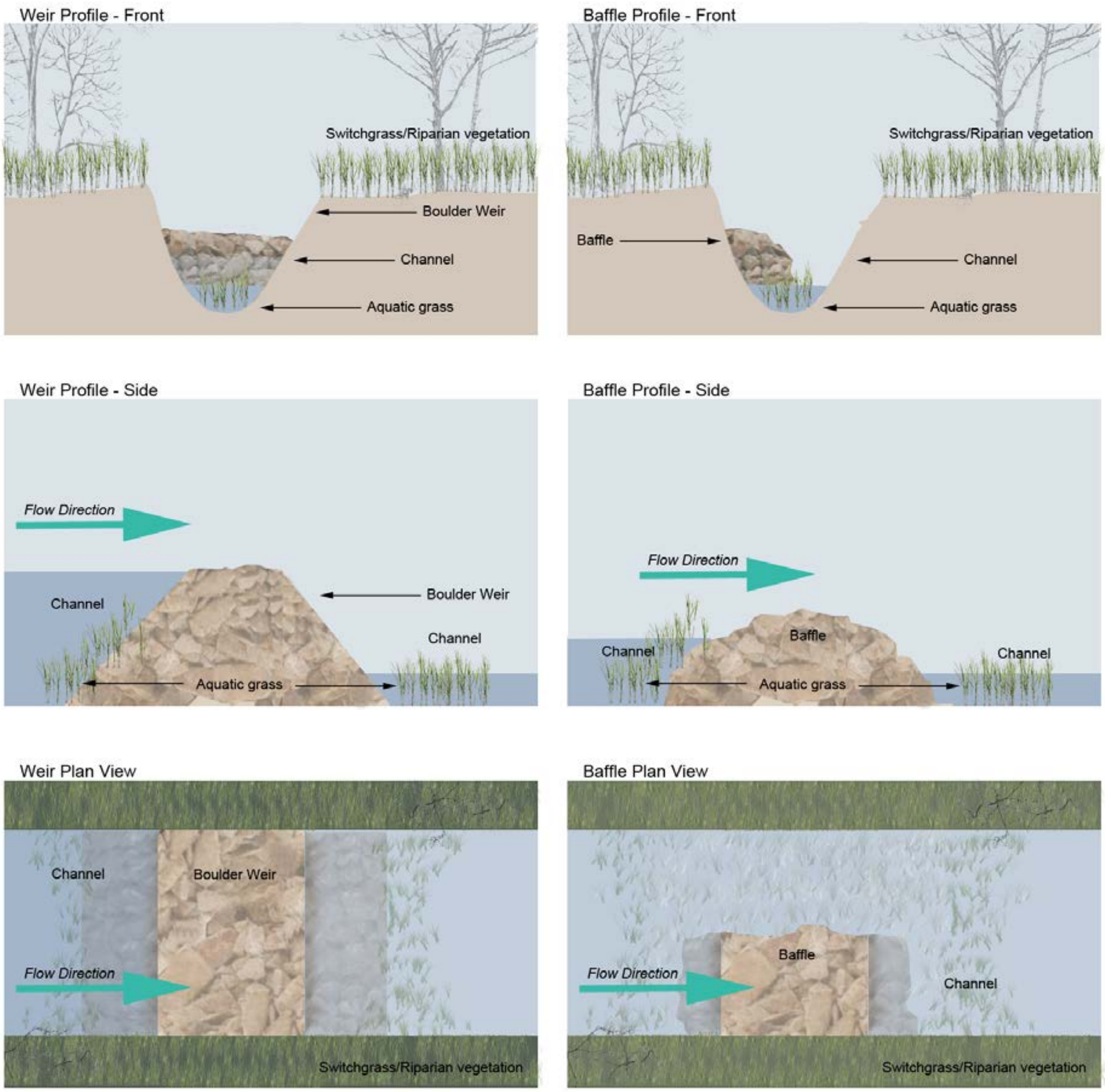


Figure 44 - Weir and Baffle Profile and Plan Illustration

overbanks of the channels could be used as riparian buffers and vegetative filter strips to remove pollutants and sediments from stormwater runoff entering False River. These vegetated buffers improve water quality through filtration, deposition, and absorption. Riparian buffer designs with stiff-stemmed grasses at their edge can slow flow velocities and flow volumes, and the resulting decrease in transport capacity can cause sediment deposition (Wilson, 1967).

The majority of plant materials for the riparian buffers should consist of existing, naturally generated vegetation suitable for the soils and hydrology of the site. The USDA NRCS provides criteria for plant selection as well as minimum standards for width of riparian zones. Shrubs and trees should be native species which supply multiple values such as wildlife habitat, timber, or aesthetics. The recommended minimum width is 35 feet perpendicular from the normal water line or bank of the channel, with a mix of native grasses and shrubs/trees, to reduce excess amounts of sediment and NPS pollutants (USDA NRCS, 2010). Swithchrass (*Panicum virgatum, Figure* 43) and Smooth Cordgrass (*Spartina alterniflora*, *Figure* 45) are native grasses suitable for buffers.

A switchgrass buffer is an effective riparian buffer capable of removing sediment in stormwater runoff. For instance, a five inch wide strip of switchgrass can dam water to a height of nearly four inches (Dabney, 1993). A wider switchgrass/woody buffer, which would include shrubs and other natural grasses, should be used to remove sediment and soluble nutrients (Lee, 2003; Lee, 2000).

In a study of stormwater runoff from natural storm events, a 23 foot switchgrass buffer removed approximately 92 percent of the sediment and a 54 foot switchgrass/woody buffer removed nearly 97 percent of the sediment; however, the wider switchgrass/woody buffer increased the removal efficiency of soluble nutrients and finer sediment particles by 20 percent (Lee, 2003). As mentioned earlier, a minimum width of 35 feet on either side of the channel is recommended by USDA NRCS, consisting of both grasses and woody vegetation.

Figure 45 - *Spartina alterniflora*

MAINTENANCE

Channel and riparian inspection and maintenance should be performed annually at a minimum. The channels and weirs should be inspected for damage and repairs made as necessary. Over time, sediment will deposit into the channel requiring removal to maintain efficiency of the weir system. Maintenance of the riparian buffer will include periodic removal and replacement of dead trees and shrubs, as well as inspection for damage from pests, wildlife, and vehicular or pedestrian traffic.

Some of the grasses, trees or shrubs chosen to supplement the existing vegetation may be planted for timber or other resources. Harvesting of grasses, trees, nuts, or fruits are permitted as long as these activities do not compromise the survival of the species or adversely affect the purpose of the riparian buffer zone. These activities should be outlined in a riparian buffer conservation plan (USDA NRCS, 2007).

CONCLUSION

False River water level and turbidity data was collected over a six month period. The water level and turbidity data was correlated to discharge and total suspended solids (TSS) to determine sedimentation rates into False River. An annual sedimentation rate of approximately 16,000 tons was estimated to enter False River through the Chenal and M-1 Canal. This estimate is based on the six month collection period and may not be representative outside of this time frame.

The collected data along with topographic and bathymetric survey, land use, soil, and rainfall data were used to develop hydrologic and hydraulic models. These models replicated existing conditions and evaluated several alternatives. The weir alternative was recommended due to its reduction in discharge, constructability, and costs. This alternative showed a peak discharge reduction of 30 percent during a 10-year, 6-hour storm event. During the same storm event, the weir alternative showed a 35 percent reduction in sediment entering False River.

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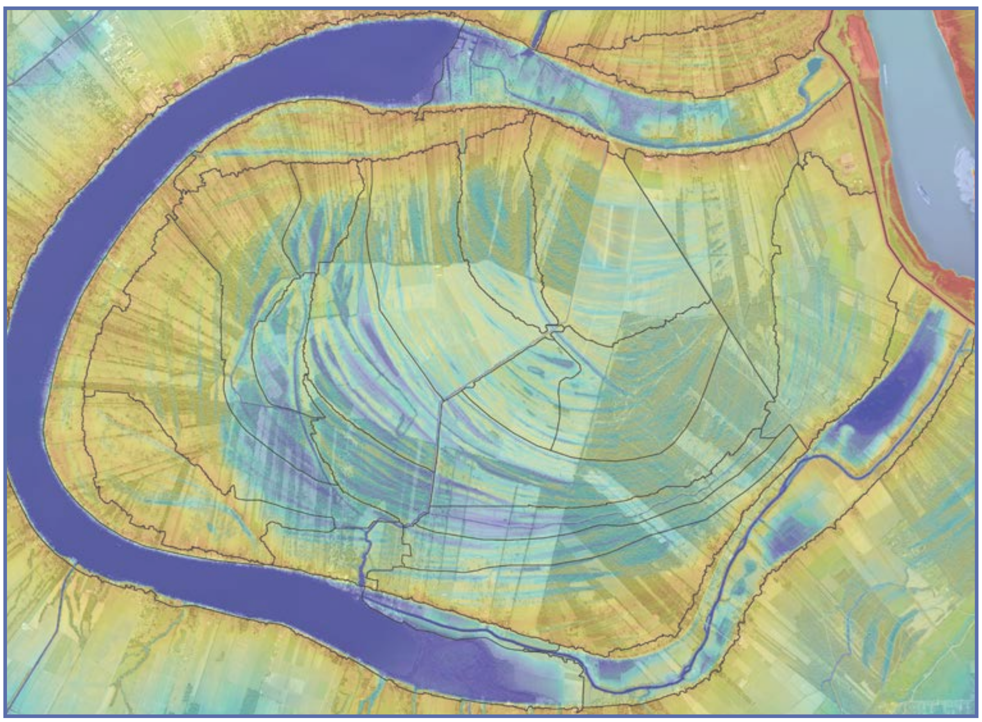
FALSE RIVER WATERSHED STUDY

Prepared for:
Louisiana Department of Natural Resources
and the False River Watershed Council

Prepared by:
C.H. Fenstermaker & Associates, LLC
June 17, 2013

FALSE RIVER WATERSHED STUDY

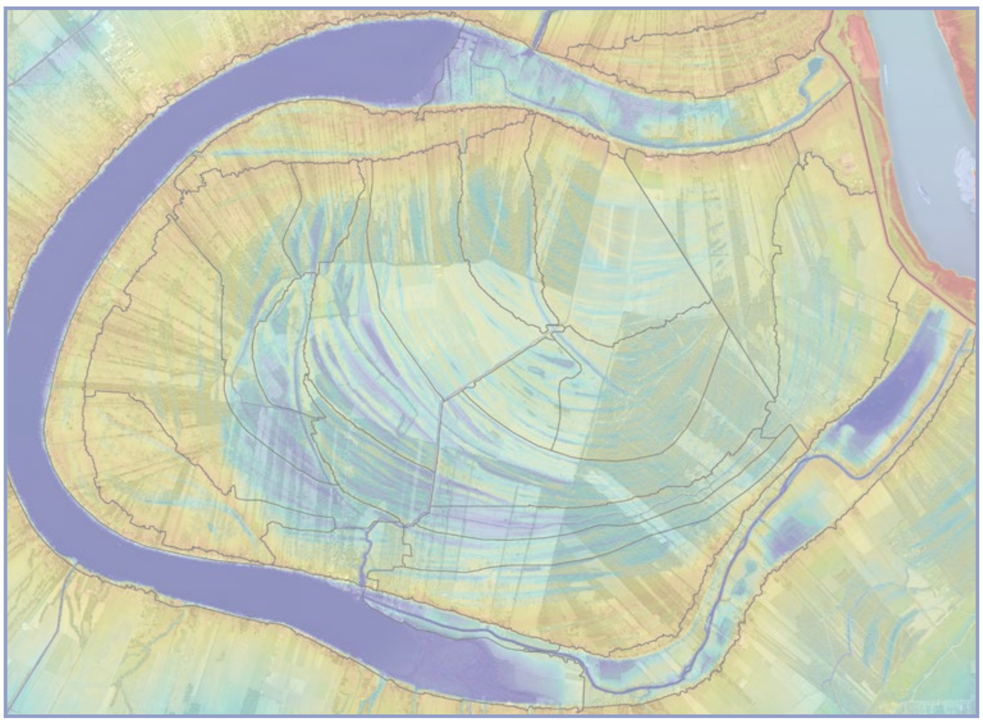
APPENDICES



CH FENSTERMAKER & ASSOCIATES, LLC

JUNE 17, 2013

APPENDIX A: PLATES



APPENDIX B: TIME OF CONCENTRATION SHEETS