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Coastal Protection and Restoration Authority

2016 Operations, Maintenance, and Monitoring Report

for

West Bay Sediment Diversion (MR-03)

State Project Number MR-03
Priority Project List 1

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Prepared by:

Erin M. Plitsch
Coastal Resources Scientist, CPRA
New Orleans Field Office
CERM, Suite 309
2045 Lakeshore Dr.
New Orleans, LA 70122

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Preface

The 2016 Operations, Maintenance and Monitoring (OM&M) report format is a streamlined approach that combines the operations and maintenance annual project inspections with the monitoring data and analyses on a project-specific basis. This report includes monitoring data collected from November 2003 through September 2015. The 2016 West Bay Sediment Diversion OM&M report is the 1st in a series of reports.

I. Introduction

The West Bay Sediment Diversion (MR-03) project was approved on the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) 1st Priority Project List. The project is located on the west bank of the Mississippi River in Plaquemines Parish, Louisiana (Figure 1). The project features include a crevasse on the right descending bank of the main Mississippi River channel, at river mile 4.7 above Head of Passes (AHP), and a number of beneficial-use areas of dredge material. The project outfall area is a large, shallow, open-ended inter-distributary basin, situated between the main river channel to the east, Grand Pass to the west, and Zinzin Bay to the south. The project area is composed of freshwater marsh, tidal flats and open water, totaling 12,294 ac (4,975 ha). Construction of the diversion channel began in September 2003 and was completed in November 2003. The West Bay Sediment Diversion is an uncontrolled diversion with a designed capacity of 50,000 cfs at the 50 percent duration stage of the Mississippi River.

The major process that forms subaerial land in the lower Mississippi River Delta (MRD) is the formation of sub-deltas and crevasse-splays. Subdeltas are “scaled down” versions of the major deltaic cycle, both in size and time (Coleman and Gagliano 1964, Wells and Coleman 1987). Subdeltas consist of relatively large receiving bays that have areal extents of 115 - 154 sq mi. (300 - 400 sq km) and depths of 32 - 49 ft (10 - 15 m) (Coleman and Gagliano 1964). Crevasse splays are a smaller sub-unit that are smaller in size, frequency, and expected life spans and generally have a receiving bay extent of approximately 0.234 sq mi. (0.59 sq km) (Boyer 1996).

Subdeltas go through two stages, constructional and destructional, during their typical life span (Scruton 1960) of 115 to 175 years (Wells and Coleman 1987). The constructional stage begins with the formation of a crevasse along a distributary’s levee. Once a crevasse occurs, a “splay” develops within the receiving bay as sediments accrete near the mouth of the crevasse (Boyer et al. 1997). After major channels have formed, rapid subaerial growth ensues. This newly formed land provides substrate for the rapid colonization of emergent vegetation, which stabilizes sediment and increases the rate of accretion (White 1993). As more channels develop by bifurcation, the rate of progradation decreases. Near the end of the constructional stage, the older parts of the subdelta enter the destructional stage (Scruton 1960). As interdistributary areas become cut off from sedimentation by natural levees and infilling of the main channel, subsidence due to compaction from dewatering causes ponding (Scruton 1960, Coleman and Gagliano 1964, Morgan 1973). Thus, the subdelta subsides from the inside out.

The West Bay Sediment Diversion project area is located on the abandoned West Bay Complex subdelta of the MRD. Subsidence (estimated to be as high as 0.45 in/yr; Day and Templet 1989)

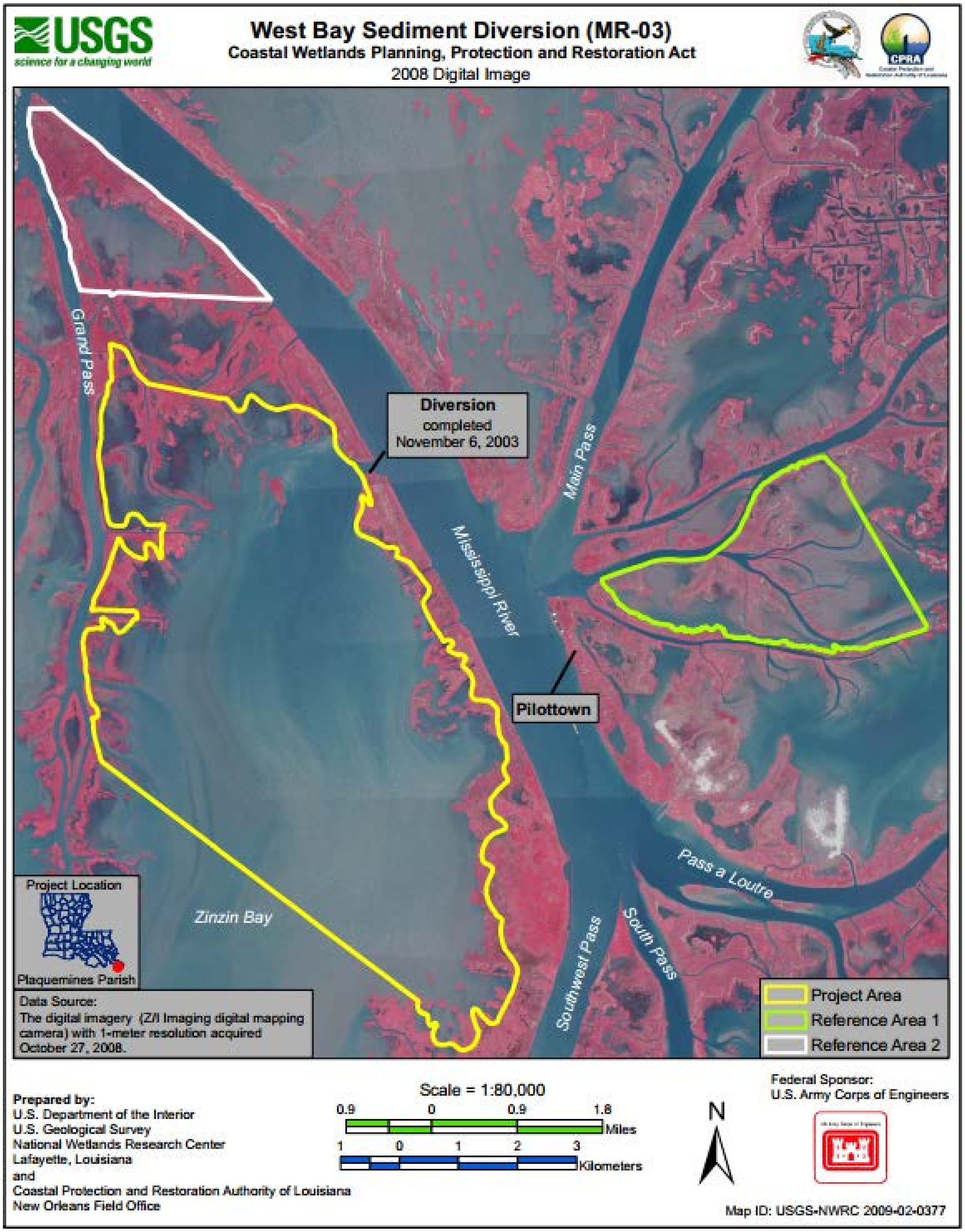

Figure 1. West Bay Sediment Diversion (MR-03) project and reference areas.

and sediment deprivation are natural characteristics of abandoned deltas (Neill and Deegan 1986, Coleman and Gagliano 1964, Kolb and Van Lopik 1966, Coleman 1988, Wells and Coleman 1987, Penland et al. 1990) and are the main factors influencing land loss in the MRD. During his study of an artificial crevasse on the eastern MRD, Marin (1996) noted that approximately one quarter of the pond bottom elevation gained from sediment accretion is lost because of shallow subsidence. Anthropogenic causes of land loss, such as leveeing, canal dredging, gas and oil exploration and withdrawal, as well as natural processes such as eustatic sea level rise, saltwater intrusion, and erosion, have contributed to wetland deterioration.

The benefits of creating artificial crevasses on the MRD became evident in the 1980's as both a cost effective and highly successful means of creating new wetlands. The Louisiana Department of Natural Resources (LDNR) constructed three crevasses in 1986 (on Pass-a-Loutre, South Pass, and Loomis Pass) that produced over 657 ac (266 ha) of emergent marsh from 1986 to 1991, and four crevasses in 1990 (two each on South Pass and Pass-a-Loutre) that produced over 400 ac (162 ha) of emergent marsh from 1990 to 1993 (LDNR 1993; Trepagnier 1994). Thirteen crevasses included in the LDNR Small Sediment Diversions (MR-01) project cumulatively produced 313 ac (127 ha) of emergent marsh between 1986 and 1993; land growth rates ranged from 28 to 103 ac (11.3 to 41.7 ha) per crevasse for the older crevasses (4 to 10 years old) and 0.5 to 12 ac (0.2 to 4.9 ha) for the younger crevasses (0 to 2 years old) (Kelley 1996). All of these constructed crevasses had a mean monthly discharge rate of less than 4,000 cubic feet per second (cfs).

The purpose of the West Bay Sediment Diversion (MR-03) project is to promote the formation of emergent marsh through construction of a crevasse and the placement of dredge material. Trepagnier (1994) suggested the idea that "the most successful crevasse would probably be one that discharges from a large pass into a large, open-ended receiving basin that allows the water to flow efficiently through the system". Open systems allow for rapid subaerial creation, thus making them mature more quickly and allow for colonization of native vegetation. The location of the West Bay Sediment Diversion (MR-03) project receiving basin, along with the shallow depth and open-ended configuration, will maximize the potential for emergent marsh creation.

a. Project Features

The West Bay Sediment Diversion project includes a conveyance channel for a large uncontrolled diversion of water and sediment from the Mississippi River. The diversion was designed to be sediment rich, with the angle, depth, and site location of the diversion chosen to optimize the concentration of bed material per unit volume of water diverted. Prior to construction of the diversion channel, a 10 in. pipeline located in the outfall channel pathway was relocated for safety reasons. The sediment diversion channel was constructed at a 120-degree angle from the downstream direction, in two phases: 1) construction of an interim diversion channel to accommodate a discharge of 20,000 cfs at the 50 percent duration stage of the Mississippi River, and 2) modification of the interim diversion channel design to accommodate full-scale diversion of 50,000 cfs at the 50 percent duration stage of the Mississippi River. This enlargement was implemented upon completion of intensive monitoring of diversion characteristics by the United States Army Corps of Engineers (USACE) Operations Division.

The USACE collects discharge data with an Acoustic Doppler Current Profiler (ADCP) upstream, downstream, and within the diversion channel (including bifurcations when formed). This data was collected approximately 12 - 16 times per year for the first five years, and will continue to be collected six times per year for the remainder of the project. As part of the channel patrol surveys performed by the Corps to monitor the navigation channel in the MRD, the USACE extended the monitoring to mile 8 AHP to provide information on channel response due to the West Bay Diversion. Cross sections in the vicinity of the diversion were extended on the right descending bank to provide information on the area outside the navigation channel. Cross sections were also extended into the diversion channel. Real time automatic stage recorders were deployed both inside the receiving area, and outside the diversion channel in the river.

The USACE has developed multiple action strategies to address the trigger points that will be monitored. Primary trigger conditions included scour hole depth limits of -40 ft within 3,000 ft of the navigation channel centerline, enlargement of the diversion channel to convey more than 30% of the river flow at the point of diversion, and/or the deposition of more than 50,000 cubic yards of induced shoal material per day in the navigation channel below the diversion. If any of these trigger conditions developed, the USACE employed a two-step process to respond and alleviate the problems. First, the mobilization of a dredging operation mines material from the anchorage area and pumps it into the diversion channel. These dredging operations help maintain control of the diversion channel, and keep the navigation channel open and safe to navigation by encouraging material to fall out in the anchorage area instead of the channel. Second, following the passage of high water, a rock sill in the diversion mouth from bank to bank would permanently fix the dimensions of the channel and prevent future threats to safe navigation in the river.

Reference Areas:

Two reference areas were selected in order to compare project-induced changes in land and water areas within the crevasse receiving bay with natural changes in areas of similar hydrologic influence (Figure 1). Vegetation and elevation surveys were not conducted in the reference areas. The first reference area (Ref 1), Brant Bayou, is due east of the project area just inside Cubit's Gap. This natural crevasse was formed in 1978 and is used as a "with project" target reference area for making comparisons. The second reference area (Ref 2) is used as a "without" project reference area, and is located due North of the project area (Figure 1). It is situated between the Mississippi River to the East, Grand Pass to the West and a pipeline canal to the South, but does not receive direct riverine input. Since these reference areas are also used to evaluate other similar projects in the Mississippi River Delta area, funding for aerial photography acquisition and analysis for these reference areas comes from the monitoring budgets of other Mississippi River Delta projects.

It was difficult to find reference areas with identical characteristics and influences as the project area. The reference areas chosen have the following limitations: 1) whereas dredge material will be placed in the project area, none will be placed in either reference area, 2) neither reference area is subjected to the open Gulf of Mexico or its wave energies, 3) both reference areas are smaller in size, and 4) Brant Pass has a smaller parent pass.

Beneficial Use of Dredged Material Areas:
Dredged material from the relocation of the gas pipeline, crevasse construction, and navigational maintenance was used beneficially to create new marsh in the project area.

The following features were constructed as part of the West Bay Sediment Diversion - Beneficial Use of Dredging Material (Figure 2)**:**

A. 2003 West Bay CWPPRA Project Initial Construction: 1,067,693 cy of material was placed in disposal area 1, and 326,354 cy of material were placed in disposal area 2.

B. 2006 CWPPRA Pilottown Anchorage Area (PAA) Dredging: 1,989,689 cy of material were utilized to create a 175 acre wetland creation site*.

C. 2009 CWPPRA PAA Dredging: 1,602,808 cy were utilized for a 105 acre wetland creation site*, and 386,233 cy of material were placed at the Cherie Island Site to create the first SRED (Sediment Retention Enhancement Device) in the basin.

D. 2012 Southwest Pass Federal Maintenance Dredging (O&M): 642,627 cy were placed at discharge site 1, and 609,158 cubic yards were placed at discharge site 2.

E. 2013 CWPPRA PAA Dredging: 2,962,616 cy were utilized from the dredging of the Pilottown Anchorage Area to create 3 additional SREDs.

F. 2015 Mississippi River Hopper Dredge Disposal Area (HDDA) Federal Maintenance Dredging (LCA-BUDMAT): 5,198,068 cy were utilized to create 285 acres, and 2,299,295 cy were utilized for a 94 acre marsh creation site*.

G: 2015 Southwest Pass Federal Maintenance Dredging (O&M): 1,244,246 cy of material were placed in the West Bay receiving basin.

H: 2015 Southwest Pass Federal Maintenance Dredging (O&M): A total of 2,397,534 cy of material was placed at 3 sites.

*Acreage amounts are estimates based upon cubic yardage available and the area of placement, and may not be indicative of final acreages.

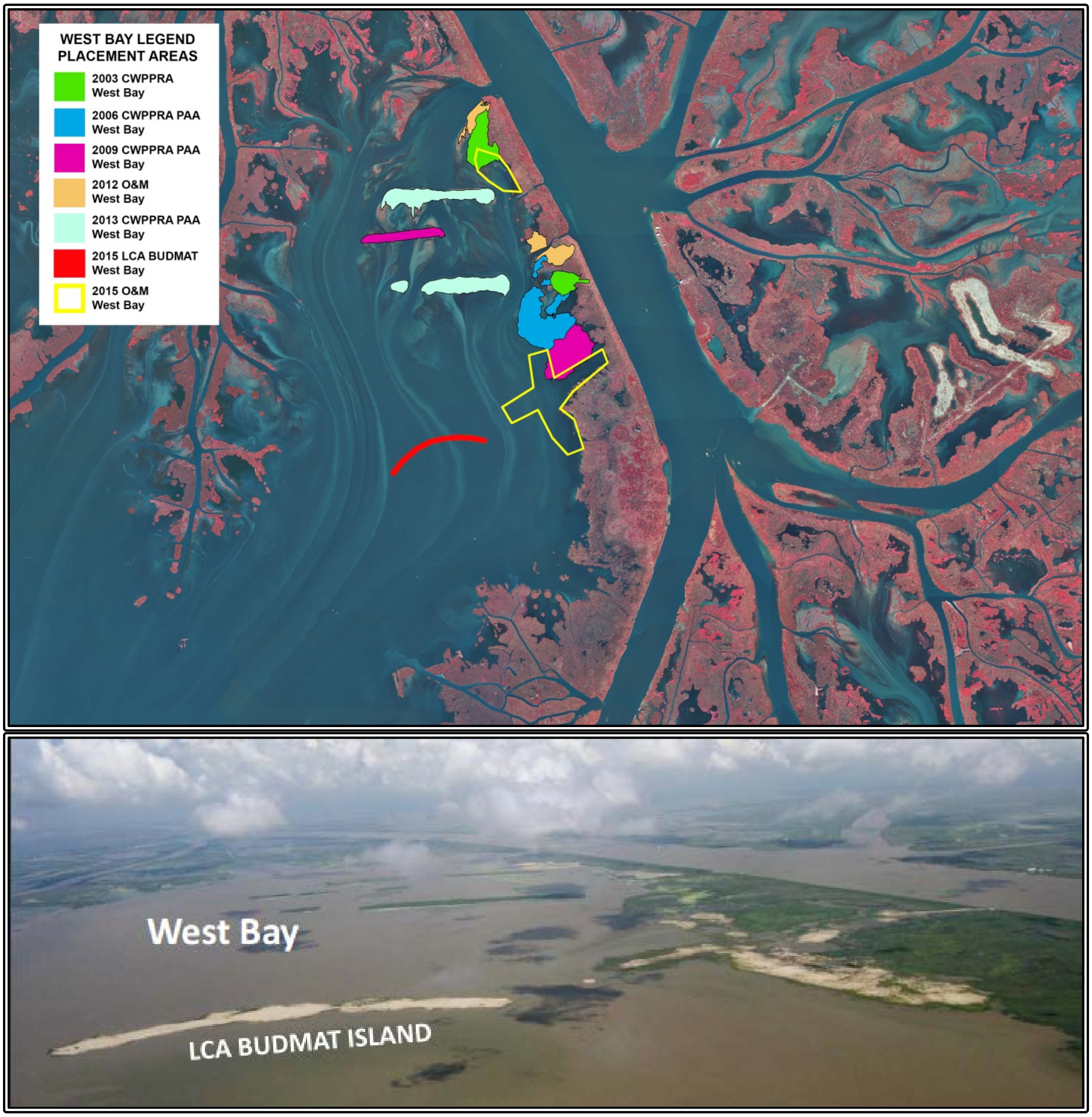

Figure 2: Map of West Bay placement areas (top), and aerial photo of placement areas (bottom). Images courtesy of USACE.

II. Maintenance Activity

a. Project Feature Inspection Procedures

Due to the lack of structural components associated with the West Bay Sediment Diversion, there is no annual maintenance inspection required for this project.

III. Operation Activity

a. Operation Plan

There is no Operation Plan for the project, as the West Bay Sediment Diversion is an uncontrolled crevasse.

b. Actual Operation

There are no operations associated with the MR-03 project. Flow rates are largely dependent upon river flow with some influence from meteorological events (fronts, precipitation, winds, etc.) and tidal exchange. Measured discharges range from negative flow to approximately 70,000 cfs, with an average of about 27,000 cfs (Figure 3).

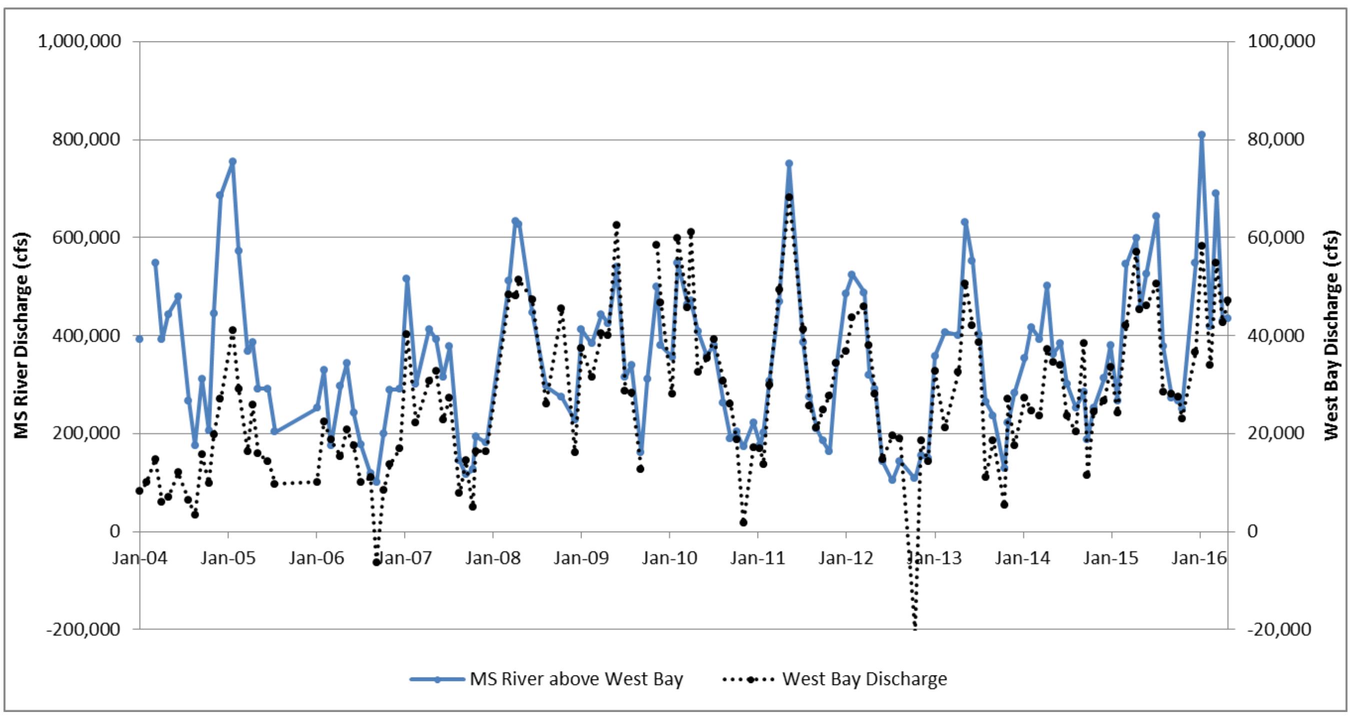

Figure 3. Monthly West Bay discharges and Mississippi River flow rates above West Bay.

IV. Monitoring Activity

This OM&M report includes data collected from November 2003 through September 2015. Monitoring efforts for the West Bay Sediment Diversion project focus on evaluating project effects on land/water ratios, bathymetry/topography, and emergent vegetation (LDNR 2003). Analysis of land/water ratios in the project and reference areas are used to determine the effects of the constructed crevasse and beneficial use of dredge material on the acreage of subaerial land. Periodic elevation surveys of the receiving bay are performed to monitor project effects on the vertical elevation of the marsh. Surveys of emergent vegetation within the crevasse receiving bay help determine if the project is effectively creating marsh substrate for colonizing vegetation. Water discharge data collected by the USACE are used to relate land gain to river discharge.

a. Monitoring Goals

The objective of the West Bay Sediment Diversion project is to promote the formation of emergent marsh through construction of a crevasse and the placement of dredge material.

The following goals contribute to the evaluation of the above objective:

1. Determine the effects of the project on land/water ratios in the project area.
2. Determine the changes in the mean elevation within the crevasse receiving bay.
3. Determine the effects of the project on emergent vegetation within the crevasse receiving bay.

b. Monitoring Elements

<u>Land-Water Analysis</u>

Land-water analysis of aerial photography is used in conjunction with topographic surveys of the project area to evaluate land creation and maintenance within the basin. To evaluate land/water ratios in the receiving bay, near-vertical, color-infrared aerial photography (1:24,000 scale) was obtained prior to construction in 2002, and in post-construction years 2008 and 2014. Future aerial photography events are scheduled for 2018 and 2021. The photography was georectified using standard operating procedures described in Steyer et al. (1995, revised 2000) to determine land/water ratios.

<u>Elevation (Topographic/Bathymetric Surveys)</u>

To document changes in the mean sediment elevation within the receiving bay related to the creation of subaerial land, elevational transect lines were established across the crevasse receiving bay. Approximately 17 cross-sectional transects were run in a northwest to southeast direction across the receiving bay. The lines were spaced 1,000 ft (304.9 m) apart for the first 5,000 ft (1524.4 m) from the mouth of the diversion, then at 1,500 ft (457.3 m) intervals to the southern project boundary. The southernmost survey line was taken along this southern boundary alignment. Elevation data was recorded at 200 ft (61 m) intervals along the cross-sectional transects and at any notable elevation changes between theses intervals. Approximately 10 cross-sectional transects were also run across the crevasse channel at 200 ft

(61m) intervals with elevations being recorded at 10 ft (3 m) intervals. Elevation surveys were conducted once pre-construction (2003, receiving bay only) and during years 2011 and 2015 (receiving bay and crevasse channel). Future elevation surveys are scheduled for 2018 and 2021.

Vegetation

Plant species composition, percent cover, and relative abundance were evaluated to document vegetation on newly created land in the receiving bay. Vegetation surveys follow the Braun-Blanquet method as described in Steyer et al. (1995, revised 2000). Transects are established once the splay islands become subaerial, and match the transects laid out for the elevation surveys. Sample stations (duplicate 4-m^2 [2-m x 2-m] plots) along each transect were established and consist of a balanced number of replicates along the marsh creation gradient. Additional transects and sample stations may be established over time as new land is created. The first vegetation survey was conducted in 2015. Future vegetation surveys are scheduled for late summer (mid-July to mid-September) 2018 and 2021.

c. Preliminary Monitoring Results

i. Land-Water Analysis

Reference area 1 gained 144 acres from 2008-2014, with a total gain of 335 acres since 2002. Reference area 2 lost 30 acres from 2008-2014 and 47 acres since 2002 (Table 1, Figures 4, 5, and 6). Reference area 1 also features a crevasse and a delta complex in the formation stage. The crevasse is depositing into a much smaller area, so subaerial land has emerged more quickly in this area than expected at the larger area of the West Bay complex. Reference area 2 is cut off from the river, so land losses there are consistent with expectations due to the subsidence and sea level rise occurring in the Mississippi River Delta region.

While the West Bay project area gained a total of 557 acres from 2002-2014, much of that gain can be attributed to beneficially placed material. A number of the disposal sites transcend the project boundary, so exact acreage of created wetlands within the land/water analysis area are difficult to ascertain. However, an estimate obtained via ArcGIS area analysis indicates that approximately 665 acres of material had been placed within the land/water analysis boundary at the time of the 2014 survey, versus the 557 acres determined via land/water analysis. Areas of loss and gain were obtained using ArcGIS image analysis difference tool (input imagery: USGS 2002 and 2014 Land/Water Classifications) and are shown in Figure 7. Some areas of known beneficially placed material appear to have experienced some land loss, or no net change. While land losses in other areas of the basin detracted from any land area gained, comparing the areas of losses and gains to the known boundaries of placed material suggests that some of the difference between placement estimates and land gain acreages might also be attributed to settlement and distribution of sediment after placement.

In addition to placement sites, one area of land directly in the path of the crevasse flow has eroded over time, though other areas in the upper portion of the basin show signs of deposition and land gain. Considering the orientation of the crevasse and path of flow into the receiving basin, the erosion of the island directly in that path is not unexpected, and the pattern of deposition in nearby areas is encouraging.

Table 1. Land acreages from Aerial Photography and Land/Water Analysis, and Percent change from 2002 (pre-construction) analysis.

	MR-03	% change	Ref 1	% change	Ref 2	% change
2002	1110	n/a	499	n/a	861	n/a
2008	1493	25.65%	680	26.62%	844	-2.01%
2014	1667	33.41%	824	39.44%	814	-5.77%

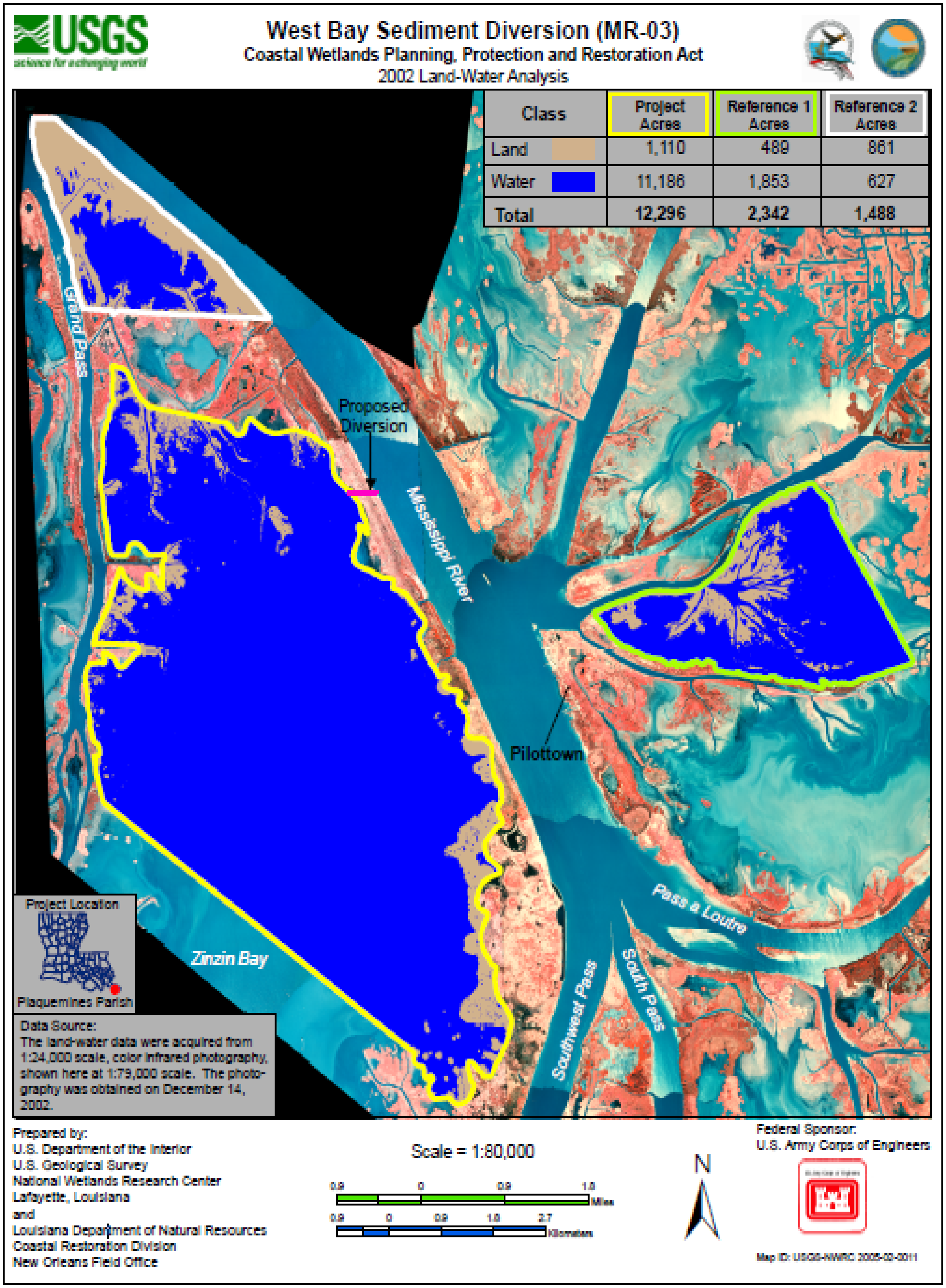

Figure 4: 2002 land/water analyses and acreage amounts.

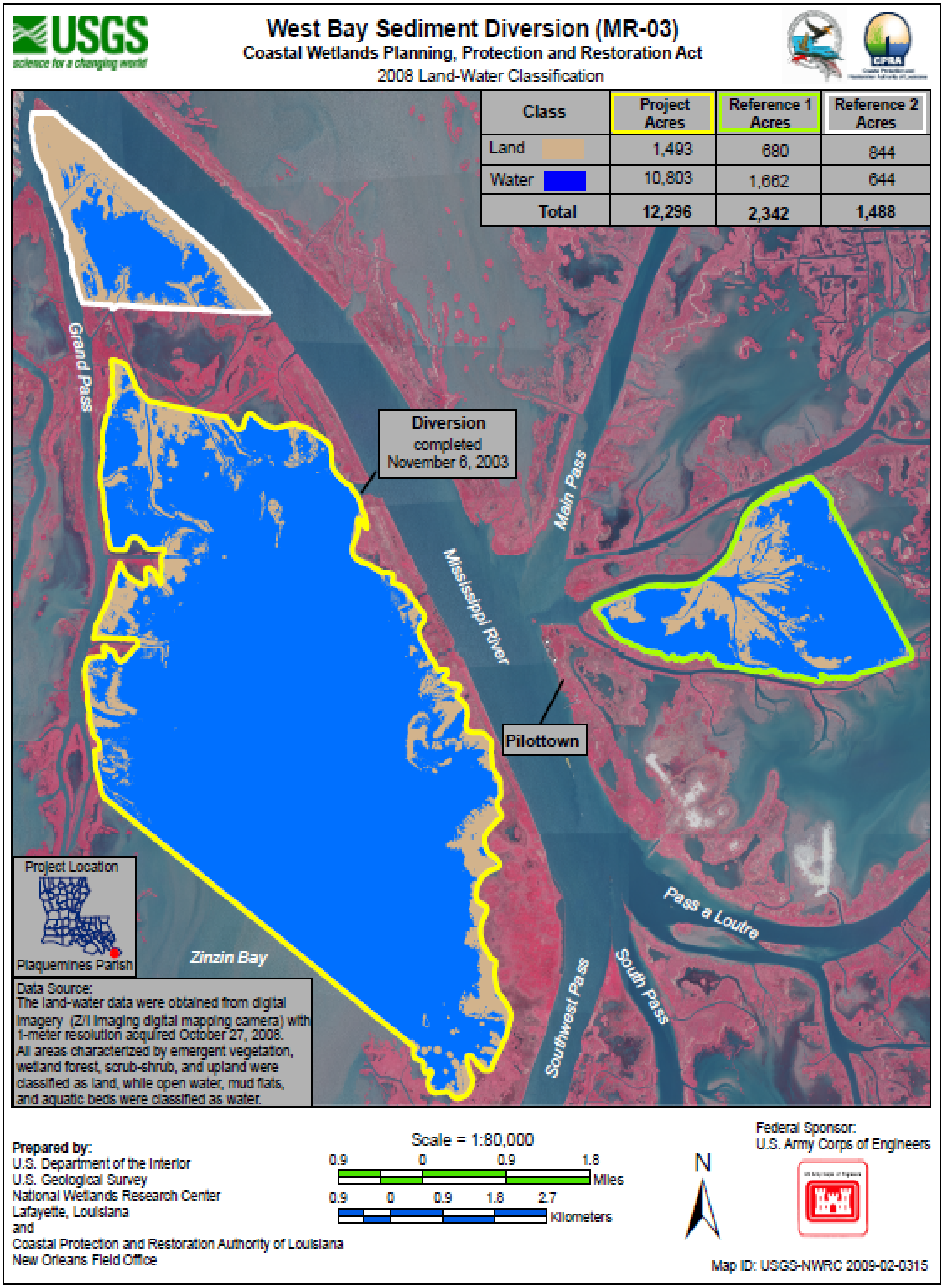

Figure 5: 2008 land/water analyses and acreage amounts.

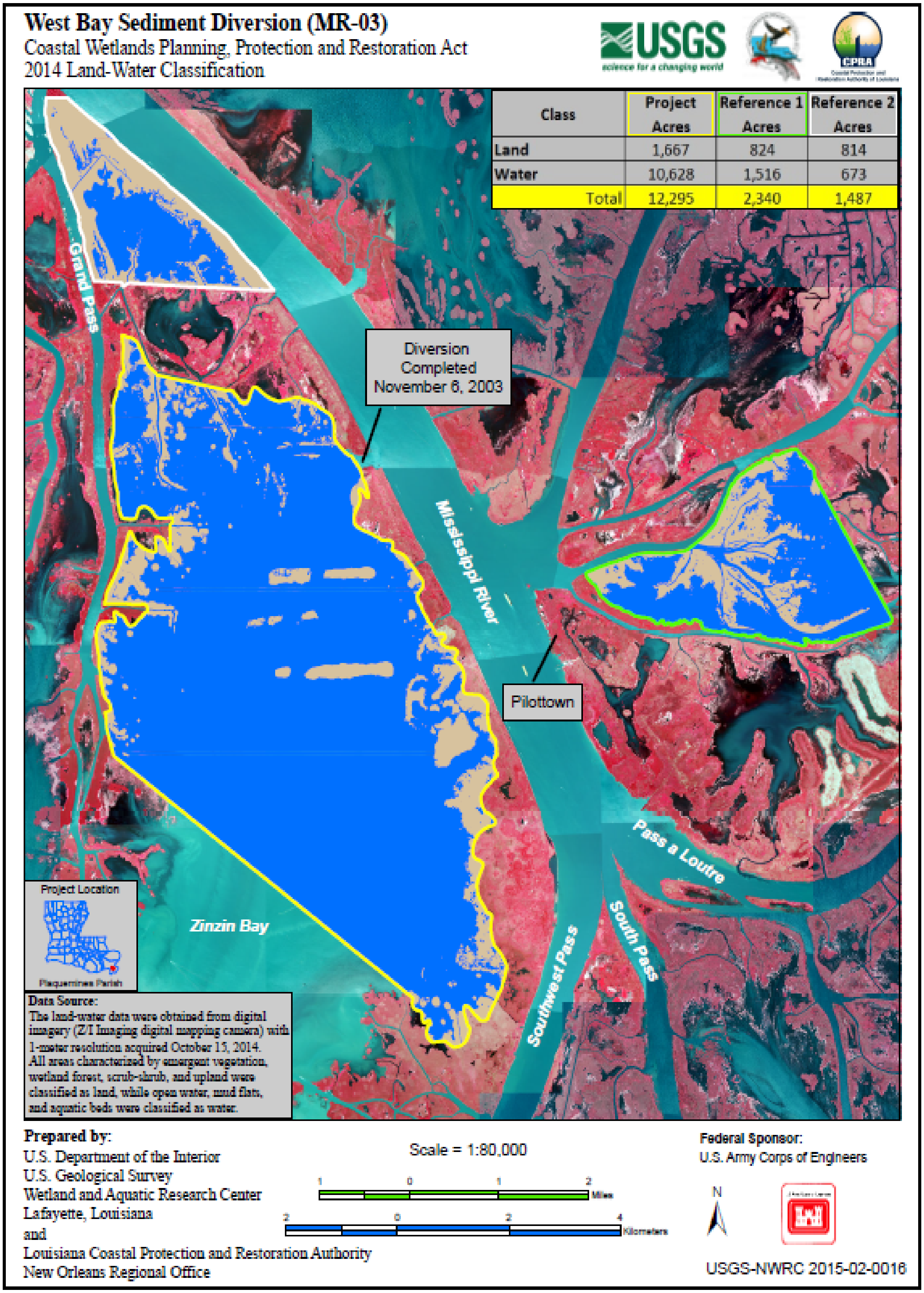

Figure 6: 2014 land/water analyses and acreage amounts.

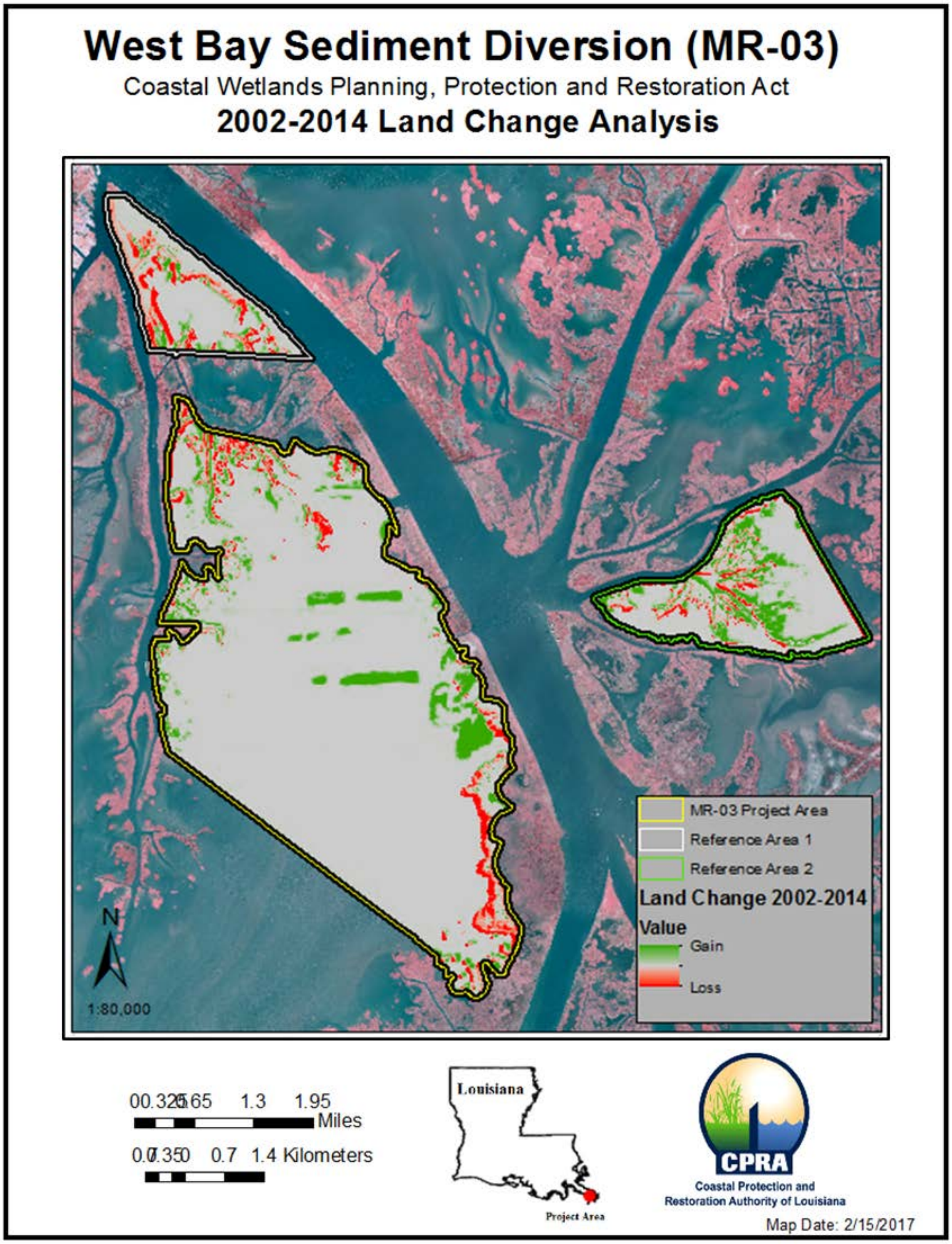

Figure 7. Areas of land gain (green) and loss (red) from 2002-2014 in the West Bay project area and Reference areas 1 and 2.

ii. Elevation (Topographic/Bathymetric Surveys)

Elevation analyses were performed by the USACE Mobile District's Spatial Analysis Center (USACE 2016).

The scour area within the crevasse channel increased slightly in depth between the 2011 and 2015 survey (Figure 8) with a gain of 2,972 cubic yards of water volume. Change analyses (Figures 9), however, show areas of both accretion and erosion in the channel, with a net gain of 19,063 cubic yards of material overall. Monitoring these changes over time will aid in evaluation of flow path and rate changes through the crevasse.

The West Bay survey extents and areas of placement material (Figure 10) were defined for volumetric analysis of the receiving area. These analyses indicated that the area experienced a net gain of 17,235,348 cubic yards of material between 2011 and 2015 (Figures 11). Approximately 4,812,490 cubic yards of this gain may be attributable to confirmed placement material, yielding a resultant 12,422,858 cubic yards of material that was likely contributed to the receiving bay via natural processes, including the diversion input (Figures 12).

Between 2003 and 2009, the survey area experienced a loss of 14,813,581 cubic yards (Barras et al. 2009). Change analyses between the 2009 and 2011 surveys indicated a net gain of 1,567,256 cubic yards (USACE 2012). However, about 1.9 million cubic yards of material was placed in the area in 2010, and was included in the 2011 survey. The difference between the net gain and known placement volume indicates an overall loss due to natural processes of about 332,744 cubic yards between 2009 and 2011. Evaluating the overall change over the project life from 2003 to 2015 indicates a net loss of 2,723,467 cy, though the sedimentation rate has increased over time, and the loss rate has slowed. In addition, differences in survey extents may have resulted in a greater perceived loss for the 2003-2015 project life, as the 2015 survey extent was over 12 million square yards (~2500 acres) smaller in area than previous surveys (Figure 10).

Table 2: Summary of volumetric change analyses for the West Bay Receiving Basin.

Years	Net Gain (cy)	Gain Rate (cy/year)	Net Loss (cy)	Loss Rate (cy/year)	BUDMAT (cy)	Change (cy)
2003-2009	3,476,559	579,426	18,290,140	3,048,357	0	-14,813,581
2009-2011	7,837,426	2,968,713	6,270,171	3,135,086	1,900,000	-332,745
2011-2015	17,979,825	3,291,834	744,477	186,119	4,812,490	12,422,858
2003-2015	**29,293,810**		**25,304,788**		**6,712,490**	**-2,723,468**

While the West Bay receiving area remains an open system with a number of possible sources of water and sediment input, the diversion crevasse is by far the largest of these inputs, and diverts flow directly from the MS River. Thus, it is likely that much of the natural sedimentary gain is due to the influence of the diversion. In addition, mechanical placement of material in strategic areas, considering the path of flow from the crevasse, has likely contributed to sediment retention within the basin.

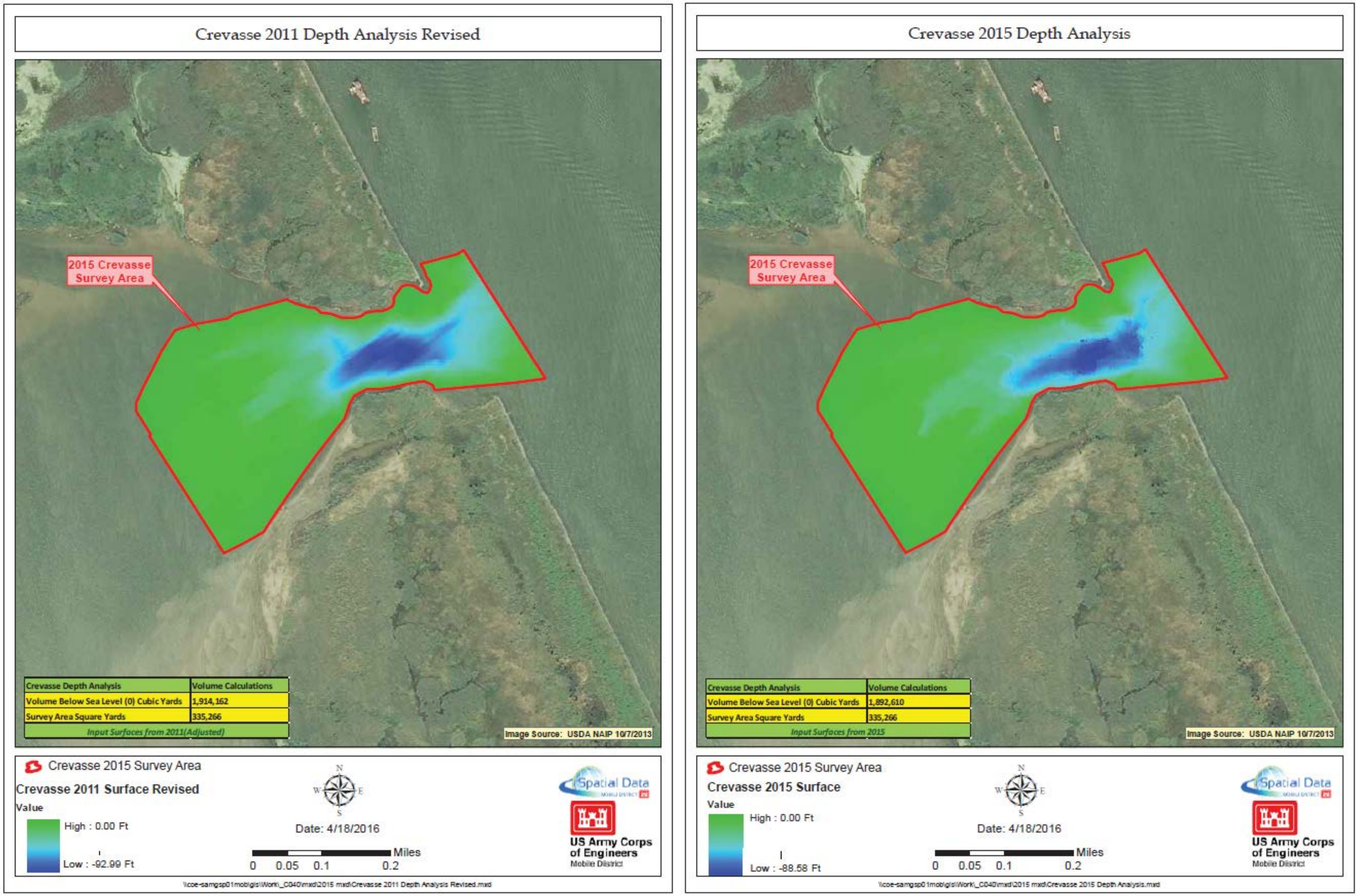

Figure 8: MR-03 2011 and 2015 depth analyses of the diversion crevasse

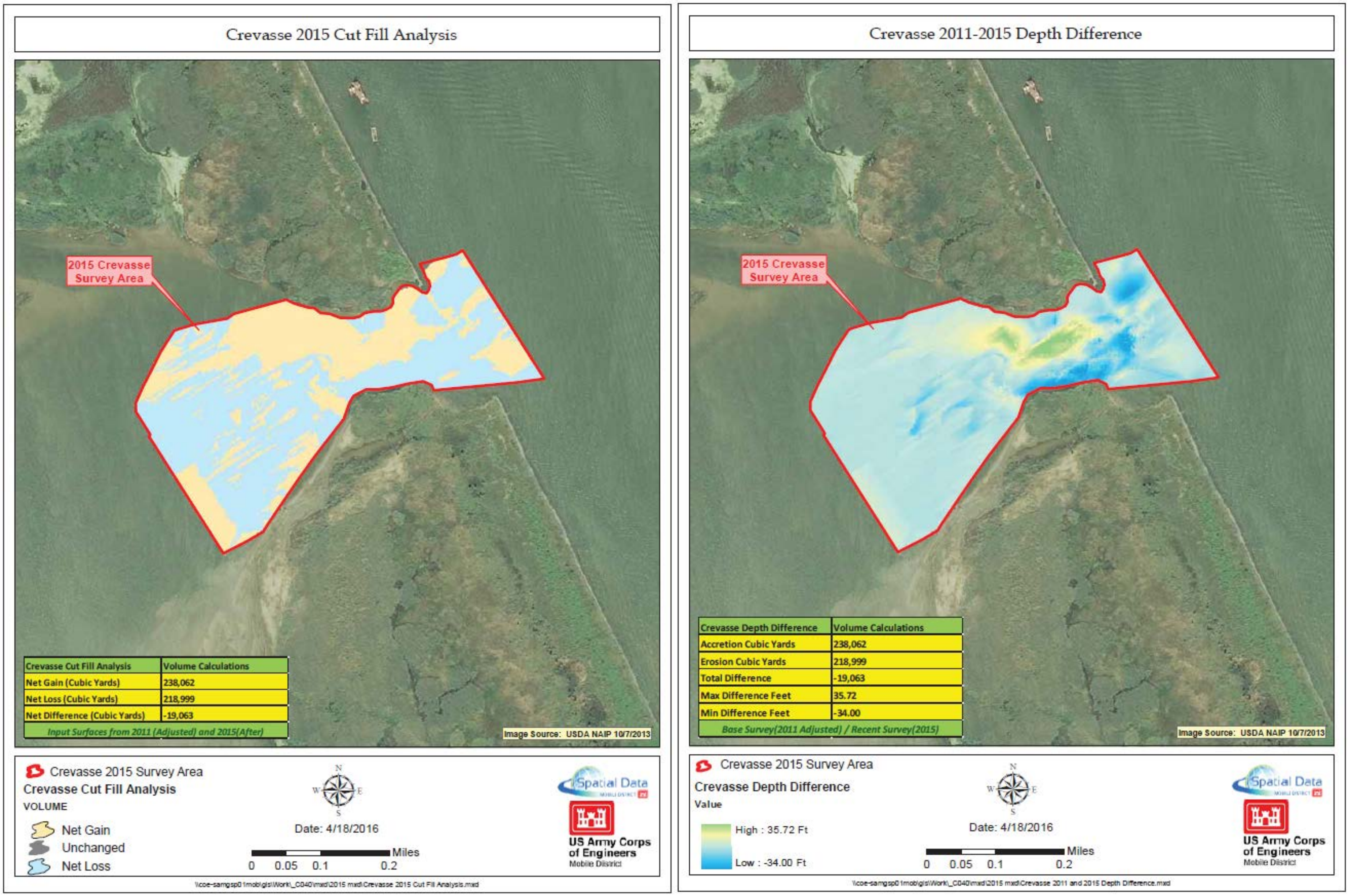

Figure 9: MR-03 2011-2015 areas of gain/loss, and depth difference analysis for the diversion crevasse.

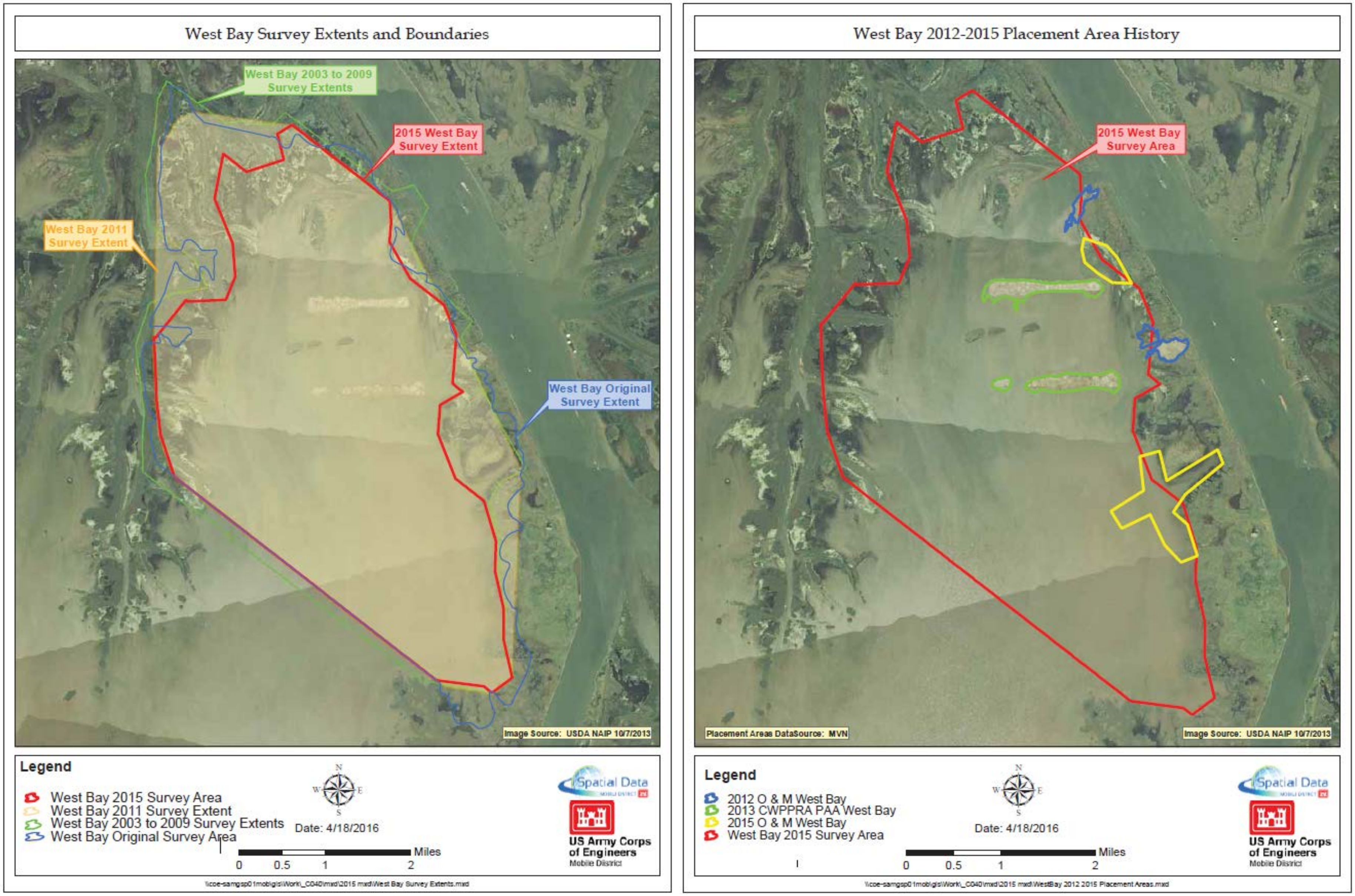

Figure 10: MR-03 available survey extents and dredge material placement areas utilized in receiving basin analyses.

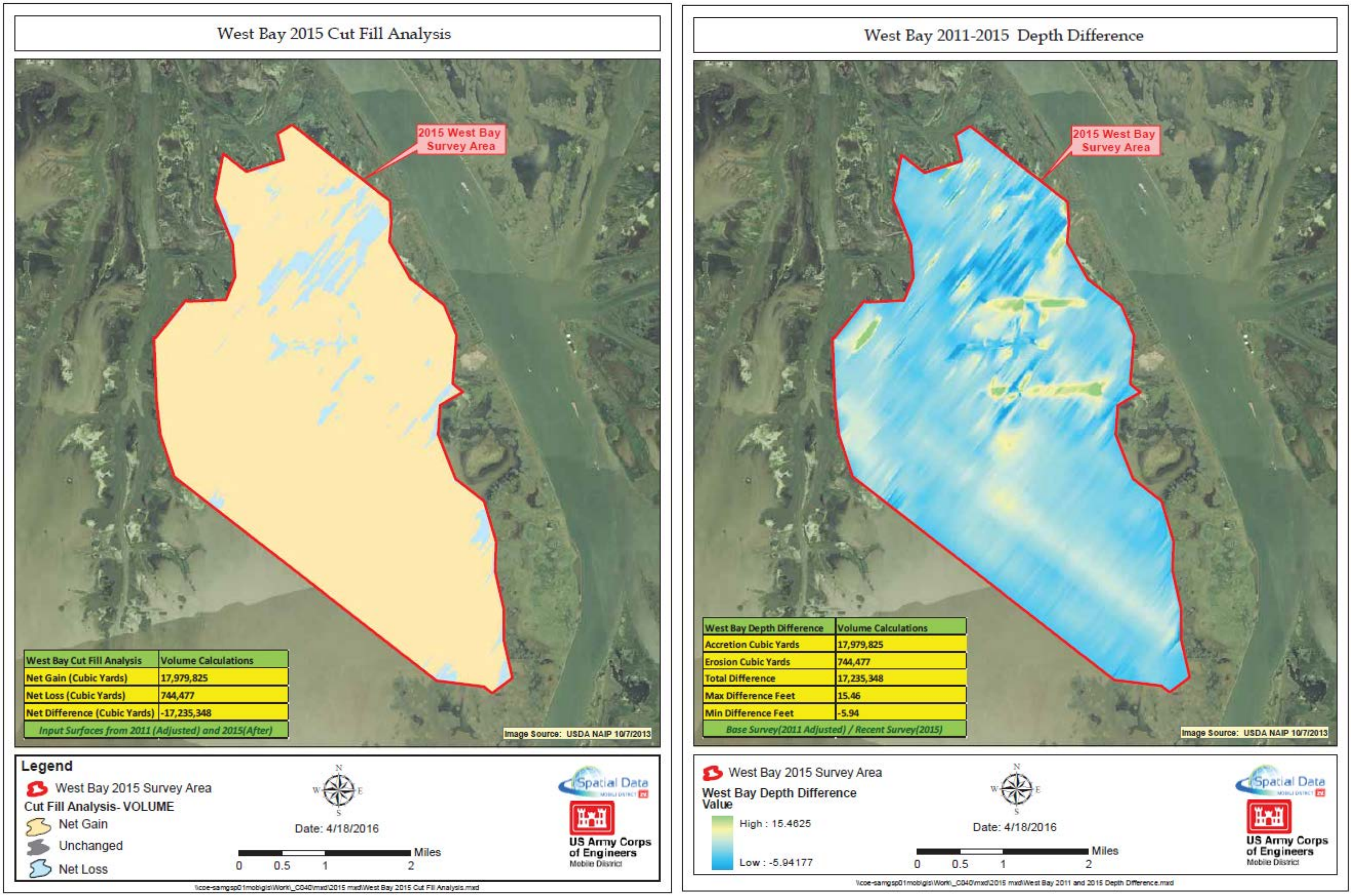

Figure 11: MR-03 2011-2015 areas of gain/loss and depth difference analysis of the receiving basin.

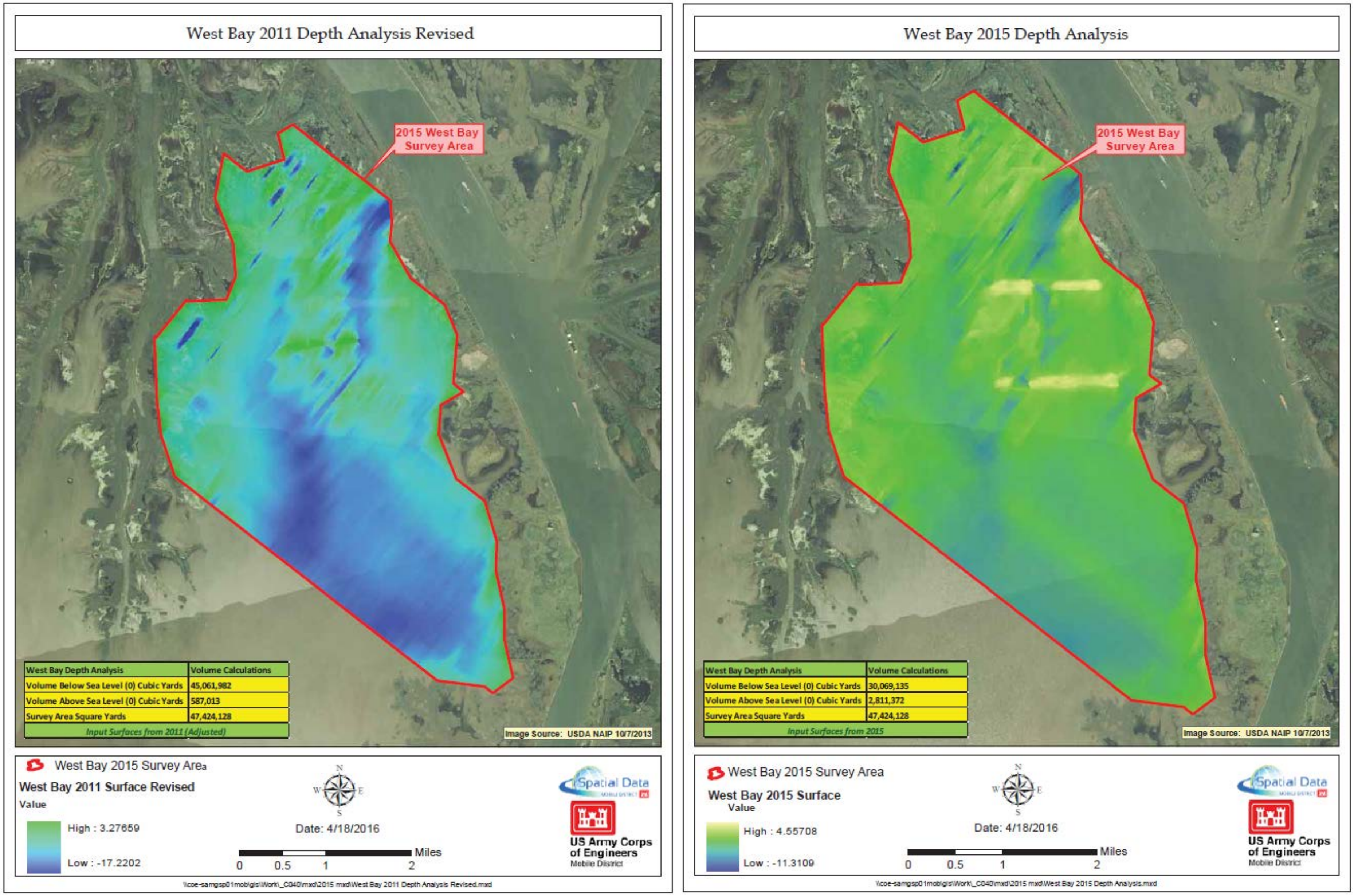

Figure 12: MR-03 2011 and 2015 depth analyses of the receiving basin.

iii. Vegetation

The first vegetation survey performed in the West Bay project area was conducted in September of 2015. While trends and comparisons cannot be analyzed until future surveys are obtained, this initial event did indicate that areas of deposition were vegetated, as were areas of newly placed dredged material. Based on the species present, the marsh classification for the area was defined as fresh-intermediate (Figure 13).

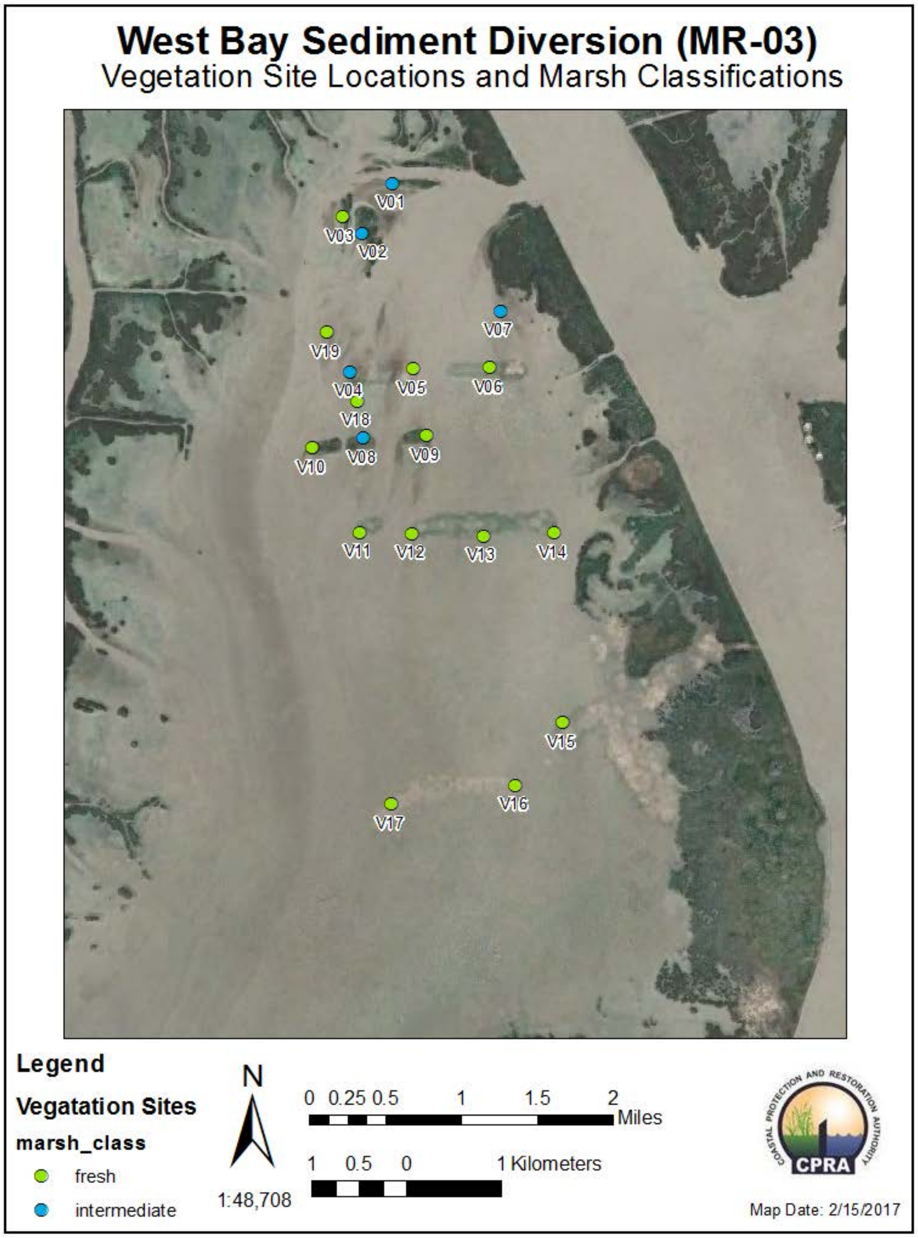

Figure 13: MR-03 vegetation stations and marsh classification.

In 2015, there were 48 species observed within 16 established vegetation plots, and percent cover ranged from <1% to 15.5%. Species richness was greatest at the most established beneficial use sites. Mudflats associated with SREDs had the least diversity (single species), while newly formed placement areas exhibited approximately 5-8 species each. Annual wildrice (*Zizania aquatica*) was the singular species present on the SRED- associated mudflats, but was also present on newly placed material sites. This is indicative of an emergent vegetative profile, as expected in newly formed or emergent land.

The Floristic Quality Index (FQI) is used to determine wetland quality based on plant species composition for a geographic area of interest. The FQI developed with the Coastwide Reference Monitoring System (CRMS) data is specific to coastal Louisiana, and was developed by assigning a Coefficient of Conservatism (CC score) based on a species' tolerance to disturbance and fidelity to a habitat. FQI scores range from 0 to 100 and are calculated based on the percent cover values and the CC scores of the species present (Cretini et al. 2011). Average FQI scores for the Mississippi River Delta (MRD) are generally lower due to the assignment of lower CC scores to non-native, opportunistic species. The 2015 FQI score for the MR-03 project area was 34 (Figure 14), which is higher than the average for the MRD (generally less than 20), but lower than the coastwide average (about 55). Though there are no CRMS sites located within the West Bay project area, this initial FQI score of 34 is consistent with the 2015 survey of nearby CRMS site 2608 (FQI=27.69), which is located between the MR-03 Project Area and Reference Area 2.

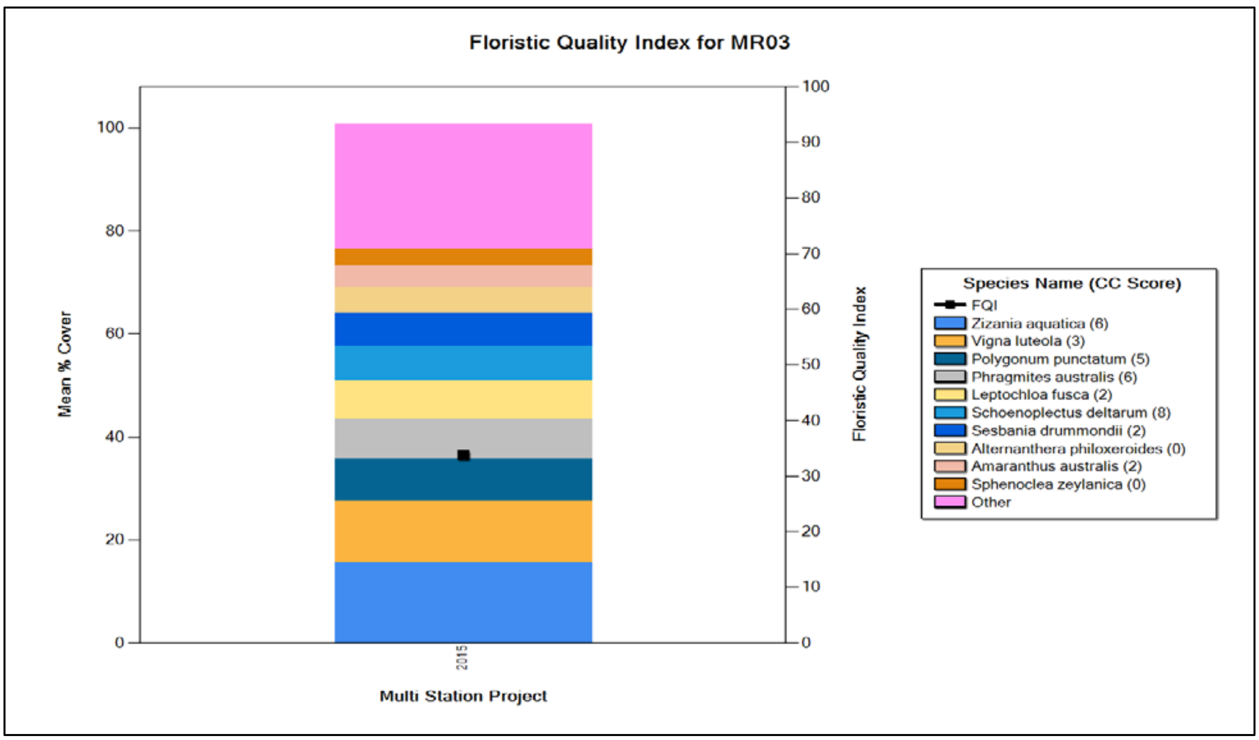

Figure 14: MR-03 FQI and percent cover for the initial vegetation sampling event in 2015. Future events will include additional plots as new land is formed, as well as these current sites to compare development and FQI trends.

VI. Conclusions

a. Project Effectiveness

The project goals are to increase land:water ratio, increase mean elevation within the receiving bay, and determine the effects on emergent vegetation in the receiving bay. The West Bay Sediment Diversion is effectively making progress towards these goals. Due to the various beneficial use events, land:water ratios have increased with the addition of strategically placed material, and those sites are vegetating naturally immediately following placement, which helps sustain the newly built land areas. Strategic placement of material is also likely aiding in sediment retention in the basin by slowing and altering the path of the flow through the area, increasing the opportunity for suspended sediments to settle out of the water column, andbe captured in the system. The mean elevation within the receiving bay has also increased considerably, and this increasing trend is expected to continue.

Studies suggest that crevasses tend to experience a timeframe of initial scour prior to the depositional period (Cahoon et al. 2011). The West Bay Sediment Diversion has experienced a similar cycle, and has entered the phase of deposition (Yuill et al. 2016). Kolker et al. (2012) found that the majority of sediment transported through the West Bay diversion crevasse was retained in the receiving area, including some deposition occurring seaward of the project boundary. Furthermore, the study found that a high river event in 2011 had a large impact, resulting in the emergence of many subaerial islands at low water level. This occurrence is reflected in the 2011 survey data, and highlights the impact and importance of seasonal high water events in the development and maintenance of land in crevasse deltas.

The land:water analyses highlight the land gains from the various events of the LCA-BUDMAT USACE Operations, and CWPPRA programs. While the land:water analysis does not reflect significant land gain via the crevasse or other natural processes as of the 2014 photography event, the strategic placement of material throughout the basin aids in the retention of sediments delivered through the crevasse, and increases in the land:water ratio are expected in the future.

Volumetric analyses derived from elevation data indicate a current sedimentation rate of more than 3 million cubic yards per year (2011-2015), and a considerable decrease in overall depth of the project area (USACE 2016). Although the 2003-2015 change indicates an overall net loss of over 2 million cubic yards over the project life, the increased sedimentation rates paired with the continued enhancement of retention via placed material from the beneficial use events suggests an optimistic potential for continued deposition increases, and in time, sub-aerial land gain. In addition, the change calculation is a conservative value, and may reflect a greater than actual loss due to the smaller survey area utilized in 2015. It is also expected that years of higher river/increased flow will continue to have a positive impact on the rate of deposition in the receiving basin.

The crevasse channel itself displayed an initial period of scouring and self-optimization, followed by filling in of some areas of the crevasse along with of the greater basin area. These changes are consistent with early crevasse evolutionary phases, and indicate that the crevasse channel may be self-optimizing, though monitoring areas of accretion and scour over time is recommended to ensure flow through the crevasse remains unhindered (Yuill et al 2016).

As this report features the first vegetation sampling event, trends are not able to be evaluated. However, initial indications are that the area is being vegetated with species consistent with those observed at nearby monitoring sites. This initial sampling event will also aid in the evaluation of vegetative community development over time on newly built land, as dredged material had been recently placed in the area. These new land areas were included in the sampling event. The placed material begins to accrue vegetation very quickly, and it is expected that the vegetative profile will continue to develop over time, increasing in both coverage and diversity as seen in areas of previous placement. The fresh-intermediate marsh classification was expected due to the riverine influence in the basin via the diversion crevasse. Newer and emergent land (i.e. mudflats) exhibited fewer species and/or lower cover than the "older" areas of land (such as the initial SRED Islands).

b. Recommended Improvements

While the BUDMAT program has been extremely positive for the West Bay receiving basin, in both creating new land area and aiding in the retention of sediment, better tracking of beneficial use placement sites and cubic yardage of material placed would aid in our ability to attribute sediment input via mechanical placement versus natural inputs when evaluating both land:water ratios and elevation changes.

To better assess elevation change in the basin, it is recommended that future survey extents/boundaries are consistent with previous surveys, and that change analyses include the 2003 survey for an evaluation of the entire project life, in addition to the changes between the two most recent surveys. In addition, documentation of the dates and times of both dredging and surveying activities, as well as exact locations, will allow for a more accurate analysis of change due to natural processes versus placed material.

While current monitoring plans do not include an evaluation of SREDs and placed material impacts on flow attenuation and sediment retention in the basin, it would be useful to assess and better understand the role these elements play in the success of the project.

c. Lessons Learned

One lesson learned from the West Bay Sediment Diversion is that riverside shoaling and crevasse scour/orientation changes should be considered when designing projects and maintenance plans. Initial optimization of both factors may decrease maintenance needs, particularly for diversion structures (versus an open/ non-structural crevasse). In addition, the West Bay Diversion demonstrates that it takes significant time to fill in a large receiving bay such as the West Bay Basin, though strategically placed dredge material and higher river years may accelerate this process. Consideration and understanding of these factors can aid in improved design and expectations of future diversions and crevasses.

VII. References

Barras, J.A., W.C. Padgett, and C.B. Sanders 2009. Aerial and Bathymetric Spatial Change Analysis of the West Bay Sediment Diversion Receiving Area. Louisiana for U.S. Army Engineer District, New Orleans (MVN) Report US Army Corps of Engineers (39 pp.).

Boyer, M. E. 1996. Constructed crevasses as a techniques for land gain in the Mississippi River Delta. M.S. thesis, Louisiana State University. 110 pp.

Boyer, M. E., J. O. Harris and R. E. Turner 1997. Constructed crevasses and land gain in the Mississippi River delta. Restoration Ecology 5(1):85-92.

Cahoon, D.R., D.A. White, and J.C. Lynch 2011. Sediment infilling and wetland formation dynamics in an active crevasse splay of the Mississippi River delta. Geomorphology, 131(3), pp.57-68.

Coleman, J. M. and S. M. Gagliano 1964. Cyclic sedimentation in the Mississippi River deltaic plain. Gulf Coast Association of Geological Societies Transactions 14:67-80.

Coleman, J. M. 1988. Dynamic changes and processes in the Mississippi River delta. Geological Society of America Bulletin 100:999-1015.

Cretini, K.F., and G.D. Steyer, 2011, Floristic Quality Index—An assessment tool for restoration projects and monitoring sites in coastal Louisiana: U.S. Geological Survey Fact Sheet 2011–3044, 4 p.

Day, J. W. Jr., and P. H. Templet 1989. Consequences of sea level rise: implications from the Mississippi Delta. Unpublished report for the Louisiana Department of Natural Resources. Baton Rouge: Coastal Restoration and Management Division. 17pp.

Kelley, S. 1996. Small Sediment Diversions (MR-01). Progress Report No. 2. Louisiana Department of Natural Resources. Baton Rouge, Louisiana. 12pp.

Kolb, C.R. and J.R. Van Lopik 1966. Depositional environments of the Mississippi River deltaic plain-Southeastern Louisiana. p. 17-61. *In*: M. L. Shirley (ed.) Deltas. Houston Geological Society, Houston, Texas.

Kolker, A.S., Miner, M.D. and Weathers, H.D. 2012. Depositional dynamics in a river diversion receiving basin: The case of the West Bay Mississippi River Diversion. Estuarine, Coastal and Shelf Science, 106, pp.1-12.

Louisiana Department of Natural Resources (LDNR) 1993. Accretion and hydrologic analyses of three existing crevasse splay marsh creation projects at the Mississippi delta. Final report to U.S. EPA Region VI, Grant No. X-006587-01-0. Baton Rouge, Louisiana. 28pp, plus appendices.

Louisiana Department of Natural Resources, Coastal Restoration Division (LDNR/CRD). 2003. Monitoring Plan for West Bay Sediment Diversion. Baton Rouge, Louisiana. 11 pp

Marin, P.E. 1996. A study of sedimentation in an artificially crevassed pond on Delta National Wildlife Refuge, Louisiana. Master thesis, University of Southwestern Louisiana. Lafayette, Louisiana. 82pp.

Morgan, J.P. 1973. Impact of subsidence and erosion on Louisiana coastal marshes and estuaries. *In* R.H. Chabreck, Proceedings of the Coastal Marsh and Estuary Management Symposium. L.S.U., Baton Rouge, Louisiana. P. 217-233.

Neill, C. and L.A. Deegan. 1986. The effect of Mississippi River delta lobe development on the habitat composition and diversity of Louisiana coastal wetlands. American Midland Naturalist 116 (2):296-303.

Penland, S., H.H. Roberts, S.J. Williams, A.H. Sallenger, Jr., D.R. Cahoon, D.W. Davis, and C.G. Groat. 1990. Coastal land loss in Louisiana. Gulf Coast Association of Geological Societies Transactions 40:685-699.

Scruton, P.C. 1960. Delta building and the deltaic sequence. *In*: Shepard, F.P. et al. Recent sediments, northwest Gulf of Mexico. Tulsa, Oklahoma. American Association of Petroleum Geologists. p. 82-102.

Steyer, G.D., R.C. Raynie, D.L. Steller, D. Fuller and E. Swenson. 1995, revised 2000. Quality management plan for Coastal Wetlands Planning, Protection, and Restoration Act monitoring program. Open-file series no.95–01 (Revised June 2000). Louisiana Department of Natural Resources, Coastal Restoration Division. Baton Rouge, Louisiana. 97 pp.

Trepagnier, C.M. 1994. Near coastal waters pilot project: Crevasse splay portion. Final report to U.S. EPA Region VI, Grant No. X-006518-01-2. Louisiana Department of Natural Resources, Coastal Restoration Division. Baton Rouge, Louisiana. 37pp, plus appendices.

United States Army Corps of Engineers (USACE). 2012. West Bay 2011 Depth Analysis Process Report. Report to USACE New Orleans District from USACE Mobile District Spatial Data Branch (OP-J)

United States Army Corps of Engineers (USACE). 2016. West Bay 2015 Depth Analysis Process Report. Report to USACE New Orleans District from USACE Mobile District Spatial Data Branch (OP-J)

Wells, J. T. and J.M. Coleman. 1987. Wetland loss and the subdelta life cycle. Estuarine, Coastal and Shelf Science 25:111-125.

White, D.A. 1993. Vascular plant community development on mudflats in the Mississippi River delta, Louisiana, USA. Aquatic Botany 45:171-194.

Yuill, B.T., Khadka, A.K., Pereira, J., Allison, M.A., & Meselhe, E.A. 2016. Morphodynamics of the erosional phase of crevasse-splay evolution and implications for river sediment diversion function. Geomorphology, 259, 12-29.