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Coastal Protection and Restoration Authority of Louisiana

Office of Coastal Protection and Restoration

2010 Operations, Maintenance, and Monitoring Report

for

Atchafalaya Sediment Delivery (AT-02)

State Project Number AT-02
Priority Project List 2

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St. Mary Parish

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Operations, Maintenance, and Monitoring Report
For
Atchafalaya Sediment Delivery
(AT-02)

Table of Contents

I. Introduction

The Atchafalaya Sediment Delivery (AT-02) project is a sediment diversion and marsh creation restoration project located inside the Atchafalaya Delta. The project lies within the Louisiana Department of Wildlife and Fisheries (LDWF) administered Atchafalaya Delta Wildlife Management Area (WMA) and is positioned approximately 29 km (18 mi) south of Morgan City in St. Mary Parish, Louisiana (figure 1). The AT-02 project is situated directly across the Atchafalaya River from the Big Island Mining (AT-03) project (figures 1 and 2) and was placed along East Pass (figure 3). The project is bounded on the north by Mile Island, the west by East Pass, and to the east and south by the Atchafalaya Bay. The project was federally sponsored by the National Marine Fisheries Service (NMFS) and locally sponsored by the Louisiana Office of Coastal Protection and Restoration (OCPR) under the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA, Public Law 101-646, Title III). The AT-02 project area consists of 833 ha (2182 acres) of fresh marsh, scrub-shrub, wetland forested, beach/bar/flat, submerged aquatics, and open water habitats (figure 3).

Atchafalaya Delta growth was originated in 1952 with the deposition of prodelta clay sediments into Atchafalaya Bay. The aggradation of prodelta clay continued until 1962 when distal bar sediments (interlaminated thin sands, silts, and clays) began to accumulate on the bay bottom and form an embryonic subaqueous delta. By the early 1970's, sand rich distributary mouth bar sediments began to aggrade the Atchafalaya River-Atchafalaya Bay interface and establish subaerial mid-channel bar and levee facies (Majersky et al. 1997; Roberts and van Heerden 1992; Roberts 1998; van Heerden and Roberts 1980; van Heerden and Roberts 1988; van Heerden et al. 1991). The substantial floods of 1973, 1974, and 1975 hastened the emergence of the subaerial delta through the frictional deposition of larger grained sediments. These deposits were formed into a bifurcating network of mid-channel bars and secondary and tertiary distributary channels. During this time, seaward channel elongation and bifurcation were the geological mechanisms governing delta growth (Roberts and van Heerden 1992; Roberts 1998; van Heerden and Roberts 1980; van Heerden and Roberts 1988; van Heerden et al. 1991). Due to these mechanisms and the large discharge flowing through East Pass, this distributary experienced considerable subaerial expression in the early 1970's. In this period of rapid delta development (1973 to 1976), the land in the Atchafalaya Delta expanded at a rate of 525 ha/yr (1297 acres/yr) (van Heerden et al. 1991). Moreover, van Heerden et al. (1983) documented that 27% of the Lower Atchafalaya River discharge flowed through East Pass from 1979 to 1981. After 1976, channel abandonment and lobe fusion became the dominant geological processes forcing delta growth. These processes are initiated when subaqueous bars form across tertiary channels leading to deposition of fine grained sediments, channel narrowing, and lobe fusion (Roberts and van Heerden 1992; Roberts 1998; van Heerden et al. 1991 van Heerden and Roberts 1980; van Heerden and Roberts 1988;). van Heerden et al. (1991) reported that the rate of land creation in the delta slowed to 193 ha/yr (477 acres/yr) from 1977 to 1991, a period dominated by channel abandonment and lobe fusion. Since this early period of subaerial delta growth, spring floods have arisen along the Atchafalaya River in 1979, 1983, 1984, 1993, 1997

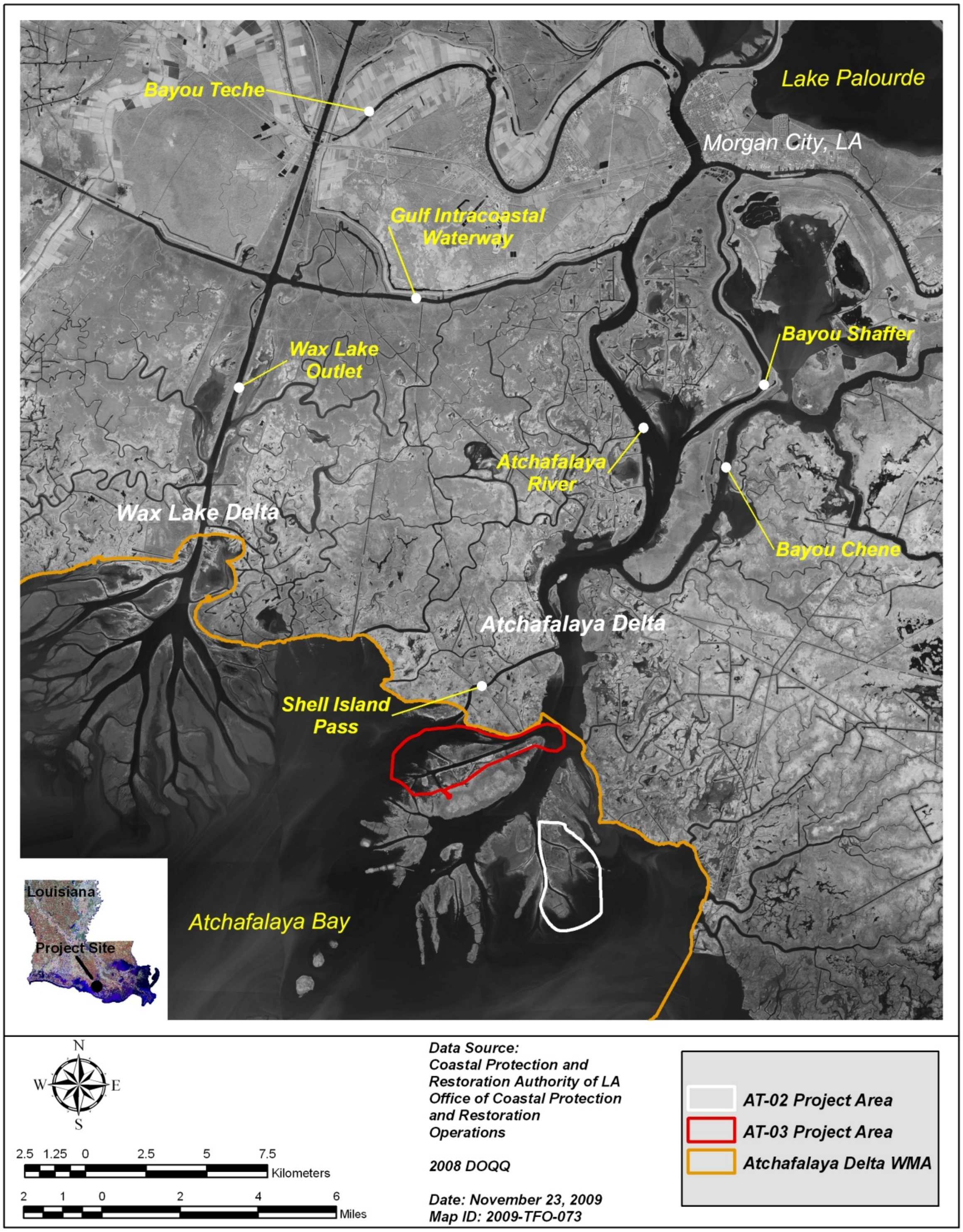


Figure 1. Location and vicinity of the Atchafalaya Sediment Delivery (AT-02) project.

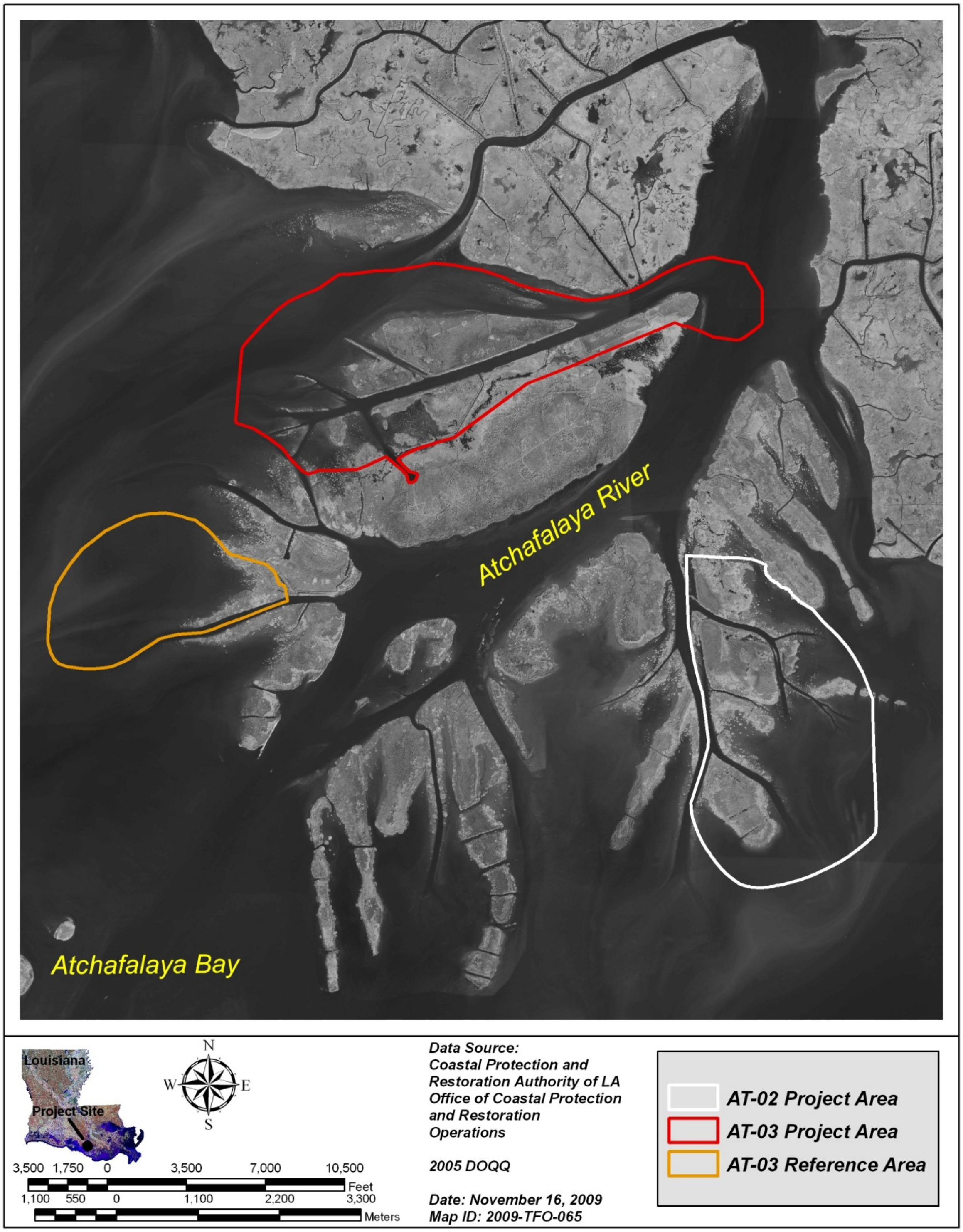


Figure 2. Location of the Big Island Mining (AT-03) project across the Atchafalaya River from the Atchafalaya Sediment Delivery (AT-02) project.

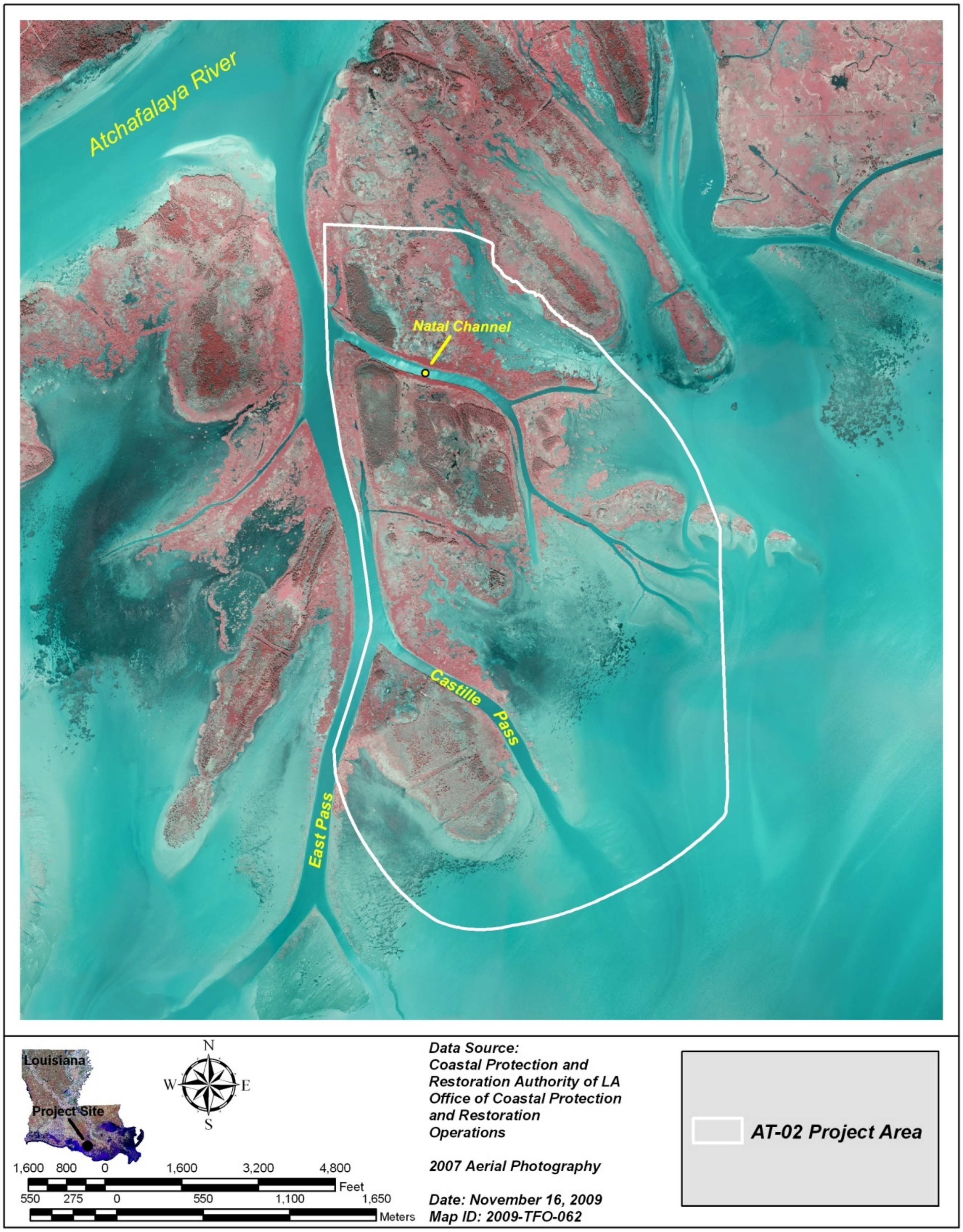


Figure 3. Location of the Atchafalaya Sediment Delivery (AT-02) project area.

(Trotter et al. 1998), 2001, and 2008. Moreover, sediment deposition and subaerial lobe creation in the Atchafalaya Delta generally occur during the late winter and spring when river stages and discharges are highest. The overlying distributary mouth bar facies in the Atchafalaya River Delta consists of approximately 60% sand and have been estimated to be 3.0 m (9.8 ft) thick (Majersky et al. 1997; Roberts 1998).

The construction and maintenance of the Lower Atchafalaya River Bay and Bar navigation channel, which extends the entire length of the Lower Atchafalaya River and Atchafalaya Bay into the Gulf of Mexico, is slowing sediment deposition and subaerial lobe creation in the Lower Atchafalaya River Delta and providing a path for sediment transport into the Gulf of Mexico (van Beek 1979; Roberts 1998). The Lower Atchafalaya River Bay and Bar navigation channel was initially constructed in 1939 to a depth of 3 m (10 ft) and a width of 30 m (100 ft). This navigation channel was expanded to its present dimensions [6 m (20 ft) deep by 122 m (400 ft) wide] in 1974 and has been sustained through annual maintenance dredging (Penland et al. 1996; Penland et al. 1997). Approximately, 12,232,880 m^3/yr (16,000,000 yd^3/yr) of sediments are dredged annually from the Lower Atchafalaya River to maintain the Lower Atchafalaya River Bay and Bar navigation channel (Mashriqui et al. 1997). To dispose of this large volume of sediments, dredged materials have been used to construct islands along the edges of the navigation channel. These artificially built islands have been placed at considerably higher elevations than the naturally created deltaic lobes (Penland et al. 1996; Penland et al. 1997; Sasser and Fuller 1988; van Beek 1979). Creation of dredged material islands in the Atchafalaya River Delta began in 1974 with the expansion of the Lower Atchafalaya River Bay and Bar navigation channel. During the period from 1974 to 1987, the vast majority of dredged materials were placed on the western banks of the Lower Atchafalaya River Delta. However since 1987, large amounts of dredged materials have also been deposited along the eastern banks of the Atchafalaya River Delta (Penland et al. 1996; Penland et al. 1997). As of 1996, 72% of the total area of the Atchafalaya River Delta was created by deposition of dredged materials while only 28% of the total area was created through natural processes (Penland et al. 1997).

The naturally created deltaic lobe islands of the Lower Atchafalaya River are generally composed of fresh marsh and mudflat habitats (Penland et al. 1996; Penland et al. 1997). Johnson et al. (1985) documented the initial colonization and spatial distribution of the naturally created Lower Atchafalaya River deltaic lobe islands as consisting of a *Salix nigra Marsh.* (black willow) association on the higher elevated upstream end of the lobe islands, a *Typha latifloia L.* (broadleaf cattail) association at intermediate elevations, and a *Sagittaria latifloia Willd.* (broadleaf arrowhead) association at intermediate and lower elevations. Later vegetation surveys showed increases in species diversity and reductions in vegetative cover in the plant community on these deltaic lobes (Sasser and Fuller 1988; Shaffer et al. 1992). In contrast, the vegetative communities on many of the constructed islands differ greatly from the naturally created islands due to placement of dredged material at higher elevations than the deltaic lobe islands. The vegetative communities on these dredged material islands are mainly composed wetland scrub-shrub, wetland forested, and bare ground habitats (Penland et al. 1996; Penland et al. 1997).

The formation of subaerial and subaqueous bars at the upstream end of two tertiary distributaries of East Pass has inhibited river discharge to portions of the eastern Atchafalaya Delta. The establishment of a subaerial bar at the head of Natal Channel in 1989 has obstructed sediment transport and partially fused the channel while the creation of a subaqueous bar on the upstream end of Castille Pass has disrupted sediment transport (Woodward-Clyde 1992). Since the shoaling at the head of Natal Channel and Castille Pass has reduced river discharge and sediment transport, delta growth has been minimized at the mouth of both distributaries (van Heerden et al. 1991). The rate of subaerial land growth inside the AT-02 project area has been estimated to be 4 ha/yr (9 acres/yr) from 1956 to 1978 and 3 ha/yr (8 acres/yr) from 1978 to 1990 (Barras et al. 1994). The Atchafalaya Sediment Delivery (AT-02) project will attempt to enhance sediment transport and delta growth in the eastern delta by restoring Natal Channel and Castille Pass to functioning tertiary distributaries and constructing dredged material islands. Natal Channel (NC) was reestablished by dredging a 1,829 m (6,000 ft) channel over its former watercourse. At the mouth the channel was bifurcated into two 457 m (1,500 ft) branches (figure 4). Castille Pass was reestablished by dredging a 610 m (2,000 ft) channel (CPC) at the head of the pass removing the subaqueous bar (figure 4). The channels were dredged to a depth of -3 m (-10 ft) NGVD 29. The materials dredged from these channels were placed into Disposal Area 1 (DA1), Disposal Area 2 (DA2), Disposal Area 3 (DA3), Disposal Area 4 (DA4), and the Castille Pass Disposal Area (CPDA) (figure 4). Earthen containment dikes were constructed for DA1, DA2, and DA3 at a 0.9 m (3 ft) NGVD 29 elevation. No containment dikes were constructed for DA4 and CPDA. The DA2 containment dike breached during construction increasing the size of the disposal area by 8 ha (20 acres) (V. Cook, OCPR, pers. comm.). Two 305 m (1000 ft) earthen jetties were installed at the head of NC to alleviate shoaling in this location (figure 4). Construction of the AT-02 project began on January 25, 1998 and was completed by March 21, 1998. The Big Island Mining (AT-03) project is a similar sediment diversion and marsh creation project in the Atchafalaya Delta that was constructed simultaneously with the AT-02 project in 1998.

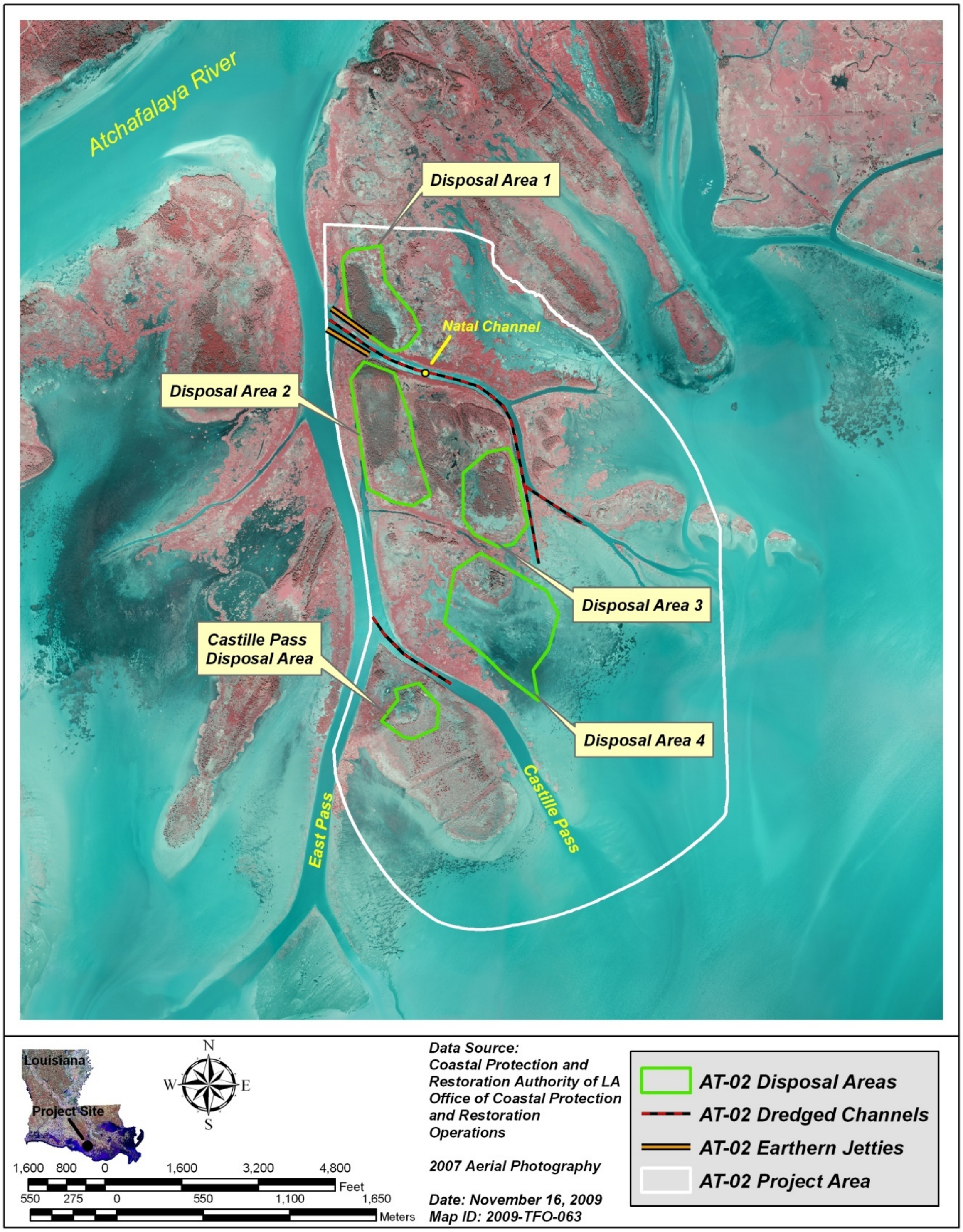


Figure 4. Location of the Atchafalaya Sediment Delivery (AT-02) project features.

II. Inspections and Maintenance Activities

a. Inspection Purpose and Procedures

The purpose of the annual inspection of the Atchafalaya Sediment Delivery (AT-02) project is to evaluate the constructed project features, identify any deficiencies, prepare a report detailing the condition of such features, and to recommend corrective actions needed, if any. Should it be determined that corrective actions are needed, OCPR shall provide, in report form, a detailed cost estimate for engineering, design, supervision, inspection, construction contingencies, and an assessment of the urgency of such repairs. The annual inspection report also contains a summary of maintenance projects undertaken since the constructed features were completed and an estimated project budget for the upcoming three (3) years for operation, maintenance and rehabilitation. The three (3) year projected operation and maintenance budget is shown in Appendix C and the summary of completed maintenance projects are outlined in Section II.b of this report.

An inspection of the Atchafalaya Sediment Delivery (AT-02) project was held on April 6, 2010 under partly cloudy skies and mild temperatures. In attendance were Brian Babin and Glen Curole of the OCPR, Dr. John Foret of the National Marine Fisheries Service (NMFS) and Mr. Edmond Mouton with the Louisiana Department of Wildlife and Fisheries (LDWF). The attendees met at the Berwick Public Boat Launch in St. Mary Parish. The inspection began at approximately 9:00 a.m. and ended at 1:00 p.m.

The field trip included a visual inspection and limited soundings of Natal and Castille Pass channels. No attempt was made to measure the geometry of the channels other than periodic depth measurements recorded using a hand-held fathometer. The primary sources of information and data used in analyzing project deficiencies and determining the need for maintenance and/or corrective actions in this report are the 2008 Topographic and Bathymetric Surveys performed by Morris P. Hebert, Inc. and the 2009 Operations, Maintenance, and Monitoring Report prepared by Mr. Glen Curole of OCPR.

b. Summary of Past Operation and Maintenance Projects

Since the completion of the Atchafalaya Sediment Delivery (AT-02) project in March 1998, no maintenance dredging or marsh creation efforts have been proposed or undertaken. As recommended in the 2005 Annual Inspection Report, a complete survey of all dredged channels and marsh fill areas was completed in the spring of 2008 by Morris P. Hebert, survey consultant contracted by the Office of Coastal Protection and Restoration.

c. Inspection Results

Upon entering East Pass from the Atchafalaya River, we encountered a very large sand bar located at the “fork” of East Pass and the river which extended a couple of thousand feet northward. Access through the mouth of East Pass was very shallow at this location which would indicate that sediment deposition in the pass is migrating southward towards the head of Natal Channel. Inspection of the Atchafalaya Sediment Project (AT-02) began at the head of Natal Channel near East Pass where significant shoaling was observed, creating a sand bar at the entrance to the channel. From survey data collected in the spring 2008, we found that the “sand bar” at the head of Natal Channel begins near Station 15+00 on the north descending bank and encompasses the entire section of the original constructed dredge channel. As the existing channel filled in, a smaller channel developed along the south descending bank. At the time of the 2008 survey, the smaller channel was approximately 100 ft wide with depths ranging between -7.0 ft to -10.0 ft NAVD 88. Traveling downstream, the 100 ft wide smaller channel proceeds along the south descending bank of Natal Channel to Station 45+00 near the bend around Ivor Island. As the channel meanders around the bend of Ivor Island near Station 50+00, the channel began to transition towards the north descending bank between Stations 50+00 to 65+00. The bottom width of the channel in this area is smaller (approximately 25 ft bottom width) and the bottom elevations average -10.0 ft NAVD 88. The south leg of remaining channel past the “fork” between Stations 70+00 and 88+00 was completely shoaled in with average elevations around 0.0 ft NAVD 88. Prior to 2003, the water depths in this reach of Natal Channel were between -6.0 ft and -6.5 ft NAVD 88. This would indicate that at some point after 2003 the primary water flow through the south leg of Natal Channel was restricted significantly or diverted through the east fork near Sta. 70+00. The east fork is a 1,500 linear foot section of Natal Channel along the southern boundary of Teal Island. In 2008, the channel depths along the east fork, south of Teal Island, ranged between -8.0 NAVD at Station 0+00 and -10.0 ft NAVD 88 at Station 15+00. Based on our observations in the field, we believe that the condition of Natal Channel is similar to conditions found in 2008 with possible narrowing of the main channel causing a reduction in flow to the southern reaches of the project area. Photos of Natal Channel and Castille Pass are shown in Appendix B.

In addition to the above observations, we have noticed that a large amount of flow down the east fork of Natal Channel south of Teal Island is being diverted via the northeast diversion channel near Sta. 55+00 of Natal Channel. We believe this is occurring due to the narrowing of Natal Channel south of the diversion channel causing an increase flow though the diversion channel. This is evident by the large areas of subaqueous to subaerial development along the channel and the subaqueous growth near the end of channel towards the Atchafalaya Bay.

III. Operation Activity

No operation activities are required for the AT-02 project.

IV. Monitoring Activity

d. Monitoring Goals

The specific measurable goals established to evaluate the effectiveness of the project are:

1. To increase the distributary potential of Natal Channel and Castille Pass by increasing their cross-sectional area and length.

2. Create approximately 92 ha (230 acre) of delta lobe islands through the beneficial use of dredged material at elevations suitable for emergent marsh vegetation.

3. Increase the rate of subaerial delta growth in the project area to that measured from historical photographs since 1956.

b. Monitoring Elements

The following monitoring elements will provide the information necessary to evaluate the specific goals listed above:

Elevation

Topographic surveys were employed to document elevation and volume changes inside the Atchafalaya Sediment Delivery (AT-02) project disposal areas. Pre-construction (March 1998) and as-built (May 1998) elevation data were collected using cross sectional survey methods (500 ft intervals) with a centerline profile. Five disposal areas (DA) were surveyed during the pre-construction and as-built periods (DA1, DA2, DA3, DA4, and CPDA). Subsequent post-construction topographic surveys were conducted without a centerline profile and DA2 and DA3 were not surveyed. These post-construction surveys were performed in April 2001 and May 2008. The surveys were reduced in scope due to budgetary constraints. All survey data were established using or adjusted to tie in with the Louisiana Coastal Zone (LCZ) GPS Network. The April 2001 topographic data were not applied to the following analysis because these surveys were not consistent with elevation data collected for the other time intervals. May 1998 and May 2008 data present a more accurate illustration of disposal area topography.

The March 1998, May 1998 and May 2008 survey data were re-projected horizontally and vertically to the UTM NAD83 coordinate system and the NAVD 88 vertical datum in meters using Corpscon® software. The re-projected data were imported into ArcView® GIS software for surface interpolation. Triangulated irregular network models (TIN) were produced from the point data sets. Next, the TIN models were converted to grid models (2.0 m^2 cell size), and the spatial distribution of elevations were mapped. The grid models were clipped to the AT-02 disposal area polygons to estimate elevation and volume changes within the fill area.

Elevation changes from March 1998-May 1998 and May 1998-May 2008 were calculated by subtracting the corresponding grid models using the LIDAR Data Handler extension of ArcView® GIS. After the elevation change grid models were generated, the spatial distribution of elevation changes in the AT-02 disposal areas were mapped in half meter elevation classes. Lastly, volume changes in the disposal areas were calculated in cubic meters (m^3) using the Cut/Fill Calculator function of the LIDAR Data Handler extension of ArcView® GIS. Note, these elevation and volume calculations are valid only for the extent of the survey area.

Bathymetry

Bathymetric surveys were employed to document sedimentation patterns in the Atchafalaya Sediment Delivery (AT-02) dredged tertiary channels. Pre-construction (March 1998) and as-built (May 1998) elevation data were collected using cross sections spaced 100 ft apart and centerline profiles. Natal (NC) and Castille Pass (CPC) channels were surveyed during the pre-construction and as-built periods. Subsequent post-construction bathymetric surveys were conducted using 500 ft intervals and centerline profiles. These post-construction surveys were performed in April 2001 and May 2008. The surveys were reduced in scope due to budgetary constraints. All survey data were established using or adjusted to tie in with the Louisiana Coastal Zone (LCZ) GPS Network. The April 2001 bathymetric data were not applied to the following analysis because the areal extents of these surveys were limited. May 1998 and May 2008 data present a more accurate illustration of the dredged channel contours.

The March 1998, May 1998, and May 2008 survey data were re-projected horizontally and vertically to the UTM NAD83 coordinate system and the NAVD 88 vertical datum in meters using Corpscon® software. The re-projected data were imported into ArcView® GIS software for surface interpolation. Triangulated irregular network models (TIN) were produced from the point data sets. Next, the TIN models were converted to grid models (2.0 m^2 cell size), and the spatial distribution of elevations were mapped. The grid models were clipped to the AT-02 dredged channel polygons to estimate elevation and volume changes within each channel.

Elevation changes from March 1998-May 1998 and May 1998-May 2008 were calculated by subtracting the corresponding grid models using the LIDAR Data Handler extension of ArcView® GIS. After the elevation change grid models were generated, the spatial distribution of elevation changes in the AT-02 dredged channels were mapped in half meter elevation classes. Lastly, volume changes in the dredged channels were calculated in cubic meters (m^3) using the Cut/Fill Calculator function of the LIDAR Data Handler extension of ArcView® GIS. Note, these elevation and volume calculations are valid only for the extent of the survey area.

Vegetation

Vegetation stations were established in the Atchafalaya Sediment Delivery (AT-02) project area to document species composition and percent cover over time. Plots were placed on DA1, DA4, and the CPDA (figure 5). Vegetation data were collected in October 1998 (5 months post-construction), October 2000 (2.5 years post-construction), and October 2007 9.5 years post-construction) via the semi-quantitative Braun-Blanquet method (Mueller-Dombois and Ellenberg 1974; Sawyer and Keeler-Wolf 1995; Barbour et al. 1999). Plant species at each station were identified, and cover values were ocularly estimated using Braun-Blanquet units (Mueller-Dombois and Ellenberg 1974) as described in Steyer et al. (1995). The cover classes used were: solitary, <1%, 1-5%, 6-25%, 26-50%, 51-75%, and 76-100%. After sampling the plot, the residuals within a 5 m (16 ft) radius were inventoried. Eighteen (18) stations were sampled in 1998 using a $1m^2$ plot size, 24 stations were sampled in 2000 using $1m^2$ and $4m^2$ plot sizes, and 24 stations were sampled in 2007 using a $4m^2$ plot size.

No reference area was established to compare vegetation communities on the naturally occurring delta islands and the AT-02 disposal areas. However, historical data from Log and Hawk Islands (1979-1998) were obtained from Louisiana State University/Coastal Ecology Institute (LSU/CEI) (figure 5). This vegetation data were used to establish community colonization and succession trends on a prograding delta island. The LSU/CEI data were also collected with the Braun-Blanquet method (Mueller-Dombois and Ellenberg 1974) and had a $1m^2$ plot size. LSU/CEI sampled 24 vegetation stations in 1979, 34 stations in 1980, 34 stations in 1982, and 55 stations in 1998.

Relative cover and importance value (IV) were calculated to summarize vegetation data. Both these parameters were grouped by disposal area and year in the project area while the reference area was grouped by year. Relative cover represents the cover of each species as a percentage of total cover (Barbour et al. 1999). An IV is calculated using a minimum of two relative measures. The following IV formula was applied to this analysis: IV = (relative cover + relative frequency)/2. IV represents each species relative contribution to the vegetative community (Barbour et al. 1999). Since relative cover and IV are relative measures, each species earns a value ranging from 0 to 100.

Figure 5. Location of the Atchafalaya Sediment Delivery (AT-02) vegetation stations and LSU/CEI's Rodney Island vegetation reference area.

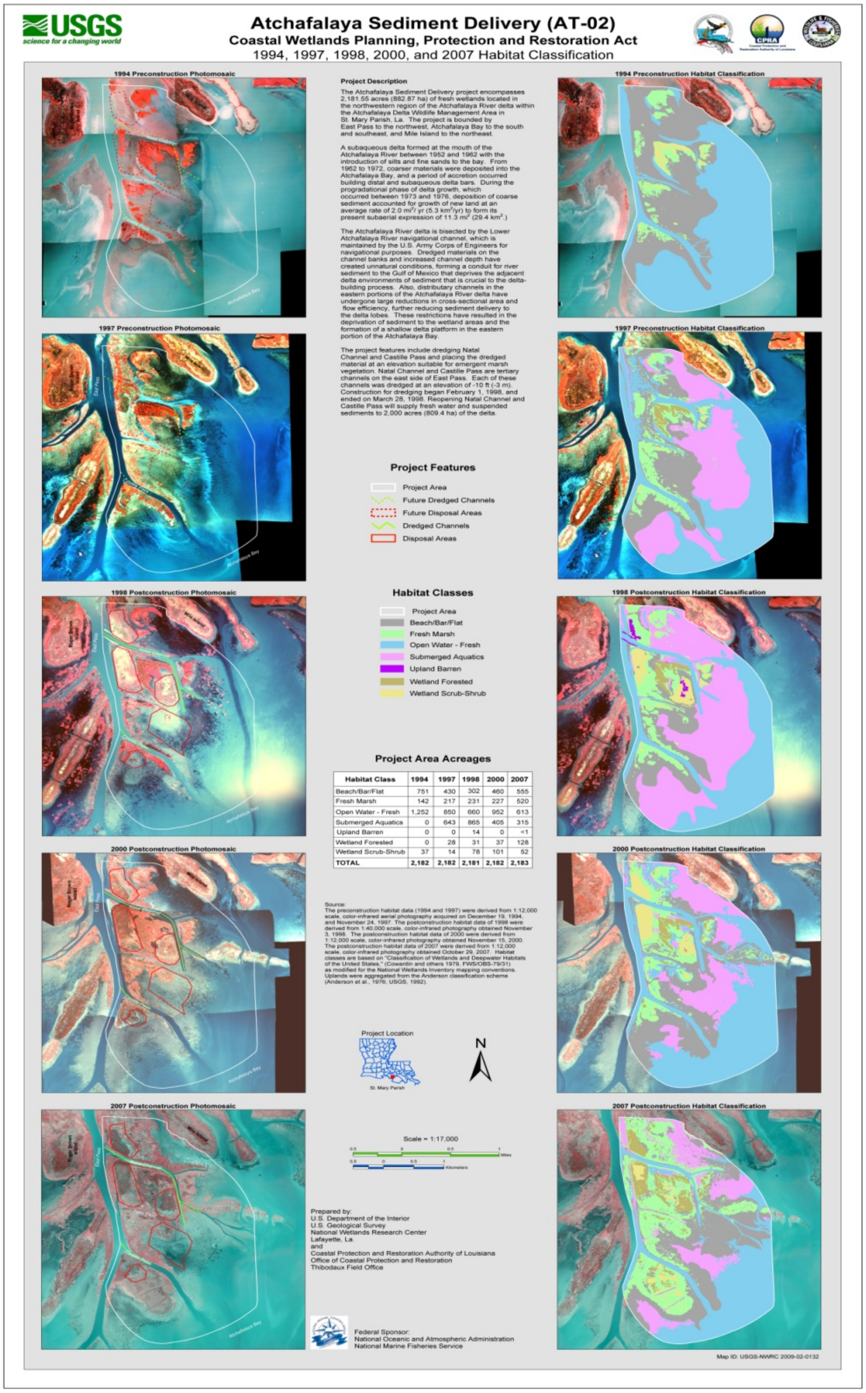
Habitat Mapping

The U.S. Geological Survey's National Wetlands Research Center (USGS/NWRC) obtained 1:12,000 and 1:40,000 scale color infrared (CIR) aerial photography to delineate habitats over time. These aerial images were classified and photo-interpreted to perform habitat analysis of the Atchafalaya Sediment Delivery (AT-02) project area [883 ha (2181 acres)]. Pre-construction aerial photographs were acquired on December 19, 1994 and November 24, 1997 at a 1:12,000 scale while post-construction photographs were acquired on November 3, 1998 (1:40,000 scale), November 15, 2000 (1:12,000 scale), and October 29, 2007 (1:12,000 scale) (figure 6). The 1998 image was obtained from LDWF at the larger scale. Aerial photographs were scanned at 300 pixels per inch and georectified using ground control data collected with a global positioning system (GPS) and digital ortho quarter quads. These individually georectified frames were assembled to produce a mosaic of the project area.

Using the National Wetlands Inventory (NWI) classification system, the 1994, 1997, 1998, 2000, and 2007 photography were photointerpreted by USGS/NWRC personnel and classified to the subclass level (Cowardin et al. 1979). The habitat delineations were transferred to 1:6,000 scale mylar base maps and digitized. After being checked for quality and accuracy, the resulting digital data were analyzed using geographic information systems (GIS) to determine habitat change over time in the project area. The habitat types were aggregated into seven habitat classes for the purpose of mapping change. Habitat changes inside the project area were calculated for the following intervals 1994-1997, 1994-1998, 1998-2000, and 1998-2007.

Habitat classes were combined further to assess land to water changes in the project area. Habitats were condensed to a land or water classification in 1994, 1997, 1998, 2000, and 2007 using the Steyer et al. (1995) protocol. Land was considered to be a combination of fresh marsh, upland barren, wetland forested, and wetland scrub-shrub. The beach/bar/flat, open water-fresh and submerged aquatics habitat classes were considered water. Once grouped into these two classes, the percentage of land and water for each time period was calculated, the land to water ratio for each time period was calculated, and the annual rate of land expansion in the project area from 1997 to 2007 was calculated. The pre-construction annual rate was calculated from 1994 to 1997.

Subaerial and subaqueous growth in the project area was qualitatively delineated by comparing the 1998 and 2007 NWI habitat assessments. Areas showing growth were classified as either subaerial growth, subaqueous to subaerial growth, or subaqueous growth. Subaerial growth occurred when the open water-fresh habitat was converted to subaerial land (fresh marsh, upland barren, wetland forested, or wetland scrub-shrub habitats). Subaqueous to subaerial growth arose when beach/bar/flat or submerged aquatics habitats were transformed to subaerial land. Subaqueous growth transpired when the open water-fresh habitat was changed to beach/bar/flat or submerged



Habitat Class	1994	1997	1998	2000	2007
Beach/Bar/Flat	751	430	302	460	555
Fresh Marsh	142	217	231	227	520
Open Water - Fresh	1,252	850	660	952	613
Submerged Aquatics	0	643	865	405	315
Upland Barren	0	0	14	0	<1
Wetland Forested	0	28	31	37	128
Wetland Scrub-Shrub	37	14	78	101	52
TOTAL	**2,182**	**2,182**	**2,181**	**2,182**	**2,183**

Figure 6. Pre-construction (1994 and 1997), as-built (1998), and post-construction (2000 and 2007) photomosaics and habitat analysis of the Atchafalaya Sediment Delivery (AT-02) project area.

aquatics habitats. Once classified, these areas were outlined using ESRI shapefiles (polygon) to calculate spatial growth in the project area from 1998 to 2007.

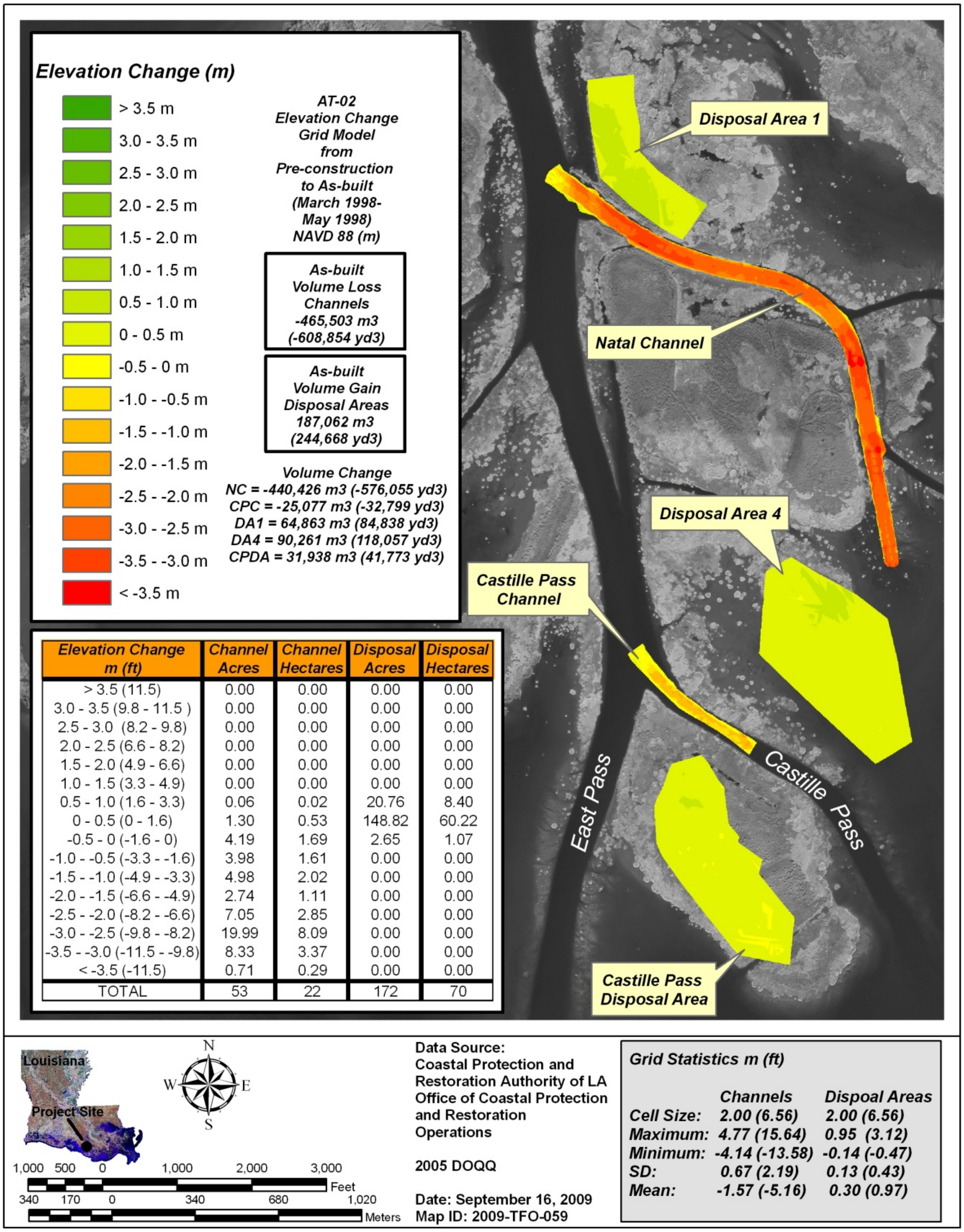
c. Preliminary Monitoring Results and Discussion

Elevation

The Atchafalaya Sediment Delivery (AT-02) project disposal areas experienced volume reductions and sediment additions since construction was completed in 1998. Elevation change and volume distributions for the AT-02 disposal areas are shown in figure 7 (March 1998-May 1998) and figure 8 (May 1998-May2008). Elevation grid models for the March 1998 (figure 9), May 1998 (figure 10), and May 2008 (figure 11) surveys are also provided. Note the low elevations found inside the unconfined disposal areas (DA4 and CPDA) during the as-built time period (figure 9). The confined AT-02 and the Big Island Mining (AT-03) disposal areas were built to substantially higher relief (Curole and Babin 2010). Approximately, 187,062 m^3 (244,668 yd^3) of sediment were deposited during construction in DA1, DA4, and CPDA (figures 7 and 10). In the post-construction period, sediment volume decreased by 51% in DA1, 58% in DA4 and increased by 405% in CPDA (figures 8 and 11). Sediment volume increased by 43,818 m^3 (57,312 yd^3) or 23% in the disposal areas from 1998 to 2008 (figures 8 and 11). These volumes and percentages are misleading because the large volume gain in the CPDA was the result of an Atchafalaya River navigation channel maintenance event initiated by the U. S. Army Core of Engineers (USACE), which pumped more than 129,481 m^3 (169,355 yd^3) of sediments into the CPDA (figure 8 and 11). The channel maintenance event occurred during the interval between 2002 and 2004. The total sediment volume loss in DA1 and DA4 from 1998 to 2008 was approximately 85,663 m^3 (112,043 yd^3), a 55% reduction in volume. The volume loss in DA1 and DA4 correlates favorably with the AT-03 disposal area 1 (DA1), which was condensed by 57% from 1998 to 2008 (Curole and Babin 2010).

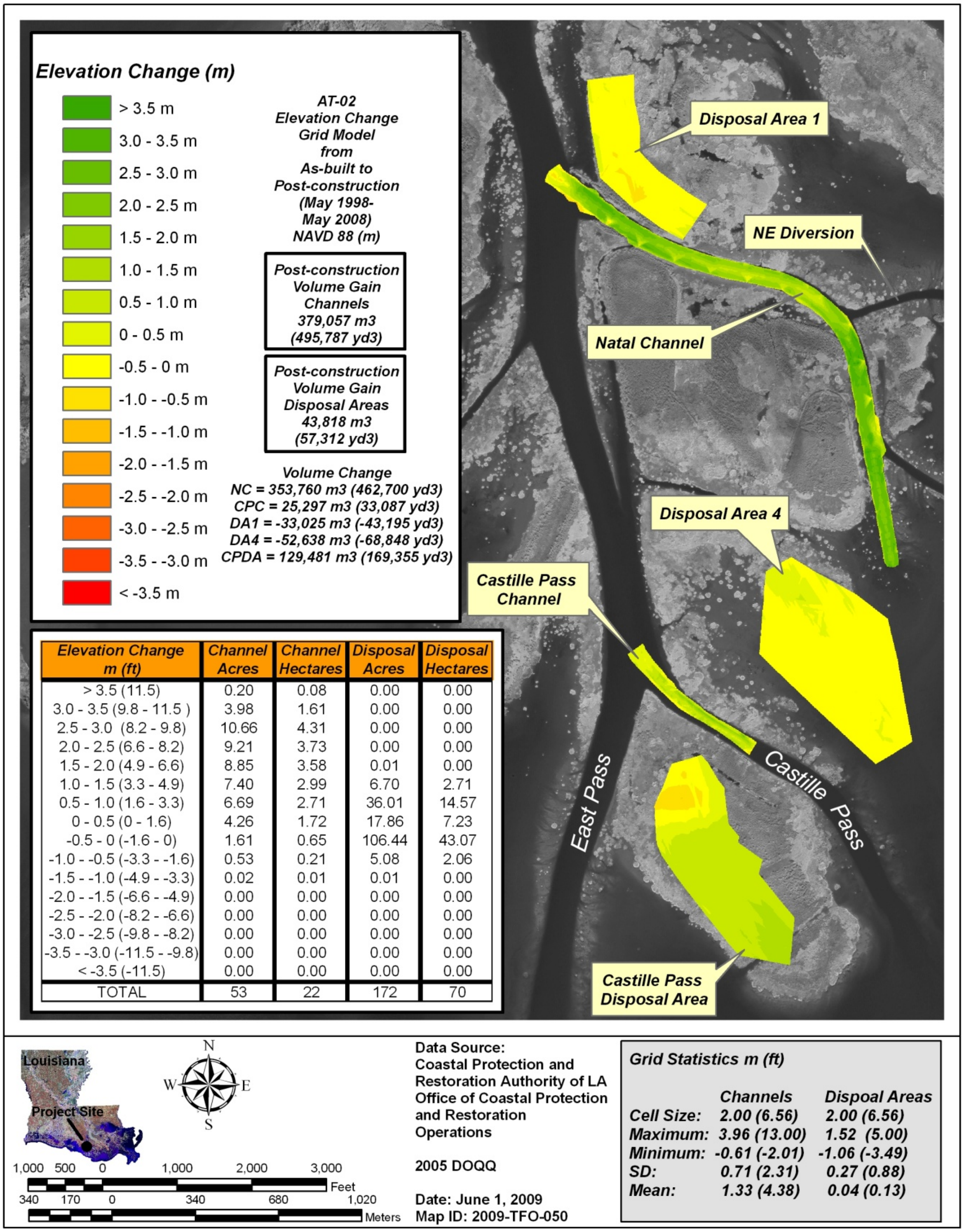
Bathymetry

The Atchafalaya Sediment Delivery (AT-02) project’s dredged channels experienced differential sedimentation patterns since construction was completed in 1998. Although disproportional shoaling occurred, both channels aggraded from 1998 to 2008 raising channel contours and bedload volumes. Elevation change and volume distributions for the AT-02 channels are shown in figure 7 (March 1998-May 1998) and figure 8 (May 1998-May 2008). Elevation grid models for the March 1998 (figure 9), May 1998 (figure 10), and May 2008 (figure 11) surveys are also provided in the accompanying appendix. Approximately, 465,503 m^3 (608,854 yd^3) of sediment were removed from the tertiary channels during construction in 1998 (figures 7 and 10). In the post-construction period, sediment volume increased by 80% in NC and 101% in CPC from 1998 to 2008 (figures 8 and 11). The total sediment volume gain in the dredged channels from 1998 to 2008 was approximately 379,057 m^3 (495,787 yd^3), an



Elevation Change m (ft)	Channel Acres	Channel Hectares	Disposal Acres	Disposal Hectares
> 3.5 (11.5)	0.00	0.00	0.00	0.00
3.0 - 3.5 (9.8 - 11.5)	0.00	0.00	0.00	0.00
2.5 - 3.0 (8.2 - 9.8)	0.00	0.00	0.00	0.00
2.0 - 2.5 (6.6 - 8.2)	0.00	0.00	0.00	0.00
1.5 - 2.0 (4.9 - 6.6)	0.00	0.00	0.00	0.00
1.0 - 1.5 (3.3 - 4.9)	0.00	0.00	0.00	0.00
0.5 - 1.0 (1.6 - 3.3)	0.06	0.02	20.76	8.40
0 - 0.5 (0 - 1.6)	1.30	0.53	148.82	60.22
-0.5 - 0 (-1.6 - 0)	4.19	1.69	2.65	1.07
-1.0 - -0.5 (-3.3 - -1.6)	3.98	1.61	0.00	0.00
-1.5 - -1.0 (-4.9 - -3.3)	4.98	2.02	0.00	0.00
-2.0 - -1.5 (-6.6 - -4.9)	2.74	1.11	0.00	0.00
-2.5 - -2.0 (-8.2 - -6.6)	7.05	2.85	0.00	0.00
-3.0 - -2.5 (-9.8 - -8.2)	19.99	8.09	0.00	0.00
-3.5 - -3.0 (-11.5 - -9.8)	8.33	3.37	0.00	0.00
< -3.5 (-11.5)	0.71	0.29	0.00	0.00
TOTAL	53	22	172	70

Figure 7. Elevation and volume change grid model from pre-construction (1998) to post-construction (1998) at the Atchafalaya Sediment Delivery (AT-02) project.



Elevation Change m (ft)	Channel Acres	Channel Hectares	Disposal Acres	Disposal Hectares
> 3.5 (11.5)	0.20	0.08	0.00	0.00
3.0 - 3.5 (9.8 - 11.5)	3.98	1.61	0.00	0.00
2.5 - 3.0 (8.2 - 9.8)	10.66	4.31	0.00	0.00
2.0 - 2.5 (6.6 - 8.2)	9.21	3.73	0.00	0.00
1.5 - 2.0 (4.9 - 6.6)	8.85	3.58	0.01	0.00
1.0 - 1.5 (3.3 - 4.9)	7.40	2.99	6.70	2.71
0.5 - 1.0 (1.6 - 3.3)	6.69	2.71	36.01	14.57
0 - 0.5 (0 - 1.6)	4.26	1.72	17.86	7.23
-0.5 - 0 (-1.6 - 0)	1.61	0.65	106.44	43.07
-1.0 - -0.5 (-3.3 - -1.6)	0.53	0.21	5.08	2.06
-1.5 - -1.0 (-4.9 - -3.3)	0.02	0.01	0.01	0.00
-2.0 - -1.5 (-6.6 - -4.9)	0.00	0.00	0.00	0.00
-2.5 - -2.0 (-8.2 - -6.6)	0.00	0.00	0.00	0.00
-3.0 - -2.5 (-9.8 - -8.2)	0.00	0.00	0.00	0.00
-3.5 - -3.0 (-11.5 - -9.8)	0.00	0.00	0.00	0.00
< -3.5 (-11.5)	0.00	0.00	0.00	0.00
TOTAL	53	22	172	70

Figure 8. **Elevation and volume change grid model from as-built (1998) to post-construction (2008) at the Atchafalaya Sediment Delivery (AT-02) project.**

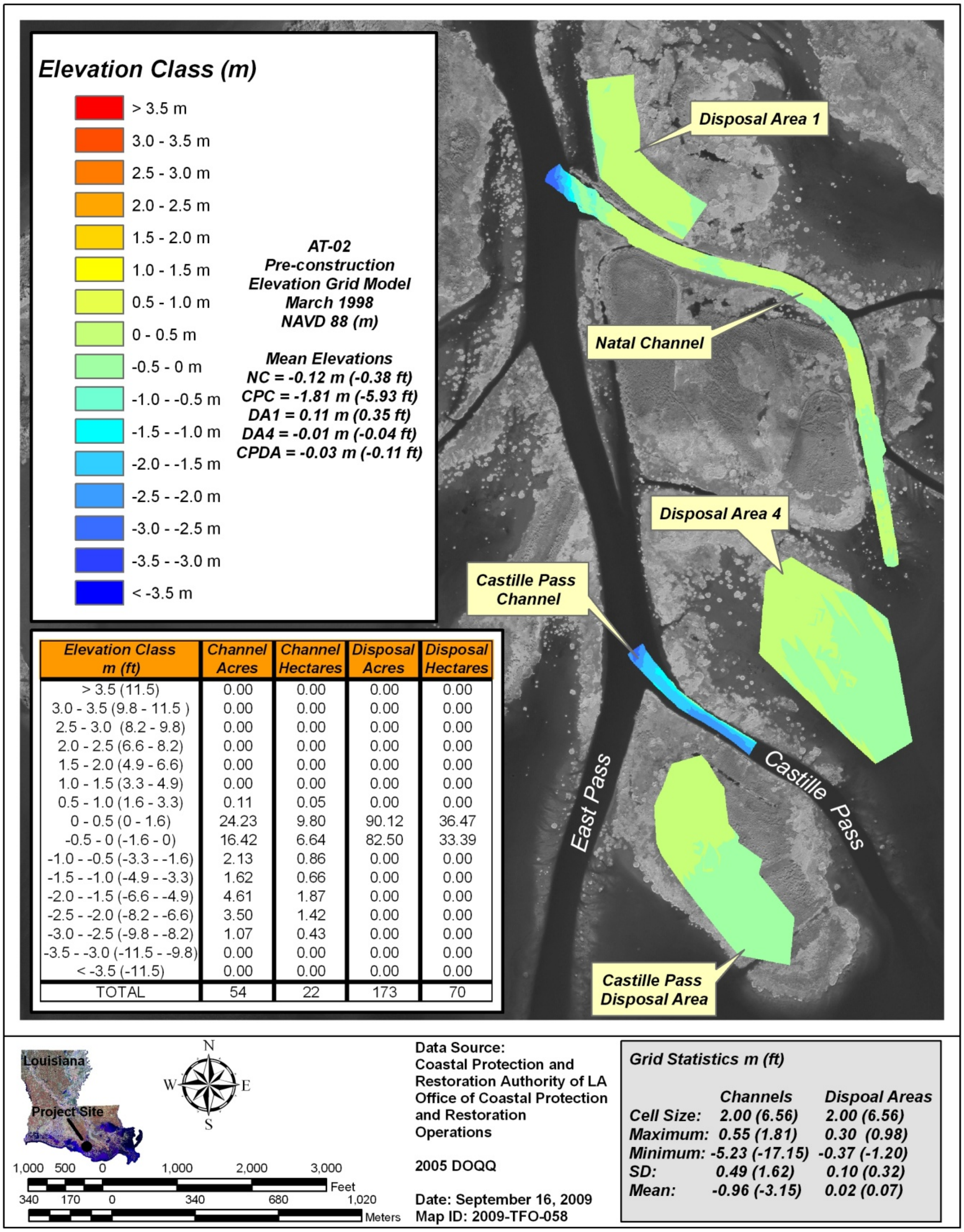
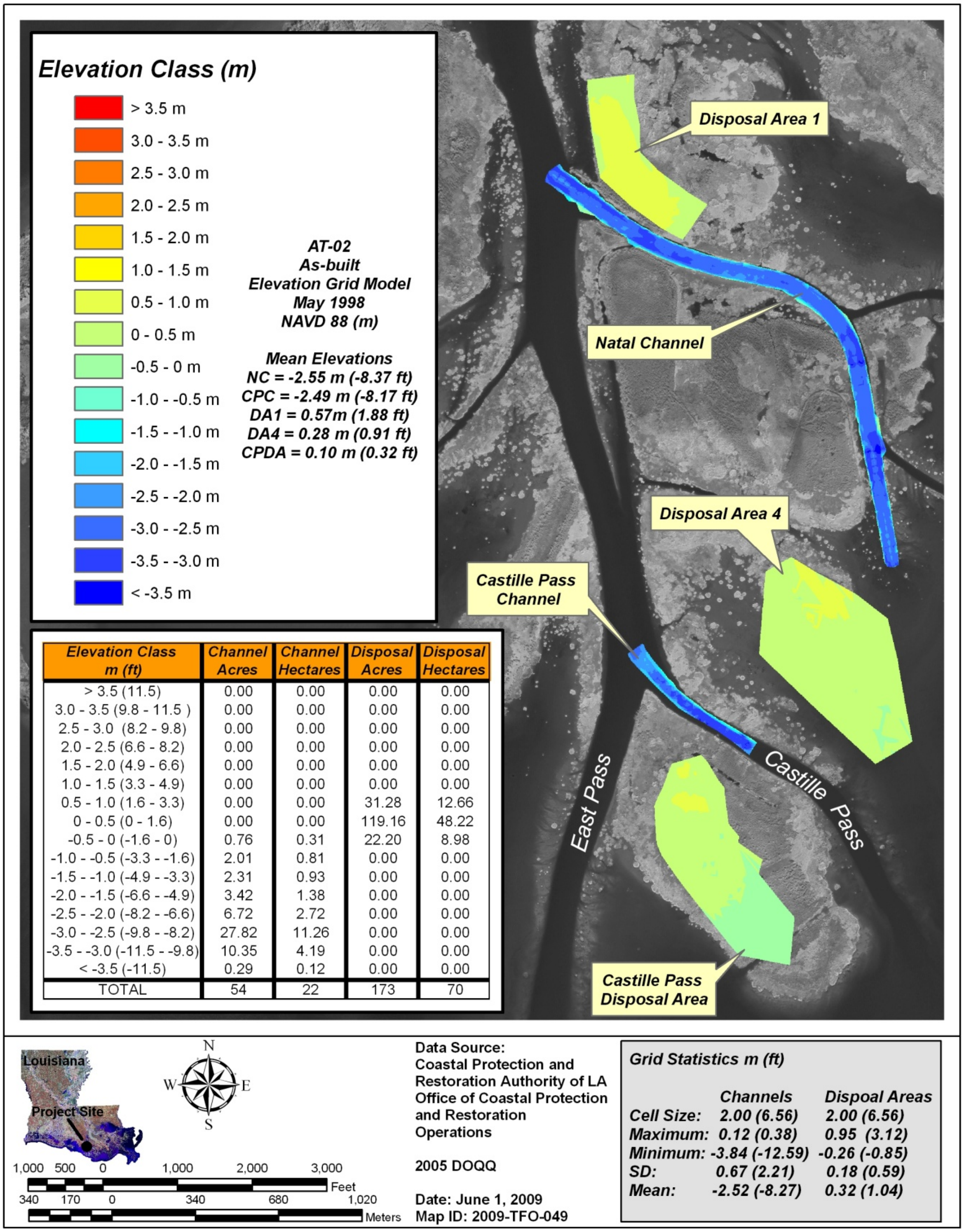
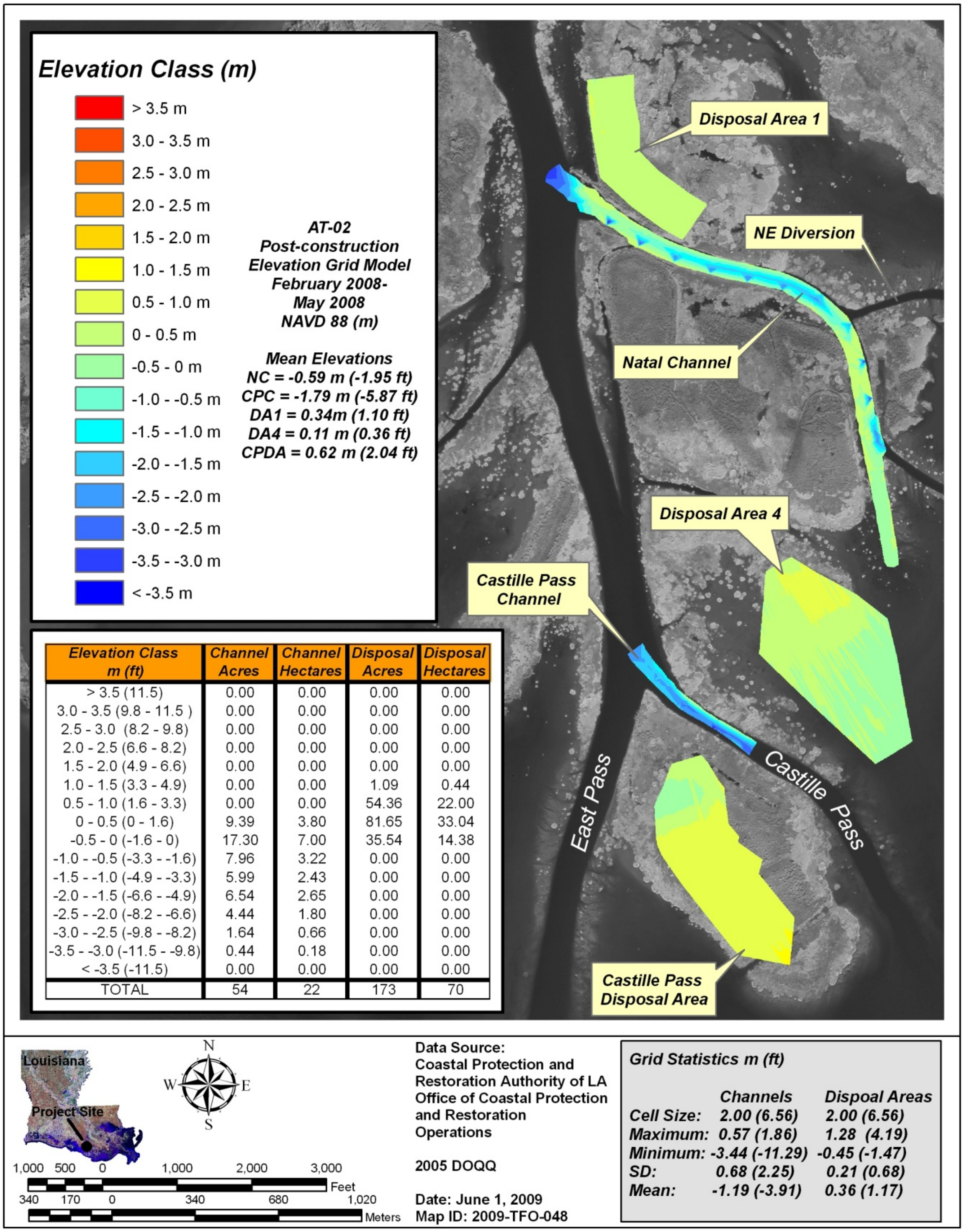


Figure 9. Pre-construction (1998) elevation grid model at the Atchafalaya Sediment Delivery (AT-02) project.



Elevation Class m (ft)	Channel Acres	Channel Hectares	Disposal Acres	Disposal Hectares
> 3.5 (11.5)	0.00	0.00	0.00	0.00
3.0 - 3.5 (9.8 - 11.5)	0.00	0.00	0.00	0.00
2.5 - 3.0 (8.2 - 9.8)	0.00	0.00	0.00	0.00
2.0 - 2.5 (6.6 - 8.2)	0.00	0.00	0.00	0.00
1.5 - 2.0 (4.9 - 6.6)	0.00	0.00	0.00	0.00
1.0 - 1.5 (3.3 - 4.9)	0.00	0.00	0.00	0.00
0.5 - 1.0 (1.6 - 3.3)	0.00	0.00	31.28	12.66
0 - 0.5 (0 - 1.6)	0.00	0.00	119.16	48.22
-0.5 - 0 (-1.6 - 0)	0.76	0.31	22.20	8.98
-1.0 - -0.5 (-3.3 - -1.6)	2.01	0.81	0.00	0.00
-1.5 - -1.0 (-4.9 - -3.3)	2.31	0.93	0.00	0.00
-2.0 - -1.5 (-6.6 - -4.9)	3.42	1.38	0.00	0.00
-2.5 - -2.0 (-8.2 - -6.6)	6.72	2.72	0.00	0.00
-3.0 - -2.5 (-9.8 - -8.2)	27.82	11.26	0.00	0.00
-3.5 - -3.0 (-11.5 - -9.8)	10.35	4.19	0.00	0.00
< -3.5 (-11.5)	0.29	0.12	0.00	0.00
TOTAL	54	22	173	70

Figure 10. **As-built (1998) elevation grid model at the Atchafalaya Sediment Delivery (AT-02) project.**



Elevation Class m (ft)	Channel Acres	Channel Hectares	Disposal Acres	Disposal Hectares
> 3.5 (11.5)	0.00	0.00	0.00	0.00
3.0 - 3.5 (9.8 - 11.5)	0.00	0.00	0.00	0.00
2.5 - 3.0 (8.2 - 9.8)	0.00	0.00	0.00	0.00
2.0 - 2.5 (6.6 - 8.2)	0.00	0.00	0.00	0.00
1.5 - 2.0 (4.9 - 6.6)	0.00	0.00	0.00	0.00
1.0 - 1.5 (3.3 - 4.9)	0.00	0.00	1.09	0.44
0.5 - 1.0 (1.6 - 3.3)	0.00	0.00	54.36	22.00
0 - 0.5 (0 - 1.6)	9.39	3.80	81.65	33.04
-0.5 - 0 (-1.6 - 0)	17.30	7.00	35.54	14.38
-1.0 - -0.5 (-3.3 - -1.6)	7.96	3.22	0.00	0.00
-1.5 - -1.0 (-4.9 - -3.3)	5.99	2.43	0.00	0.00
-2.0 - -1.5 (-6.6 - -4.9)	6.54	2.65	0.00	0.00
-2.5 - -2.0 (-8.2 - -6.6)	4.44	1.80	0.00	0.00
-3.0 - -2.5 (-9.8 - -8.2)	1.64	0.66	0.00	0.00
-3.5 - -3.0 (-11.5 - -9.8)	0.44	0.18	0.00	0.00
< -3.5 (-11.5)	0.00	0.00	0.00	0.00
TOTAL	54	22	173	70

Figure 11. **Post-construction (2008) elevation grid model at the Atchafalaya Sediment Delivery (AT-02) project.**

81% expansion in volume (figures 8 and 11). While it appears that CPC experienced greater shoaling than NC in the post-construction period, these percentages are deceiving because a very small volume 25,077 m^3 (32,799 yd^3) was dredged from CPC in 1998 (figure 7). CPC only aggraded 0.70 m (2.30 ft) and had an average channel contour of 1.79 m (5.87 ft) while NC aggraded 1.96 m (6.42 ft) and had an average channel contour of 0.59 m (1.95 ft) (figure 8). None of the Big Island Mining (AT-03) channels aggraded as much as NC during the ten year interval since these projects were constructed. Moreover, CPC and AT-03's secondary channel (CA) experienced the least shoaling, and CPC maintained the deepest channel contour (Curole and Babin 2010). Interestingly, CPC has aggraded to its pre-construction contours (figures 9 and 11) and volumes (figures 7 and 8) signifying that the CPC discharge rate is in equilibrium with its flow field and sediment load (DuMars 2002; Letter et al 2008; Mashriqui 2003; Edmonds and Slingerland 2007; Edmonds and Slingerland 2008). Conversely, NC is not capturing enough of the East Pass discharge to prevent large scale shoaling and channel narrowing (DuMars 2002; Letter et al. 2008; Roberts and van Heerden 1992; Mashriqui 2003). The bathymetric record (figures 8 and 11) provides evidence showing that NC is diverting flow to a former distributary (NE Diversion) located north of the bifurcation (Roberts and van Heerden 1992; van Heerden and Roberts 1980; van Heerden and Roberts 1988; van Heerden et al. 1991) contributing to the aggradation downstream of the diversion (Letter et al 2008). In the future, NC may abandon the constructed bifurcated channels and reoccupy its former course. Ironically, the original project design included the NE diversion channel. However, the channel was eliminated from the design due to a potential title conflict over property ownership. Currently, the NC constructed bifurcation is receiving enough discharge to form a mid channel bar and extend the east fork channel seaward while the west fork of the constructed bifurcation is shoaling (figures 4 and 6). Moreover, the constructed bifurcation forms an asymmetrical bifurcation, which is the most stable and common type of bifurcation (Edmonds and Slingerland 2008). In conclusion, the cross-sectional area of NC has decreased while the length of the east fork has increased since construction. CPC seems to be in equilibrium with its flow field and modifications to its cross-sectional area and length have been minimal. Therefore, the goal to increase the distributary potential of these channels by increasing their cross-sectional area and length has been partially realized at this time due to the elongation of the east fork of Natal Channel and the formation of the mid channel bar. However, the extensive shoaling and narrowing of Natal Channel and stable nature of Castille Pass Channel have also adversely impacted the distributary potential of these channels.

Vegetation

The Atchafalaya Sediment Delivery (AT-02) vegetation data show that similar vegetation communities inhabit the disposal areas while the historical reference area community is different. Moreover, the similarities and the disparities in these communities appear to be related to elevation and other variables. The results of the relative cover and importance value (IV) analysis are graphically illustrated in figure

12 and figure 13 for disposal area habitats. The LSU/CEI vegetation data are delineated in figures 14 (relative cover) and 15 (IV). Note the differences between relative cover and IV is correlated with the frequency that a species populates vegetation plots. For example if a species is found in only a few plots with a high cover value, the species is likely to have a high relative cover value but probably will not have a high IV. The dominant species found in the CPDA were *Eichhornia crassipes (Mart.) Solms* (common water hyacinth) and *Colocasia esculenta (L.) Schott* (coco yam). By 2007, *Zizaniopsis miliacea (Michx.) Doell & Aschers.* (giant cutgrass)

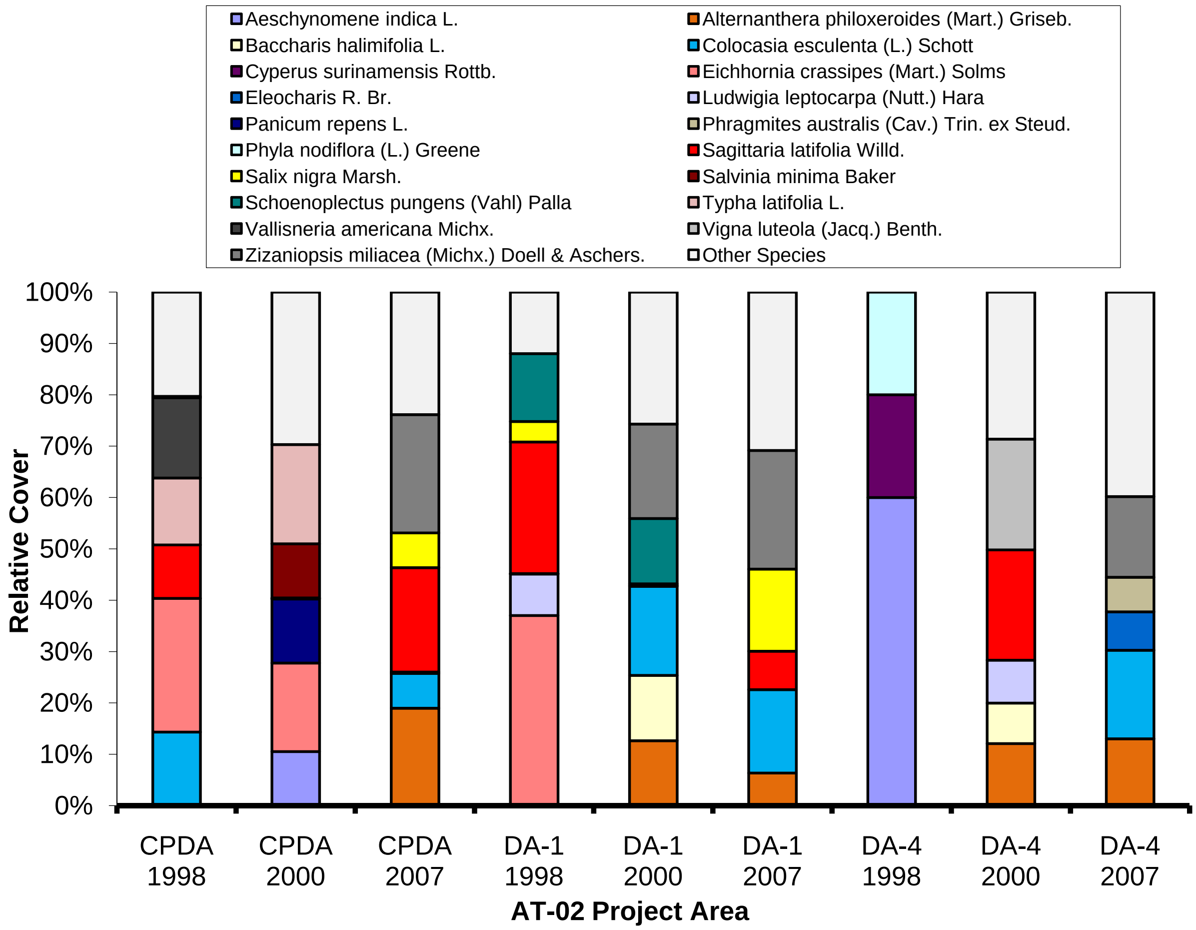


Figure 12. **Relative cover of the top five vegetation species populating the Atchafalaya Sediment Delivery (AT-02) disposal areas from 1998 to 2007. Ocular vegetation data were grouped by disposal area and year.**

and *Alternanthera philoxeroides (Mart.) Griseb.* (alligatorweed) became the dominant species. The changes in the CPDA community are probably a result of elevation differences incurred between 1998 and 2007 (figure 8). The dominant species found in DA1 in 1998 were *Eichhornia crassipes (Mart.) Solms* (common water hyacinth) and *Sagittaria latifloia Willd.* (broadleaf arrowhead). By 2007, *Zizaniopsis miliacea (Michx.) Doell & Aschers.* (giant cutgrass) and *Salix nigra Marsh.* (black willow) became the dominant species. Sucession in DA1 (figure 8) probably was a factor

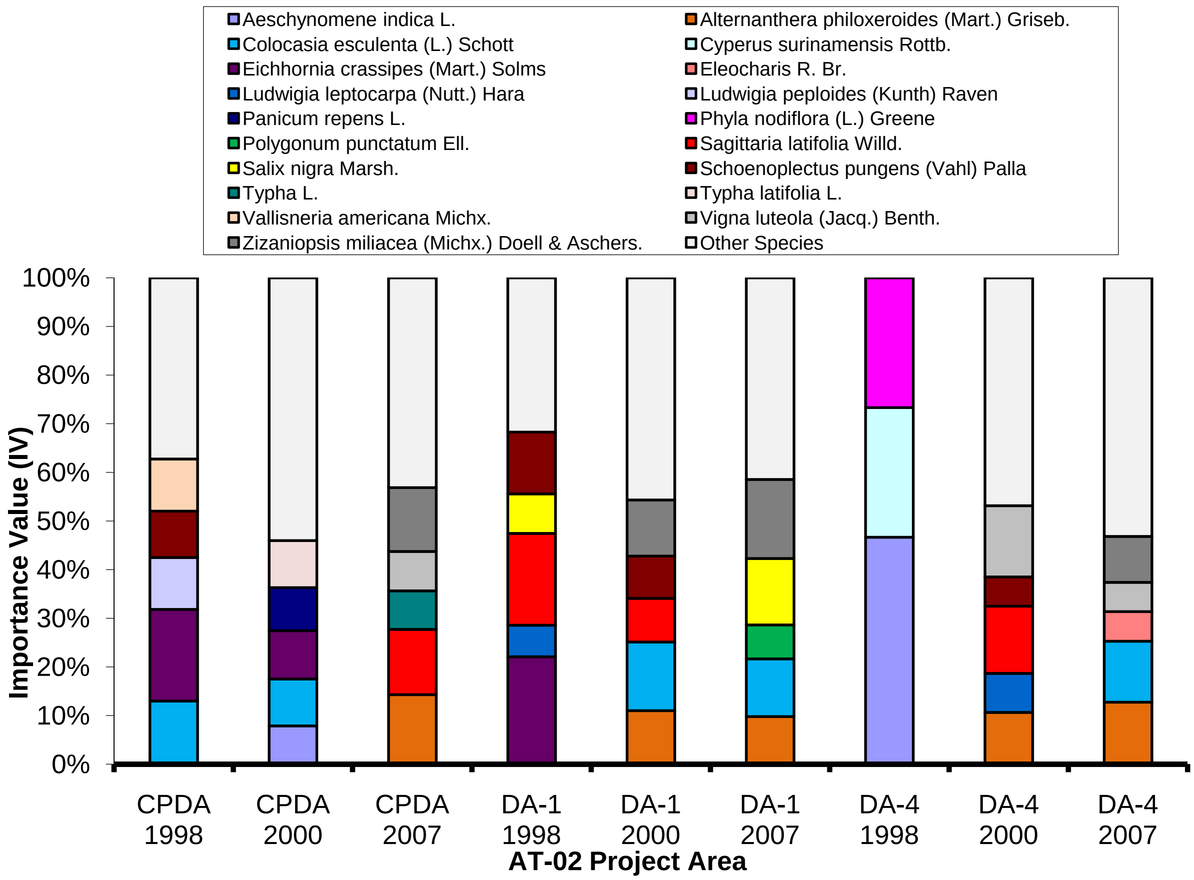


Figure 13. **Importance value (IV) of the top five vegetation species populating the Atchafalaya Sediment Delivery (AT-02) disposal areas from 1998 to 2007. Ocular vegetation data were grouped by disposal area and year.**

influencing change in this disposal area. No species were dominant in DA4 in 1998 because only 5% of this disposal area was vegetated. By 2007, *Colocasia esculenta (L.) Schott* (coco yam) and *Alternanthera philoxeroides (Mart.) Griseb.* (alligatorweed) became the dominant species. Approximately, 74% of DA4 was vegetated by 2007. Figure 12 and figure 13 show the similarities and the differences in the CPDA, DA1, and DA4 vegetation communities from 1998 to 2007. Although CPDA and DA1 were inhabited by several matching species before 2007, after 2007 these disposal areas became more parallel suggesting that the disposal of dredge material by the USACE (figure 8) exerted some influence on the CPDA vegetation community. Conversely, DA4 exhibited many of the same species, but this disposal area subsided from 1998 to 2007 (figure 8). All the disposal areas experienced increases in species diversity and mean cover since 1998. The LSU/CEI historical reference areas have different vegetation community structures than the AT-02 disposal areas. One of the fundamental differences between the project and historical data sets is the naturally created deltaic lobe islands were established at low relief

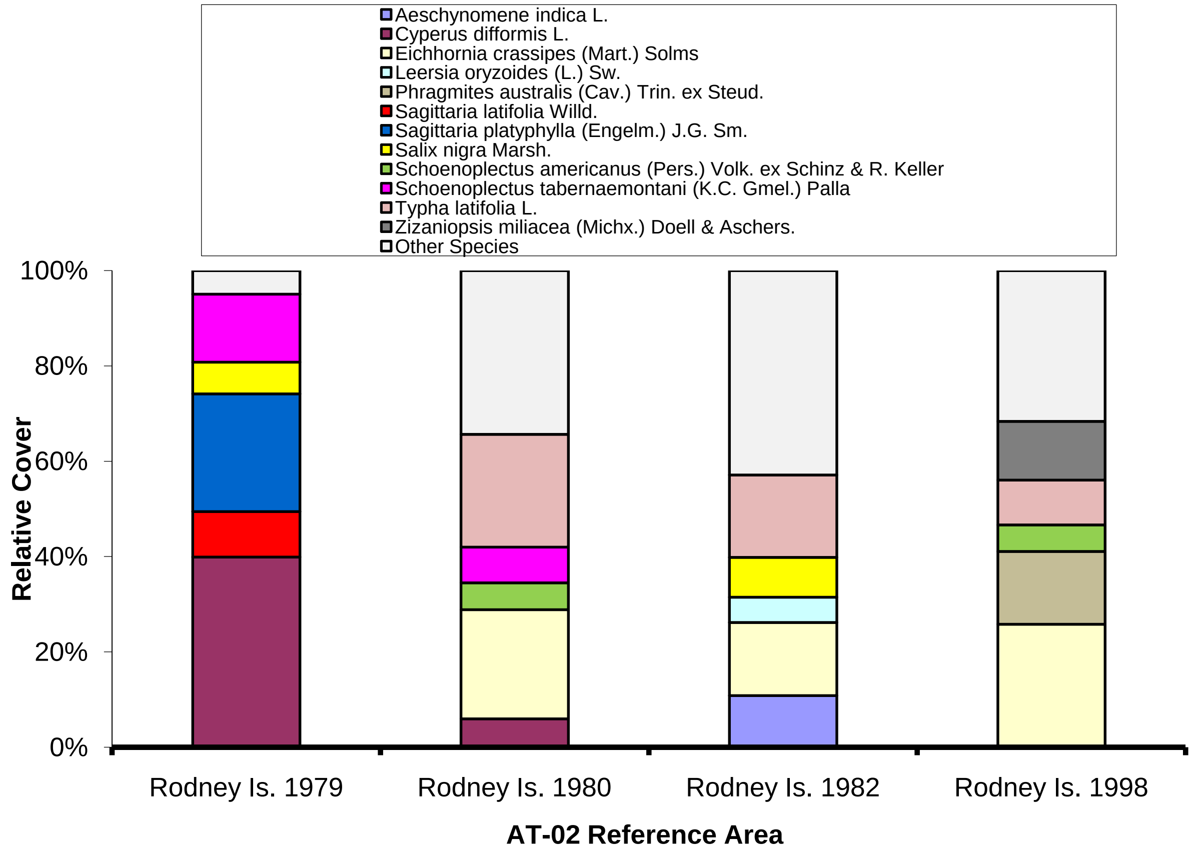


Figure 14. **Relative cover of the top five vegetation species populating the Atchafalaya Sediment Delivery (AT-02) historical reference area from 1979 to 1998. Ocular vegetation data were grouped by year. Vegetation data provided courtesy of Louisiana State University/Coastal Ecology Institute (LSU/CEI).**

(Sasser and Fuller 1988; Shaffer et al. 1992; Johnson et al. 1985; Penland et al. 1996; Penland et al. 1997). However, CPDA and DA4 were also established at low elevations (figure 10), and their vegetation communities do not resemble the Rodney Island historical data. Therefore, other factors besides elevation are probably influencing these vegetation communities. In conclusion, vegetation data show that similar vegetation communities inhabit the disposal areas while the historical reference area community is different.

Habitat Mapping

The Atchafalaya Sediment Delivery (AT-02) project area experienced habitat colonization, succession, and disturbance since construction was completed in 1998. The initial post-construction (as-built) habitat change analysis of the project area (1994-1998) show increases in wetland scrub-shrub (111%) and fresh marsh (63%) habitats and decreases in beach/bar/flat (-60%) and open water-fresh (-47%) habitats. Two new habitats were created during this 4 year time period, 865 acres (350 ha) of submerged aquatics and 31 acres (13 ha) of wetland forested (table 1 and figure 6).

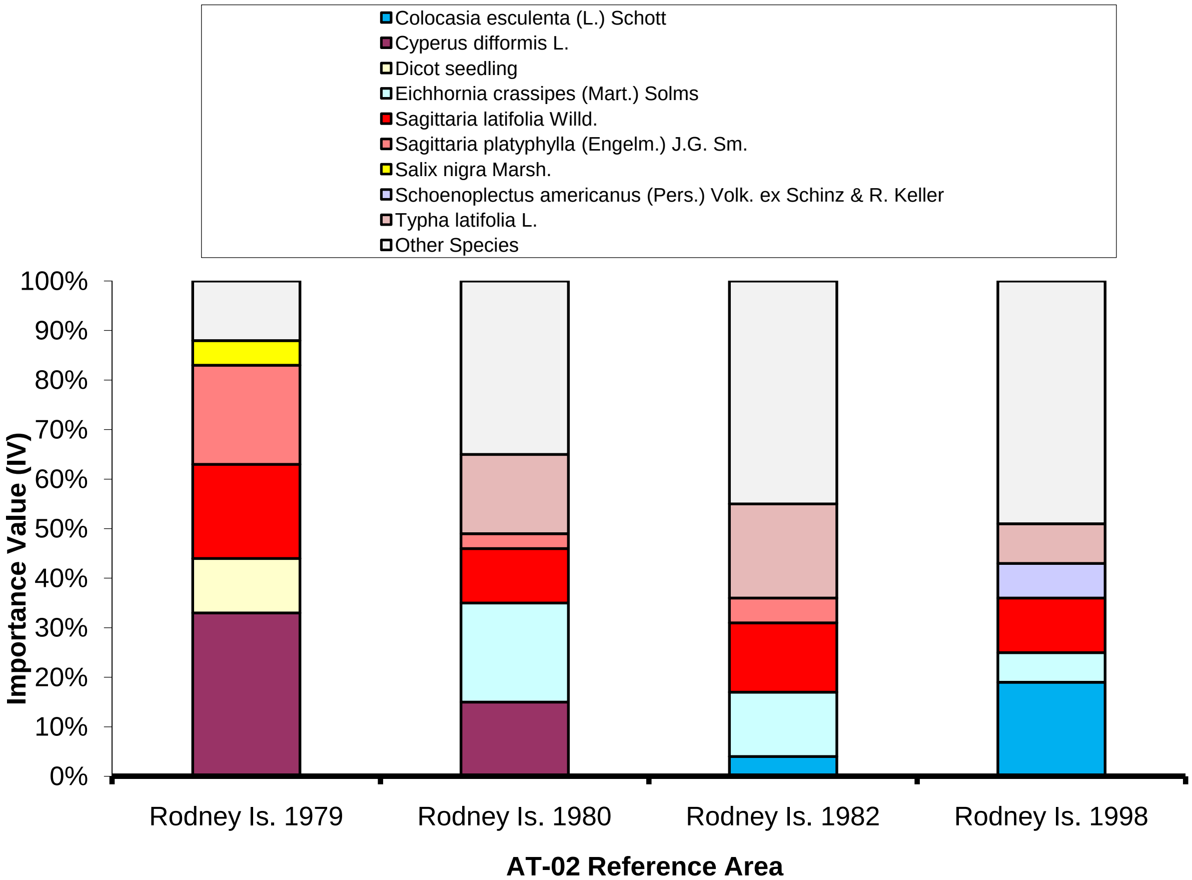


Figure 15. Importance value (IV) of the top five vegetation species populating the Atchafalaya Sediment Delivery (AT-02) historical reference area from 1979 to 1998. Ocular vegetation data were grouped by year. Vegetation data provided courtesy of Louisiana State University/Coastal Ecology Institute (LSU/CEI).

Combined mosaics and habitat maps for all sampling intervals (1994, 1997, 1998, 2000, and 2007) are chronologically arranged in figure 6. Mosaics and habitat maps for each interval are located in appendix A for clarity and will not be referred to again in this text. By 1998, the project area consisted of 40% submerged aquatics, 30% open water-fresh, 14% beach/bar/flat, 11% fresh marsh, 4% wetland scrub-shrub, 1.4% wetland forested, and 0.6% upland barren habitats (figure 6). The considerable enlargement of the wetland scrub-shrub habitat denotes that higher elevated wetlands were created in DA2 and DA3 during construction (figure 6). Subsequent (1998-2000 and 1998-2007) post-construction habitat change analysis reveals wetland forested gains in 2000 (19%) and 2007 (313%), beach/bar/flat gains in 2000 (52%) and 2007 (84%), fresh marsh losses in 2000 (-2%) and gains in 2007 (125%), open water-fresh gains in 2000 (44%) and losses in 2007 (-7%), wetland scrub-shrub gains in 2000 (29%) and losses in 2007 (-33%), and submerged aquatics losses in 2000 (-53%) and 2007 (-64%) (table 1 and figure 6). By 2007, the project area consisted of 28% open water-fresh, 25% beach/bar/flat, 24% fresh marsh, 14% submerged aquatics, 6% wetland forested, and 2% wetland scrub-shrub habitats (figure 6). Since construction,

Table 1. **National Wetlands Inventory habitat classes, acreages, and changes photo-interpreted from 1994, 1997, 1998, 2000, and 2007 aerial photography for the Atchafalaya Sediment Delivery (AT-02) project.**

Habitat Class Project Area	*1994 Acres*	*1997 Acres*	*1998 Acres*	*2000 Acres*	*2007 Acres*	*94-97 Change*	*94-98 Change*	*98-00 Change*	*98-07 Change*
Beach/Bar/Flat	751	430	302	460	555	-321	-449	158	253
Fresh Marsh	142	217	231	227	520	75	89	-4	289
Open Water-Fresh	1,252	850	660	952	613	-402	-592	292	-47
Submerged Aquatics	0	643	865	405	315	643	865	-460	-550
Upland Barren	0	0	14	0	<1	0	14	-14	-14
Wetland Forest	0	28	31	37	128	28	31	6	97
Wetland Scrub-Shrub	37	14	78	101	52	-23	41	23	-26
TOTAL	2,182	2,182	2,181	2,182	2,183	0	-1	1	2

considerable acreage of submerged aquatic habitats were converted to either fresh marsh, beach/bar/flat, or open water-fresh habitats, and a large part of the wetland scrub-shrub habitat underwent succession to form wetland forested habitats. Over time fresh marsh species continued to expand their range through colonization of submerged aquatic, beach/bar/flat, and open water-fresh habitats (figure 6). The sizeable reduction in wetland scrub-shrub habitat from 2000 to 2007 (-49%) is attributable to forest maturation in DA1, DA2, and DA3 (figure 6). Not all the growth inside the AT-02 project area is a result of the project or fluvial processes. During two dredge disposal events, the USACE placed dredged material inside the AT-02 project area significantly impacting habitats (figure 16). The first disposal event occurred between 1998 and 2000 and altered approximately 29 ha (72 acres) of submerged aquatic and open water-fresh habitats along the east fork of Natal Channel. The second event transpired between 2002 and 2004 and modified approximately 49 ha (120 acres) of beach/bar/flat, submerged aquatic, open water-fresh, and fresh marsh habitats along Castille Pass (figures 6 and 16). These two USACE disposal events contributed to the enlargement of fresh marsh, beach/bar/flat, wetland forested, and wetland scrub-shrub habitats. In closing, the project area has been altered since construction through colonization, succession, and disturbance (USACE dredge disposal events).

The Atchafalaya Sediment Delivery (AT-02) project area experienced considerable subaqueous growth and moderately high subaerial growth before construction. Pre-construction habitat change analysis of the project area (1994-1997) show increases in fresh marsh (53%) habitats and decreases in and wetland scrub-shrub (-62%), beach/bar/flat (-43%), open water-fresh (-32%) habitats while submerged aquatics 260 ha (643 acres) and wetland forested 11 ha (28 acres) habitats were created (table 1 and figure 6). In 1994 and 1997, the project area consisted of 57% (1994) and 39% (1997) open water-fresh, 34% (1994) and 20% (1997) beach/bar/flat, 7% (1994) and 10% (1997) fresh marsh, 2% (1994) and 0.6% (1997) wetland scrub-shrub, 0% (1994) and 29% (1997) submerged aquatics, and 0% (1994) and 1% (1997) wetland forested habitats (figure 6). During this 3 year pre-construction interval, extensive conversion of open water-fresh and beach/bar/flat habitats to submerged aquatics habitat transpired, fairly small acreages of the large beach/bar/flat habitat were colonized by

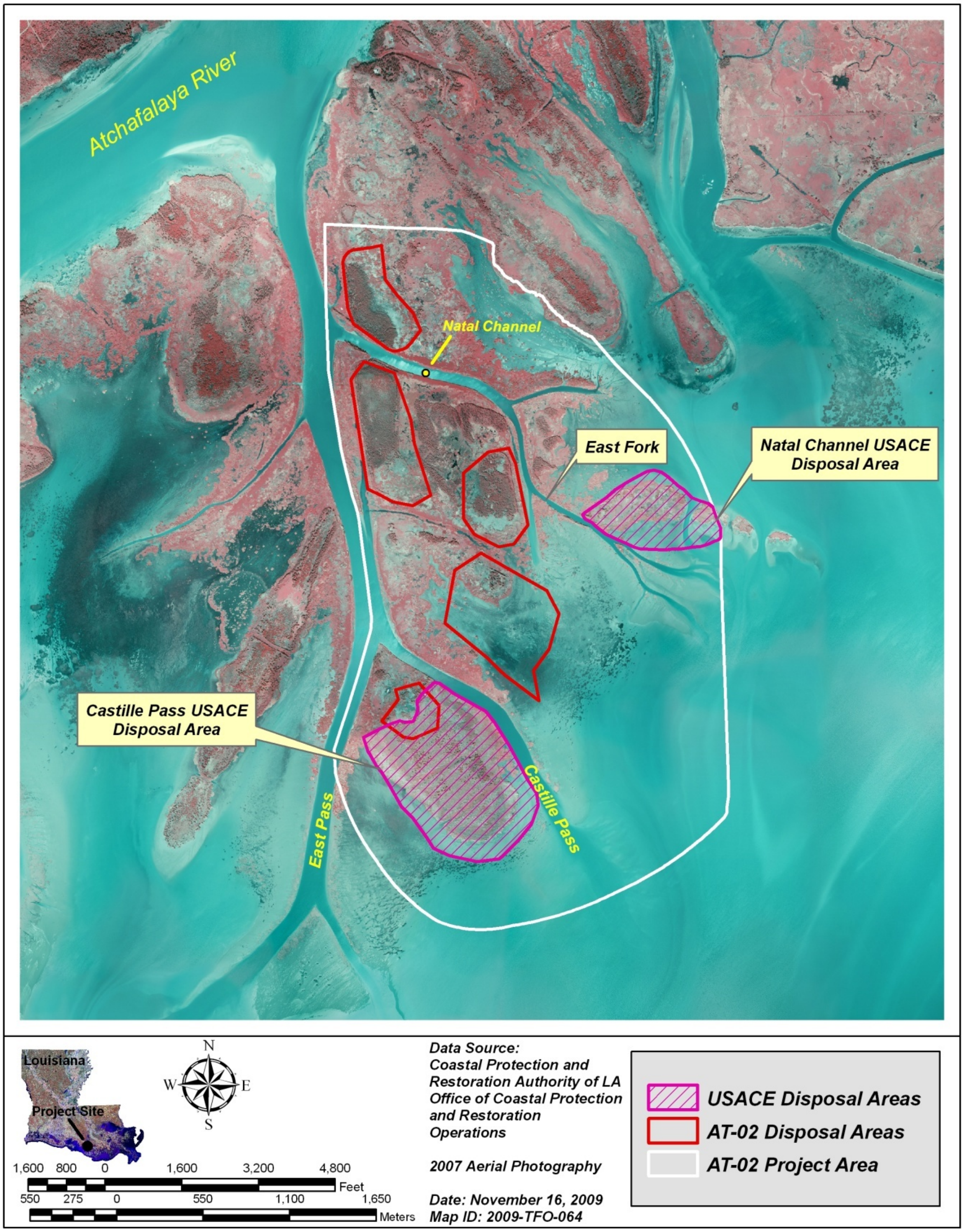


Figure 16. **Location of USACE dredge disposal areas inside the Atchafalaya Sediment Delivery (AT-02) project.**

fresh marsh vegetation, and a sizeable part of the wetland scrub-shrub habitat underwent succession to form wetland forested habitats. The distribution and abundance submerged aquatic habitats can be ephemeral because these environments are very susceptible to changes in light penetration. Increases or decreases in light penetration alternatively regulate the growth or declines in this habitat (Cho and Poirrier 2005; Koch 2001). The sizeable reduction in wetland scrub-shrub habitat in the pre-construction period (-62%) is attributable to forest maturation. Although submerged aquatics environments are very dynamic, habitat expansion at a rate of 89 ha/yr (219 acres/yr) is noteworthy (table 1 and figure 6). Fresh marsh and wetland forested habitats enlarged their areal extent by 30 ha (75 acres) or 11 ha/yr (26 acres/yr) and 11 ha (28 acres) or 4 ha/yr (10 acres/yr) in the pre-construction period (table 1 and figure 6). The substantial spring flood of 1997 probably induced these increases in submerged aquatics and fresh marsh habitats (Trotter et al. 1998). While the rate of fresh marsh development was appreciably higher following construction, the pre-construction data illustrates that subaerial growth was occurring in the project area before construction.

The Atchafalaya Sediment Delivery (AT-02) project showed gains in subaerial land during the post-construction and the pre-construction period. Since construction (1998), the land acreage in the project area has continually expanded. The percentage of subaerial land in the project area was 16% in 1998, 17% in 2000, and 32% in 2007 (figure 17). These percentages correspond to land to open water ratios of 1.0:5.2 (1998), 1.0:5.0 (2000), and 1.0:2.1 (2007). Approximately, 178 ha (441 acres) of subaerial land habitats were created for the ten year period from 1997 (pre-construction) to 2007 (post-construction). Moreover, 140 ha (346 acres) of the subaerial land habitats were established after construction from 1998 (as-built) to 2007 (post-construction). The subaerial land gain was composed of fresh marsh [123 ha (303 acres)] and woody habitats [56 ha (138 acres)]. The rate of this subaerial land expansion was 18 ha/yr (44 acres/yr) from 1997 to 2007 (table 1 and figure 6). The creation of 178 ha (441 acres) of subaerial land habitats exceeds the projected goal to create 92 ha (230 acres) of delta lobe islands in the project area. Although 78 ha (192 acres) of the project area were impacted by the USACE dredge disposal events (figure 16), 101 ha (249 acres) of the created subaerial land were not. Therefore, the goal was surpassed without the USACE created environments. Pre-construction data (1994-1997) show fairly high gains in subaerial land inside the project area. The percentage of subaerial land in the project area was 8% in 1994 and 12% in 1997 (figure 17). These percentages correspond to land to open water ratios of 1.0:11.2 (1994) and 1.0:7.4 (1997). Approximately, 32 ha (80 acres) of subaerial land habitats were created for the 3 year pre-construction period from 1994 to 1997. The pre-construction subaerial land gain was primarily comprised of fresh marsh [30 ha (75 acres)]. The rate of this subaerial land expansion was 11 ha/yr (27 acres/yr) from 1994 to 1997 (table 1 and figure 6). The flood of 1997 probably catalyzed this expansion in fresh marsh habitats (Trotter et al. 1998). The pre-construction data illustrates that subaerial land growth was occurring in the project area before construction.

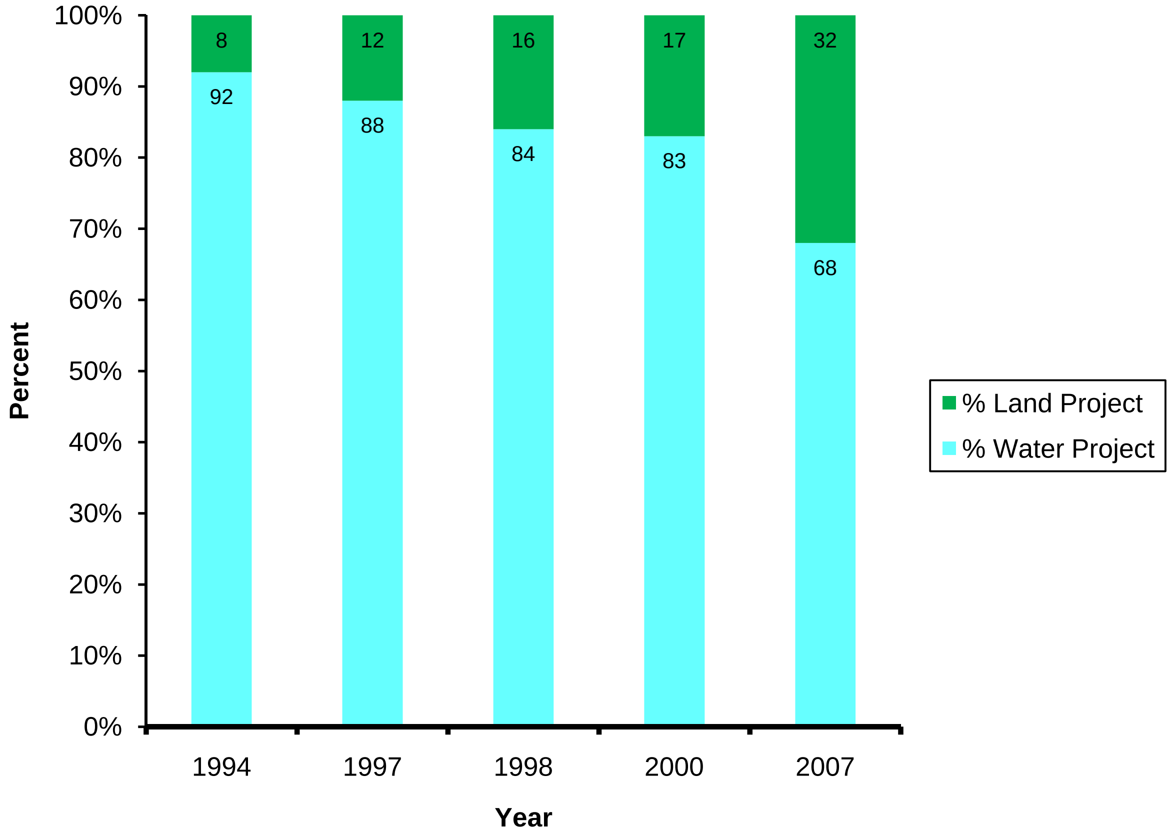


Figure 17. Percentage of land and water inside the Atchafalaya Sediment Delivery (AT-02) project area in 1994 (pre-construction), 1997 (pre-construction), 1998 (as-built), 2000 (post-construction), and 2007 (post-construction).

The Atchafalaya Sediment Delivery (AT-02) project area experienced subaerial growth, subaqueous to subaerial conversion, and subaqueous growth since construction. Figure 18 delineates the growth in the project area from 1998 to 2007. Small acreages [2 ha/yr (5 acres/yr)] of subaqueous habitats were converted to subaerial habitats (subaqueous to subaerial) inside the AT-02 disposal areas from 1998 to 2007. This occurred primarily through the colonization of beach/bar/flat habitat by fresh marsh and wetland forested vegetation. A large part of this subaqueous to subaerial growth arose along the perimeter margins of the disposal areas. However, the unconfined disposal areas (DA4 and CPDA) display subaqueous to subaerial growth inside their enclosures (figure 18). Very little subaerial [0.02 ha/yr (0.05 acres/yr)] (open water-fresh to subaerial habitat) or subaqueous [0.2 ha/yr (0.5 acres/yr)] (open water-fresh to beach/bar/flat or submerged aquatics habitat) growth developed in the disposal areas. The largest part of this subaerial and subaqueous growth occurred along the edges of DA2 and DA3 (figure 18). Outside the disposal areas subaerial growth [2 ha/yr (4 acres/yr)] has emerged along East Pass and Natal Channel. The largest geomorphic feature to develop in the project area is a

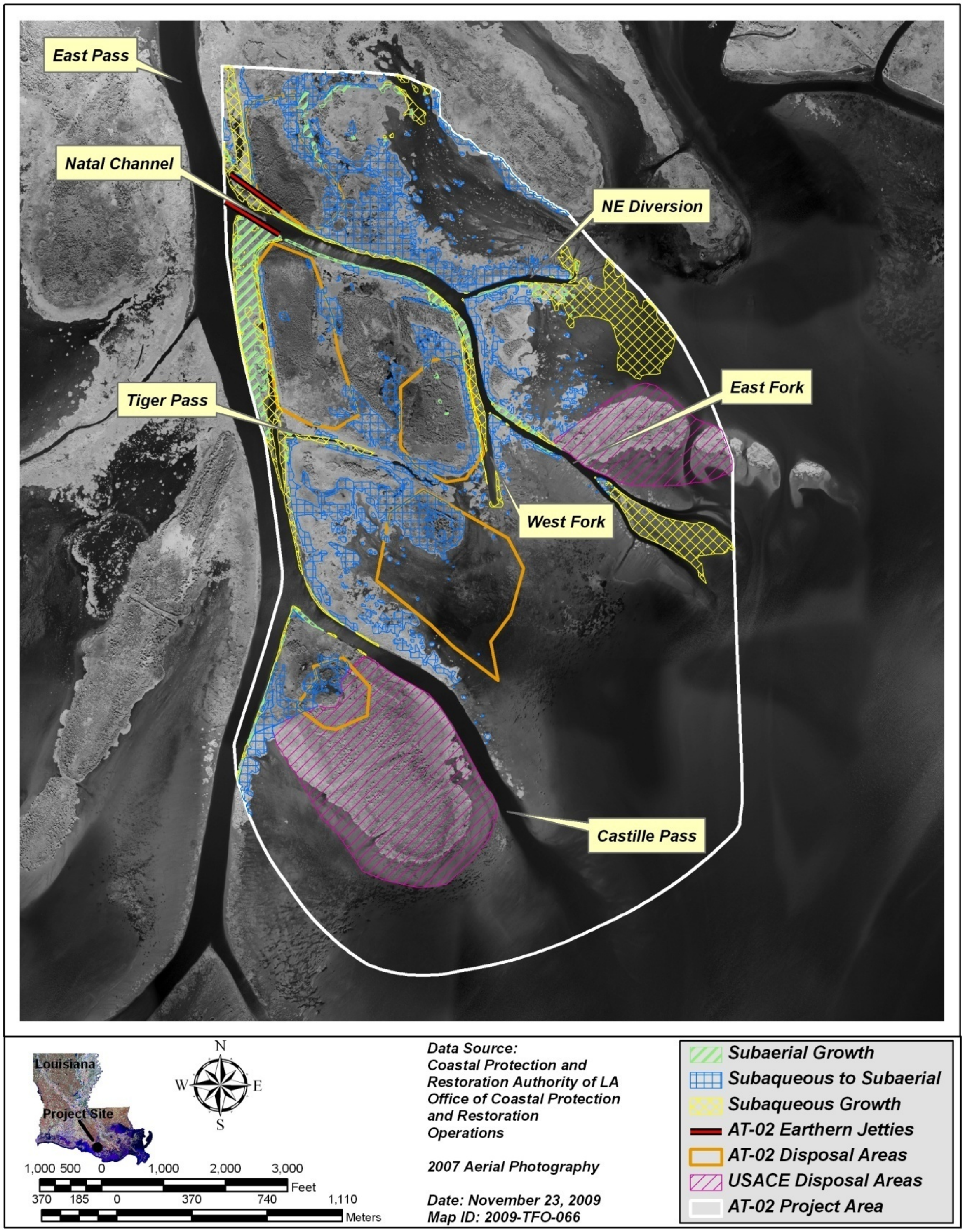


Figure 18. **Location of areas experiencing subaerial growth, subaqueous to subaerial conversion, and subaqueous growth inside the Atchafalaya Sediment Delivery (AT-02) project area.**

predominantly subaerial bar that formed in the lee of the southern jetty at the head of NC (figure 18). This subaerial feature extends for 1067 m (3500 ft) from the earthen structure to the fused Tiger Pass considerably narrowing East Pass at this location. The presence of this emergent feature indicates that sediment is depositing on the downdrift end of the jetty. Furthermore, the subaerial feature seems to be a discontinuous part (separated by NC) of a bar that formed in the Atchafalaya River and has been narrowing the eastern bank of East Pass since 1997 (figure 6). Other interesting subaerial formations are found along the southern bank of NC, the NE diversion, the east fork of NC, and east bank of East Pass south of CP (figure 18). A sizeable portion of the project area outside the disposal areas underwent subaqueous to subaerial conversion [6 ha/yr (16 acres/yr)]. The areas experiencing this conversion are found throughout the project area but are concentrated in settings located adjacent to channel banks (figure 18). Of particular note, a large continuous acreage that extends from DA1 to the NE diversion has incurred subaqueous to subaerial conversion. Although no accretion plots were established, sediment additions to the project area likely raised landscapes to subaerial elevations. Several noteworthy subaqueous features [5 ha/yr (12 acres/yr)] were created in the project area from 1998 to 2007 (figure 18). The first of these features is the afore mentioned predominantly subaqueous bar that extends down East Pass and occupies a small portion of the project area north of the earthen jetties (figure 18). The formation of this bar is important because NC has undergone channel abandonment and lobe fusion in the recent past (van Heerden et al. 1991). Secondly, the most prominent features created in the AT-02 project area are the formation of a subaqueous mid channel bar and seaward levee extensions at the mouth of NC (figure 18). The enlargement of these features indicate that the delta is growing at this location (Edmonds and Slingerland 2007; Edmonds and Slingerland 2008; Roberts and van Heerden 1992; Roberts 1998; van Heerden and Roberts 1980; van Heerden and Roberts 1988; van Heerden et al. 1991; DuMars 2002; Letter et al. 2008; Mashriqui 2003). Moreover, the river mouth bar model of delta growth is the dominant mechanism forcing delta expansion, and the creation of this mid channel bar infers that some bedload transport is occurring within the project area (Edmonds and Slingerland 2007). However, the NE diversion is rerouting discharge away from the mid channel bar causing shoaling north of the bifurcation and in the west fork (Letter et al 2008). Indeed, the west fork of the bifurcation is aggrading (figure 18), but asymmetrical bifurcations are common in fluvial deltas (Edmonds and Slingerland 2008). In the future, NC may abandon the constructed bifurcated channels and occupy the NE diversion. The third subaqueous feature is the absence of a mid channel bar at the mouth of Castille Pass (CP). Although discharge through CP is large enough to keep the channel stable, no mid channel bar is forming at the mouth of CP. Mashriqui (2003) corroborates this by providing evidence showing that very little sand is being deposited at the mouth of CP. Furthermore, the CP bifurcation seems to also be asymmetrical (Edmonds and Slingerland 2008) discharging larger volumes of water and sediment through East Pass because mid channel bars and natural levees are extending East Pass seaward south of the CP bifurcation (figure 18). In conclusion, the goal to increase the rate of subaerial delta growth in the project area was attained due to the formation of a mid channel bar and the large acreage of emergent subaerial growth [8 ha/yr (20 acres/yr)] (subaqueous to subaerial conversion and subaerial growth) occurring in the project area since construction. Moreover, these rates exceed the Barras et al. 2004 estimates of subaerial land growth inside the AT-02 project area from 1956 to 1978 [4 ha/yr (9acres/yr)] and from 1978 to 1990 [3 ha/yr (8acres/yr)].

V. Conclusions

a. Project Effectiveness

The results of the Atchafalaya Sediment Delivery (AT-02) project reveal that two of the project goals were attained and one was partially realized ten years after construction. The first goal to increase the distributary potential of Natal Channel and Castille Pass by increasing their cross-sectional area and length has been partially achieved at this time due to the elongation of the east fork of Natal Channel and the formation of the mid channel bar. The creation and enlargement of these features indicate that the delta is growing at this location (Edmonds and Slingerland 2007; Edmonds and Slingerland 2008; Roberts and van Heerden 1992; Roberts 1998; van Heerden and Roberts 1980; van Heerden and Roberts 1988; van Heerden et al. 1991; DuMars 2002; Letter et al. 2008; Mashriqui 2003). Moreover, the river mouth bar model of delta growth is the dominant mechanism forcing delta expansion, and the creation of this mid channel bar infers that some bedload transport is occurring within the project area (Edmonds and Slingerland 2007). However, the extensive shoaling and narrowing of Natal Channel and stable nature of Castille Pass Channel have also adversely impacted the distributary potential of these channels. The cross-sectional area of NC has decreased while the length of the east fork has increased since construction. CPC seems to be in equilibrium with its flow field and modifications to its cross-sectional area and length have been minimal. NC is also experiencing channel narrowing and modifications to its channel morphology partially due to the reoccupation of a former distributary. Therefore, the distributary potential of these channels has alternately increased (NC elongated and formed mid channel bar) and decreased (NC cross-sectional area has narrowed and CPC cross-sectional area has not been expanded) since construction. The second goal to create approximately 92 ha (230 acres) of delta lobe islands through the beneficial use of dredged material at elevations suitable for emergent marsh vegetation was accomplished because approximately 101 ha (249 acres) were created. Actually, 178 ha (441 acres) of subaerial land habitats were created in the project area, but 78 ha (192 acres) of subaerial land habitats were constructed by the USACE dredge disposal events. The third goal to increase the rate of subaerial growth in the project area was achieved because of the formation of a mid channel bar and the large acreage of emergent subaerial growth occurring in the project area since construction. The subaerial growth rate outside of the disposal areas was 8 ha/yr (20 acres/yr), which exceeded pre-construction Barras et al. (1994) growth rate estimates. Of particular note, a large continuous acreage of subaerial habitat was created in the project area, and this acreage extends from DA1 to the NE diversion. Although most of the mid channel bar is subaqueous, its formation indicates that the delta is growing seaward at this location. In conclusion, the AT-02 project has been partially successful in increasing the distributary potential of NC and CPC, was successful in creating 92 ha (230 of delta lobe islands, and increasing the subaerial growth rate during the 10 year post-construction period.

b. Recommended Improvements

The Atchafalaya Sediment Delivery (AT-02) project would have been more sustainable if the following improvements would have been incorporated into the design of the project. The first step in the design process should have been to conduct a geomorphic assessment of the area surrounding the diversion location. The process would help select a diversion location that is conducive to sediment transport. Secondly, a conceptual model should have been created. This type of model estimates the hydrodynamics and sediment transport capacity of the overall system (the river and the receiving basin). Thirdly, a hydrodynamic and sediment transport model should have been created. These models quantify water and sediment discharge and forecast morphological changes to channels and landscapes. If these three steps would have been undertaken, the future outcome of the diversion could have been predicted, like the shoaling of Natal Channel.

The monitoring regime of the Atchafalaya Sediment Delivery (AT-02) project should have been expanded to estimate the geomorphic processes affecting the project area. The current data collection scheme is very reactionary (passive). The data collected from these methods only confirm what already happened. The data show where the channel has shoaled or where new landforms are visible. This data leads to speculation as to why the channel shoaled or why the new landforms were created. A more dynamic sampling protocol is needed to determine the mechanisms forcing geomorphic change in the project area. This protocol should include quantitative estimates of discharge (Q) during flood and non-flood conditions. The discharge measurements should consist of water velocity and volume, suspended sediment concentrations, and channel stratigraphy. The suspended sediment and channel stratigraphy data should be qualitative and quantitative to estimate the probability of geomorphic change in the project area. In addition, the habitat mapping, bathymetry, and topography procedures should be continued to locate change within the project area over time. Moreover, the data collected from this type of sampling regime could be used to not only foresee changes in the project area but also could be used to design more sustainable sediment diversion projects.

Considering the extent of shoaling which is causing a reduction in the channel cross sections and depths along Natal Channel leading to less flow capacity and sediment transport, we are recommending that a small scale dredging project be implemented within the coming years to open as much of the channel as possible and re-establish the additional flow needed to continue the lobe development of the southern reaches of Natal Channel. With less than adequate maintenance funding available for hydraulically dredging the channel and creating additional marsh, we are recommending that Natal Channel be mechanically dredged to open the shoaled areas. The spoil material obtained from excavation operations shall be broadcasted along the bank of Natal Channel. This work will require a new permit or permit modification which would be obtained prior to construction. OCPR has entered into preliminary discussions with the land owner, Lousiana Department of Wildlife and Fisheries (LDWF), to perform the work in-house using their barge and excavation equipment. We are currently working out the details with LDWF for implementing this work. The operations and maintenance funds set aside for this work are included in the three (3) year budget under Appendix C.

c. Lessons Learned

One channel morphology and sediment transport lesson was learned from the Atchafalaya Sediment Delivery (AT-02) project. This lesson is that creating the NC bifurcation and bypassing the NE diversion channel during construction led to extensive aggradiation in NC. Ironically, the original project design included the NE diversion channel. However, the channel was eliminated from the design due to a potential title conflict over property ownership. The area directly south of the NE diversion has incurred large scale shoaling and channel narrowing. In the future, this section of NC could fuse eliminating discharge to an expanding part of the delta. Moreover, the NE diversion channel is a historical distributary of NC, and has been persistently discharging part of NC flow since 1976. Since the diversion channel has a shorter course to Atchafalaya Bay, the hydraulic efficiency of this channel is greater than the constructed bifurcation. Therefore, it seems that NC would have sustained less shoaling and higher discharges if the project design would have been rerouted to reoccupy the diversion channel bypassing the constructed bifurcation.

One disposal area lesson was learned from the Atchafalaya Sediment Delivery (AT-02) project. Containment dikes should be installed on the outer perimeter of all disposal areas to retain dredged sediments and allow consolidation. After construction and primary consolidation, these dikes can be removed or gapped to allow drainage and tidal activity. DA4 and the CPDA were built to lower relief because they were unconfined. As a result, containment dikes should be installed in all disposal areas to retain sediments and to elevate wetlands.

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Appendix A

AT-02 Photomosaic and Habitat Analysis Maps

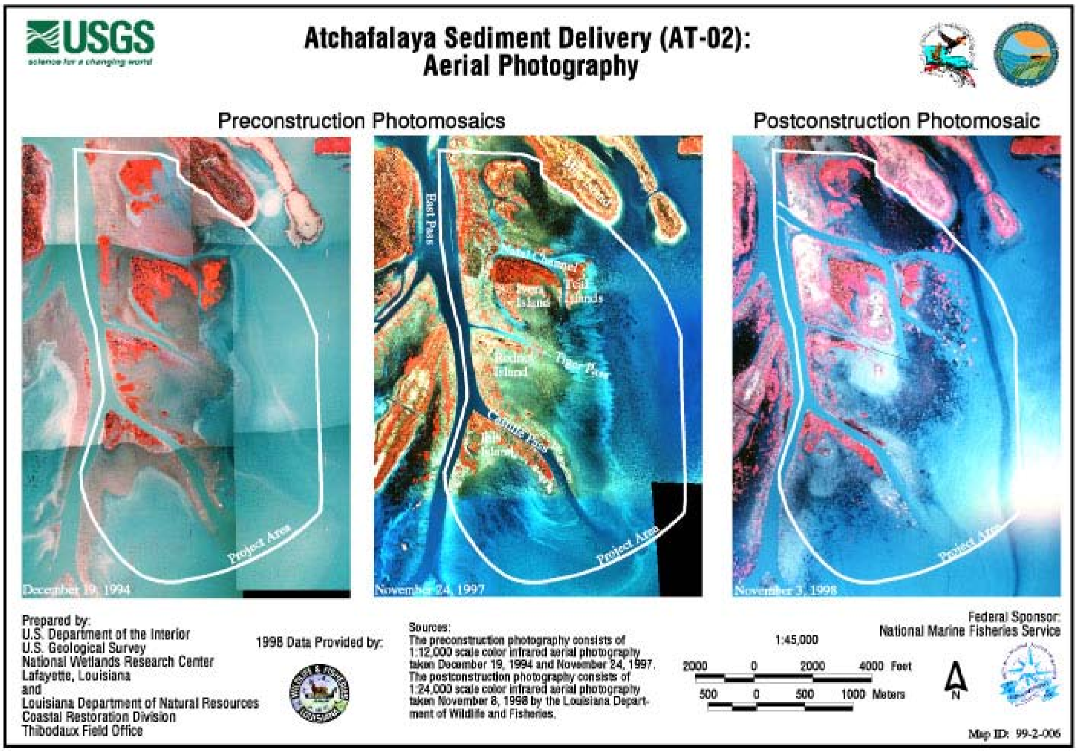

Figure. **Pre-construction (1994 and 1997) and as-built (1998) photomosaics of the Atchafalaya Sediment Delivery (AT-02) project area.**

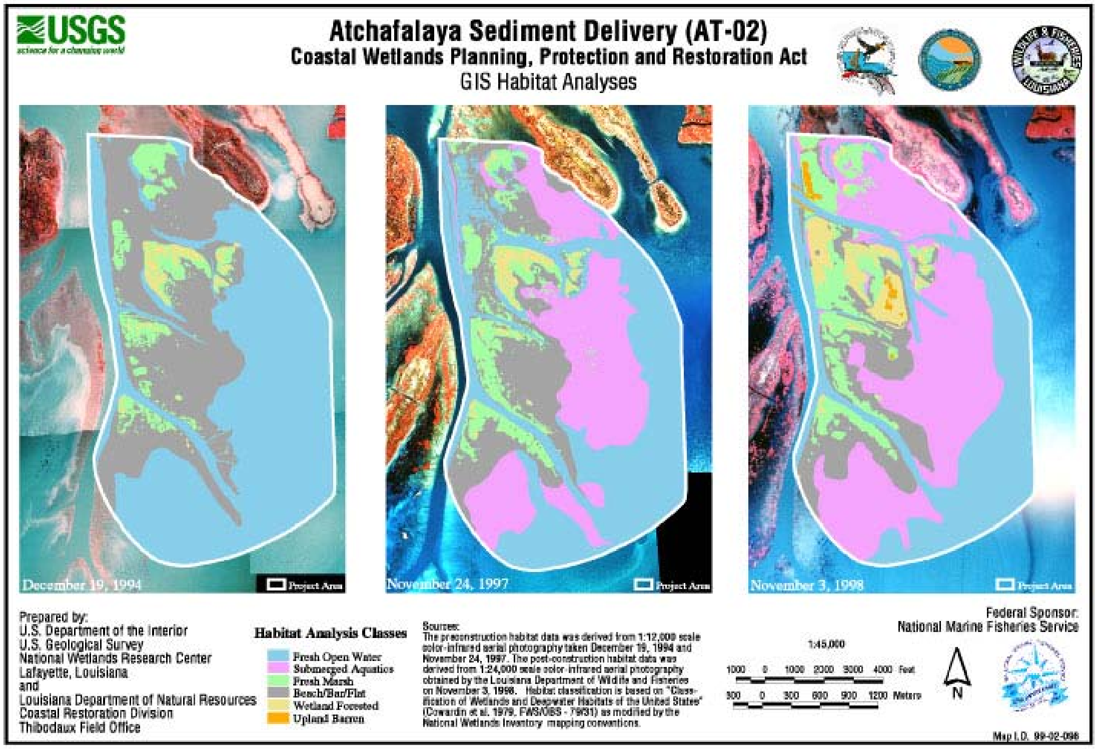

Figure. Pre-construction (1994 and 1997) and as-built (1998) habitat analysis of the Atchafalaya Sediment Delivery (AT-02) project area.

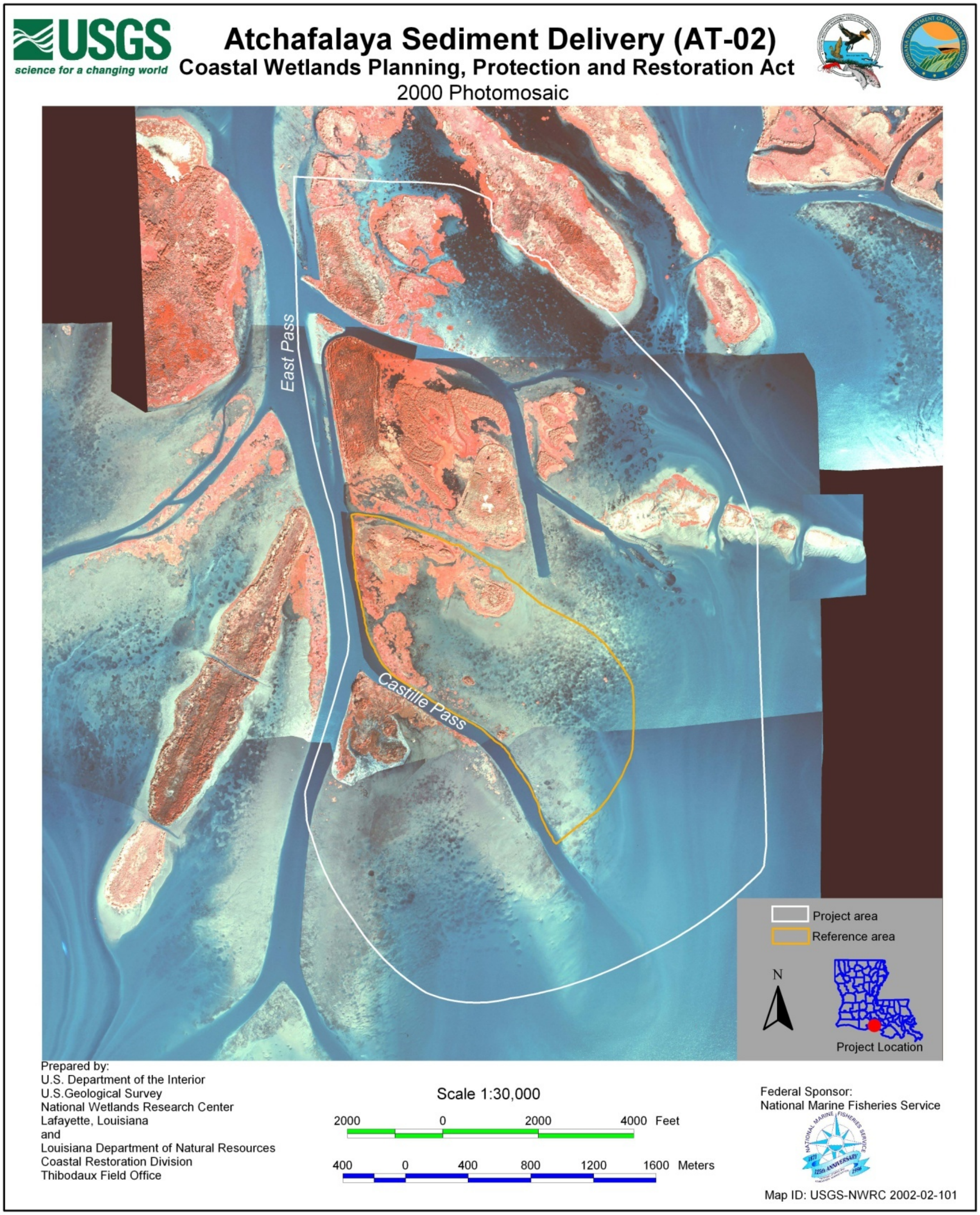

Figure. **Post-construction (2000) photomosaic of the Atchafalaya Sediment Delivery (AT-02) project area.**

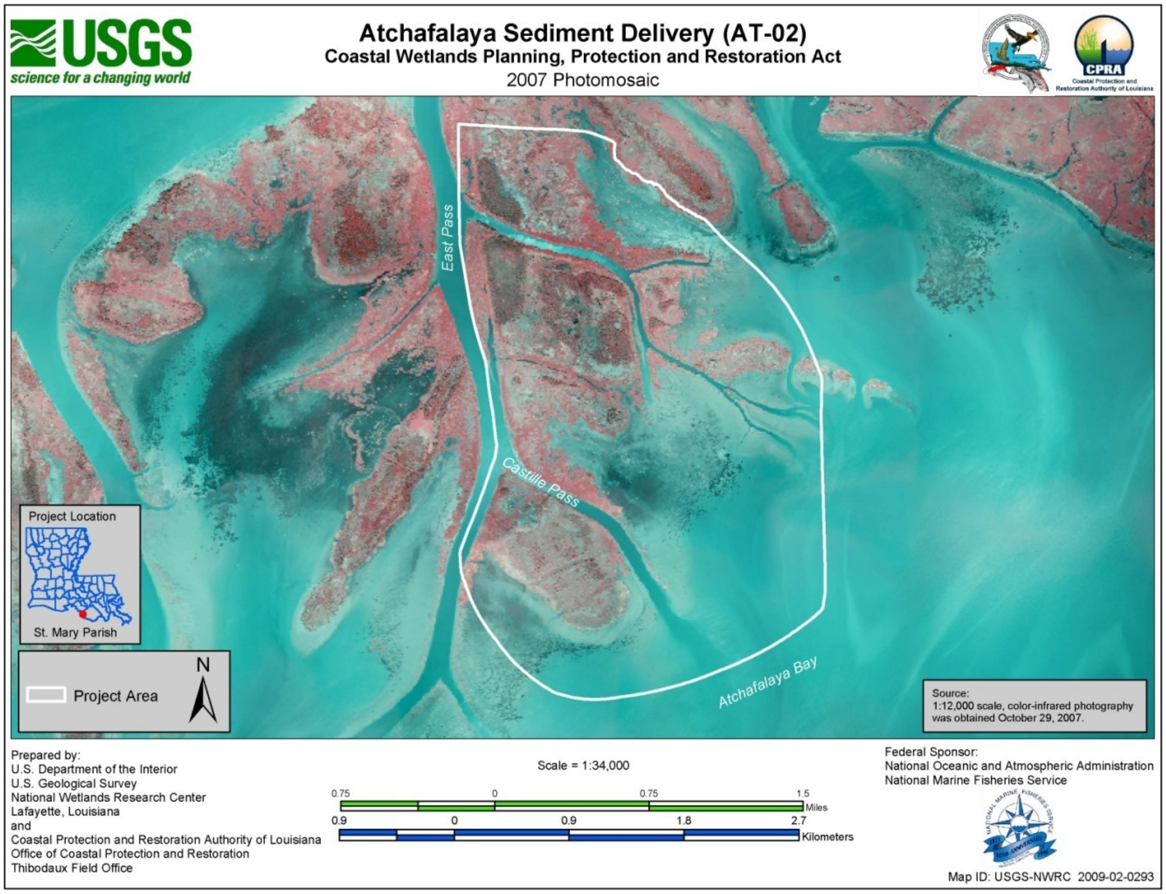

Figure. **Post-construction (2007) photomosaic of the Atchafalaya Sediment Delivery (AT-02) project area.**

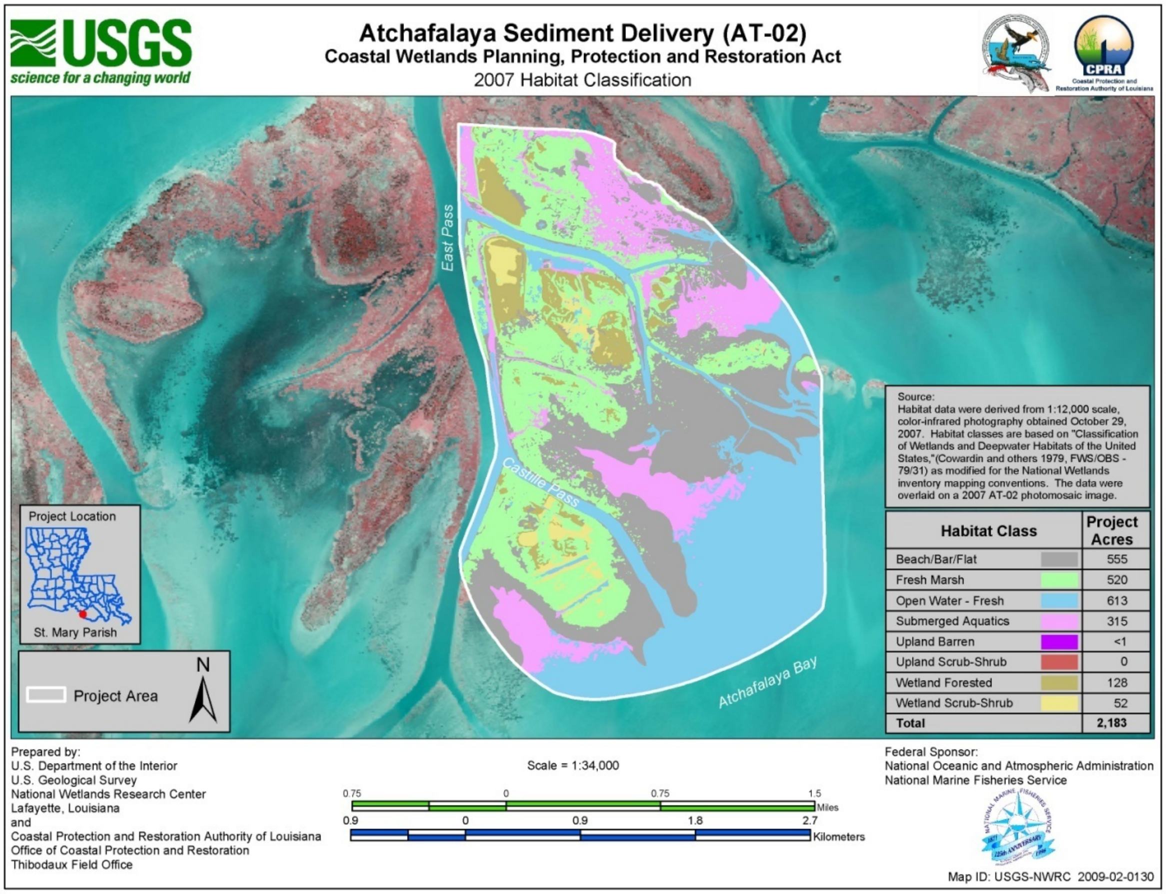

Figure. Post-construction (2007) habitat analysis of the Atchafalaya Sediment Delivery (AT-02) project area.

Appendix B

AT-02 Inspection Photos

Photo No.1 - Dredge plant located at the head of East Pass at the time of the inspection. Not certain of the areas that are being dredged or who has contracted the dredge.

Photo No.2 - View of Natal Channel from the head (near Sta. 15+00) looking southeast.

Photo No.3 - View of Natal Channel near the bend at Sta. 70+00 looking south.

Photo No.4 - View of bar that developed at the end of Natal Channel looking southeast from the mouth.

Photo No.5 - View of bar that developed at the end of Natal Channel looking southeast from the mouth.

Photo No.6 – View of vegetation along bar at the mouth of Natal Channel.

Photo No.7 - View of vegetation along bar at the mouth of Natal Channel.

Photo No.8 – View of vegetation near bar at the mouth of Natal Channel.

Photo No.9 – view of the northeastern diversion channel north of Natal Channel near Sta. 55+00.

Photo No.10 – view of northeastern diversion channel north of Natal Channel near Sta. 55+00.

Photo No.11 – View of the northeastern diversion channel north of Natal channel near Sta. 55+00.

Photo No.12 – View of marsh at the mouth of Castille Pass looking north.

Photo No.13 – view of marsh at the mouth of Castille Pass looking northeast.

Photo No.14 – view of marsh at the mouth of Castille Pass looking northeast.

Appendix C

AT-02 Three Year Budget and Worksheets

ATCHAFALAYA SEDIMENT DELIVERY PROJECT (AT-02)
Three-Year Operations & Maintenance Budgets 07/01/2010 - 06/30/13

Project Manager	O & M Manager	Federal Sponsor	Prepared By
	Brian Babin	*NMFS*	*Brian Babin*

	2010/2011	2011/2012	2012/2013
Maintenance Inspection	$ 2,652.00	$ -	$ 2,813.00
Structure Operation	$ -	$ -	$ -
Administration	$ -	$ 6,000.00	$ -

Maintenance/Rehabilitation

10/11 Description:

	2010/2011
E&D	
Construction	$ -
Construction Oversight	$ -
Sub Total - Maint. And Rehab.	$ -

11/12 Description: Secondary Monument Maintenance, Maintenance Dredging of Natal Channel

	2011/2012
E&D	$ 5,000.00
Construction	$ 300,000.00
Construction Oversight	$ 20,000.00
Sub Total - Maint. And Rehab.	$ 325,000.00

12/13 Description:

	2012/2013
E&D	$ -
Construction	$ -
Construction Oversight	$ -
Sub Total - Maint. And Rehab.	$ -

	2010/2011	2011/2012	2012/2013
Total O&M Budgets	**$ 2,652.00**	**$ 331,000.00**	**$ 2,813.00**

Total O&M Budget 2010 through 2013	**$336,465**
Unexpended O&M Budget	**$409,818**
Remaining O&M Budget (Projected)	**$72,888**

OPERATIONS & MAINTENANCE BUDGET WORKSHEET

Project: Atchafalaya Sediment Delivery Project (AT-02)

FY 10/11 –

Administration		$ 0
O&M Inspection & Report		$ 2,652
Operation:		$ 0
Maintenance:		$ 0
E&D:	$	
Construction:	$	
Construction Oversight:	$	
General Maintenance:	$	

Operation and Maintenance Assumptions:
Biennial Inspection (2010/2011) - $2,652

FY 11/12 –

Administration		$ 6,000*
O&M Inspection & Report		$ 0
Operation:		$ 0
Maintenance:		$325,000
E&D:	$ 5,000**	
Construction:	$300,000	
Construction Oversight:	$ 20,000***	

Operation and Maintenance Assumptions:
Assume maintenance/ adjustment of secondary monuments at a lump sum cost of $5,000 **and $1,000* for LDNR administration. Maintenance Dredging of Natal Channel – Included in year 11/12 is a lump sum of $300,000 for planning, permitting and dredging of Natal Channel should the landowner agree perform this work. OCPR administration costs for planning and construction oversight of maintenance dredging is estimated to be approximately $5,000* and $20,000***, respectively.

FY 12/13 –

Administration			$ 0
O&M Inspection & Report			$ 2,813
Operation:			$ 0
Maintenance:			$ 0
E&D:	$ 0		
Construction:	$ 0		
Construction Oversight:	$ 0		

Operation and Maintenance Assumptions:
Biennial Inspection (2012/2013) – (2,652 x 6% = $2,813)

2008-2011 Accounting

Unexpended funds from Lana Report:	$ 414,608.76
FY08 Expenditures by LDNR:	$ -4,791.00
Estimated Unexpended Funds:	$ 409,817.76