# MORGANZA TO THE GULF OF MEXICO, LA: FINAL POST AUTHORIZATION CHANGE REPORT AND REVISED PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT MAY 2013

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## COMMUNICATION

FROM

## THE ASSISTANT SECRETARY OF THE ARMY, CIVIL WORKS, THE DEPARTMENT OF DEFENSE

TRANSMITTING

A REPORT CONCERNING THE UPDATE MORGANZA TO THE GULF OF MEXICO, LOUISIANA, HURRICANE AND STORM DAMAGE RISK REDUCTION PROJECT

## PART 2 OF 2

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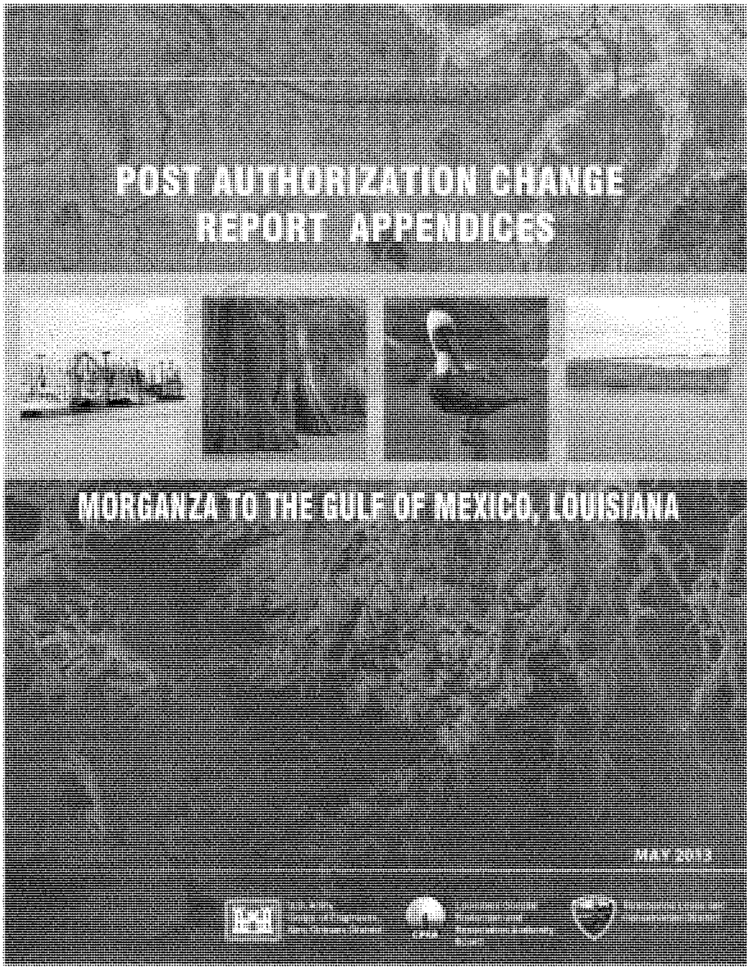

POST AUTHORIZATION CHANGE
REPORT APPENDICES
MORGANZA TO THE GULF OF MEXICO, LOUISIANA
MAY 2013

**MORGANZA TO THE GULF OF MEXICO, LOUISIANA PAC**
**ENGINEERING APPENDIX**

# Table of Contents

MORGANZA TO THE GULF OF MEXICO, LOUISIANA PAC
ENGINEERING APPENDIX

MORGANZA TO THE GULF OF MEXICO, LOUISIANA PAC
ENGINEERING APPENDIX

**MORGANZA TO THE GULF OF MEXICO, LOUISIANA PAC**
**ENGINEERING APPENDIX**

**MORGANZA TO THE GULF OF MEXICO, LOUISIANA PAC**
**ENGINEERING APPENDIX**

Plates

**MORGANZA TO THE GULF OF MEXICO, LOUISIANA PAC
ENGINEERING APPENDIX**

| | |
|---|---|
| 3 of 3 | Reach G-1 & G-2 Plan View Station 3087+35 to Station 3162+35 |
| 1 of 4 | Reach H-1 Plan View Station 3224+12.12 to Station 3313+12 |
| 2 of 4 | Reach H-1 & H-2 Plan View Station 3313+12 to Station 3416+12 |
| 3 of 4 | Reach H-2 & H-3 Plan View Station 3416+12 to Station 3531+12 |
| 4 of 4 | Reach H-3 Plan View Station 3531+12 to Station 3640+67 |
| 1 of 3 | Reach I-1 & I-2 Plan View Station 3640+67 to Station 3750+65 |
| 2 of 3 | Reach I-2 & I-3 Plan View Station 3750+65 to Station 3855+70 |
| 3 of 3 | Reach I-3 Plan View Station 3855+70 to Station 3941+76 |
| 1 of 5 | Reach J-2 Plan View Station 3941+75.55 to Station 4048+75 |
| 2 of 5 | Reach J-2 Plan View Station 4048+75 to Station 4156+69 |
| 3 of 5 | Reach J-2 & J-1 Plan View Station 4156+69 to Station 4261+76 |
| 4 of 5 | Reach J-1 Plan View Station 4261+76 to Station 4367+74 |
| 5 of 5 | Reach J-1 Plan View Station 4367+74 to Station 4438+85.25 |
| 1 of 3 | Reach K Plan View Station 4438+85+25 to Station 4543+85 |
| 2 of 3 | Reach K Plan View Station 4543+85 to Station 4658+86 |
| 3 of 3 | Reach K Plan View Station 4658+86 to Station 4706+98.84 |
| 1 of 3 | Reach L Plan View Station 4706+98.84 to Station 4812+00 |
| 2 of 3 | Reach L Plan View Station 4812+00 to Station 4942+00 |
| 3 of 3 | Reach L Plan View Station 4942+00 to Station 5021+78 |
| M2G-L-01 | Plan Sta 2160+70 to Sta 2245+00 |
| M2G-L-02 | Plan Sta 2245+00 to Sta 2220+00 |
| M2G-L-03 | Plan Sta 2320+00 to Sta 2400+00 |
| M2G-L-04 | Plan Sta 2400+00 to Sta 2520+00 |
| M2G-L-05 | Plan Sta 2520+00 to Sta 2640+00 |
| M2G-L-06 | Plan Sta 2640+00 to Sta 2760+00 |
| M2G-L-07 | Plan Sta 2760+00 to Sta 2810+63.35 |
| MTG-L-08 | Plan Sta 2810+63.35 to Sta 2916+65 |
| MTG L-09 | Plan Sta 2916+65 to Sta 3072+80 |
| MTG L-10 | Plan Sta 2948.83 to Sta 3072+80 |
| MTG L-11 | Plan Sta 3072+80 to Sta 3200+00 |
| G-1 | Reach I Profile 1Soil and Geologic Profile |
| G-2 | Reach I Profile 2 Soil and Geologic Profile |
| G-3 | Levee Reach I-1 BL Sta 1254+00 to 1339+00 Density and Shear Strength |
| A | Levee Reach A and Barrier Alignment 100 Yr LORR Base Yr Conditions with Overbuild Section |
| B | Levee Reach B 100 Yr LORR Base Yr Conditions with Overbuild Section |
| E | Levee Reach E 100 Yr LORR Base Yr Conditions with Overbuild Section |
| F | Levee Reach F 100 Yr LORR Base Yr Conditions with Overbuild Section |
| G | Levee Reach G 100 Yr LORR Base Yr Conditions with Overbuild Section |
| H1 | Levee Reach H1 100 Yr LORR Base Yr Conditions with Overbuild Section |
| H2 | Levee Reach H2 & H3 100 Yr LORR Base Yr Conditions with Overbuild Section |
| I | Levee Reach I 100 Yr LORR Base Yr Conditions with Overbuild Section |
| J3 | Levee Reach J3 100 Yr LORR Base Yr Conditions with Overbuild Section |
| J | Levee Reach J 100 Yr LORR Base Yr Conditions with Overbuild Section |

**MORGANZA TO THE GULF OF MEXICO, LOUISIANA PAC ENGINEERING APPENDIX**

| | |
|---|---|
| KL | Levee Reach K & L 100 Yr LORR Base Yr Conditions with Overbuild Section |
| SWL-A | Lockport to Larose Reach (a) 100 Yr LORR Base Yr Conditions with Overbuild Section |
| LWL-CN | LGM Reach C-North 100 Yr Base Yr Conditions with Overbuild |
| SA-1 | Levee Reach A & Barrier Alignment Theoretical Settlement Analysis |
| SA-2 | Levee Reach B Theoretical Settlement Analysis |
| SA-3 | Levee Reach E Theoretical Settlement Analysis |
| SA-4 | Levee Reach F Theoretical Settlement Analysis |
| SA-5 | Levee Reach G Theoretical Settlement Analysis |
| SA-6 | Levee Reach H Theoretical Settlement Analysis |
| SA-7 | Levee Reach I Theoretical Settlement Analysis |
| SA-8 | Levee Reach J Theoretical Settlement Analysis |
| SA-9 | Levee Reach K Theoretical Settlement Analysis |
| SA-10 | Levee Reach L Theoretical Settlement Analysis |
| SA-11 | Reach C-North Theoretical Settlement Analysis |
| SA-12 | Lockport to Larose Reach (a) Theoretical Settlement Analysis |
| SA-13 | Lockport to Larose Reach (b) Theoretical Settlement Analysis |
| C-703A | Black Bayou 56' Sector Gate 100 Yr Final Site Plan |
| C-705 | Black Bayou Canal 56' Sector Gate Cross Sections |
| C-709A | Shell Canal West 30' Stop Log Gate 100 Yr Final Plan |
| C-711 | Shell Canal West 35' Sector Gate Cross Sections |
| C-745A | GIWW West 125' Sector Gate Plan 100 Yr Final Site Plan |
| C-748 | GIWW West 125' Sector Gate 100 Yr Cross Sections |
| C-842A | Environmental Control Structure Reach E Final Site Plan 100 Yr |
| C-843 | Environmental Control Structure Reach E Cross Sections |
| S-003A | 56' Sector Gate Masonry Elevation Transverse |
| S-005A | 56' Sector Gate Foundation Plan |
| S-026A | 125' Sector Gate Masonry Plan |
| S-027A | 125' Sector Gate Masonry Sections |
| S-029A | 125' Sector Gate Foundation Plan |
| S-055A | Sluice Gate Front Elevation |
| S-057A | Sluice Gate Section |
| S-058A | Sluice Gate Foundation Plan |
| S-061A | 20' Stop Log Masonry Plan |
| S-063A | 20' Stop Log Gate Foundation Plan |
| S-082A | Environmental Control Structure Masonry Elevation Flood Side |
| S-084A | Environmental Control Structure Section |
| S-085A | Environmental Control Structure Foundation Plan |
| S-094A | T-Wall Type 2A-2B |
| S-095A | T-Wall Type 2C-2E |

# 1 INTRODUCTION

## 1.1 LOCATION AND DESCRIPTION OF PROJECT AREA

## 1.2 General

The project/study area is about 60 miles southwest of New Orleans, Louisiana and includes most of Terrebonne Parish and the portion of Lafourche Parish between the eastern boundary of Terrebonne Parish and Bayou Lafourche. The authorized Morganza to the Gulf of Mexico project (MTG) was intended to function as a 1% annual exceedance probability (100-year) coastal storm damage risk reduction system. In addition to flood risk reduction, the structural features of the authorized project were designed to provide tidal exchange, environmental benefits, and navigational passage. See Figure 1 for a map showing the post authorization change Morganza to the Gulf levee alignment. The levee reaches on the western extent (Barrier Reach) and eastern extent (Larose C North and Lockport to Larose Reaches) of the current PAC alignment were not part of the authorized alignment. Note that the Morganza alignment has evolved throughout the PAC analysis and these western and easternmost levee reaches do not appear on every map in this appendix. Refer back to Figure 1 as necessary.

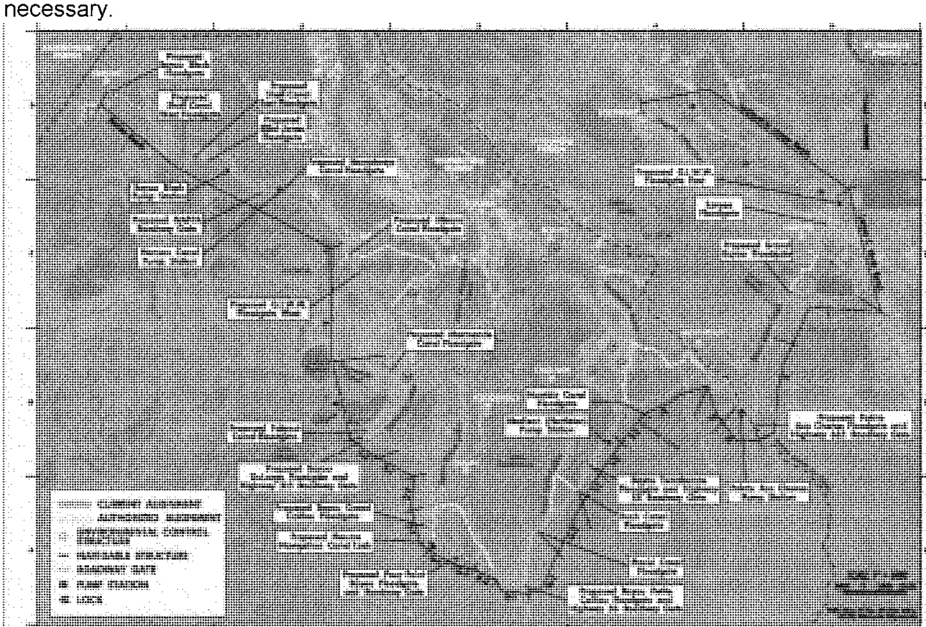


**Figure 1 - Morganza to the Gulf Alignment**

The PAC report is not a reformulation of the project; it includes an analysis of pre-and post-Katrina 1% Annual Exceedance Probability (AEP) design alternatives, the project levee alignment, and other features integral to the project. The two alternatives considered for this report are shown below-

- 3% AEP Storm Surge Risk Reduction System (3% AEP alternative)
- 1% AEP Storm Surge Risk Reduction System (1% AEP alternative)

## 1.3 Description of the 1% AEP Alternative

The 1% AEP alternative is a hurricane levee system that provides risk reduction for water levels that have a 1 percent chance of occurring each year. Levee elevations range from 14.0 to 24.0 feet for base year (2035) conditions and from 19.5 to 26.5 feet NAVD88 for future year (2085) conditions assuming relative sea level rise of approximately 2.4 feet by 2085 (intermediate scenario).

## 1.4 Description of the 3% AEP Alternative

The 3% AEP alternative is a hurricane levee system that provides risk reduction for water levels that have a 3 percent chance of occurring each year. Levee elevations range from 9.0 to 18.0 feet for base year (2035) conditions and from 13.0 to 20.0 feet NAVD88 for future year (2085) conditions assuming relative sea level rise of approximately 2.4 feet by 2085 (intermediate scenario).

## 1.5 Purpose

This Engineering Appendix outlines the engineering and design work done to support the preparation of the Morganza to the Gulf Post Authorization Change Report. The appendix summarizes modeling, hydraulic design, geotechnical investigations, structural design, levee design and cost estimates. Additional technical details including modeling reports, plates, calculations, soil boring logs, etc. are available at MVN and can be provided upon request. See list of references at the end of this report.

All elevations are referenced to North American Vertical Datum, NAVD 88 unless otherwise noted.

# 2 CLIMATOLOGY, HYDROLOGY, HYDRAULICS, AND WATER QUALITY

## 2.1 CLIMATOLOGY

### 2.1.1 Climate

The climate in the area is humid subtropical and is subject to significant polar influences during the winter as a cold air masses periodically move southward over the area displacing warm moist air. Prevailing southerly winds create a strong maritime character. This movement from the Gulf of Mexico helps to decrease the range between hot and cold temperatures and provides a source of abundant moisture and rainfall.

### 2.1.2 Temperature

Temperature records are available for Louisiana, published by the National Oceanic and Atmospheric Administration's (NOAA) National Climatic Data Center (NCDC). The records can be downloaded on the agency's website at http-//www1.ncdc.noaa.gov/pub/orders/IPS-E94999DE-130D-4437-8BB1-312509AAD725.pdf. The website has detailed records available for three locations in each parish within the study area. The monthly and annual mean normals over a 100 year timeframe, 1910-2010, are shown in Table 1. The average annual mean normal temperature is 66.6 degrees Fahrenheit (°F), with monthly mean temperature normal varying from 39.5 °F in February to 86.1 °F in August. A maximum extreme temperature of 102 (°F) was recorded at Morgan City during July of 1980 and a minimum extreme of 10 (°F) was recorded during the month of December at Morgan City.

**Table 1- Normal Temperatures (Source- NCDC)**

| Station | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Franklin - 3NW | 51.9 | 55.1 | 61.3 | 67.2 | 74.6 | 79.7 | 81.4 | 81.1 | 77.4 | 68.6 | 60.3 | 54.1 | 67.7 |
| Galliano | 53.0 | 55.7 | 62.3 | 67.9 | 75.1 | 80.1 | 81.9 | 81.8 | 78.5 | 69.9 | 62.2 | 55.3 | 68.6 |
| Morgan City | 51.8 | 54.8 | 61.2 | 67.4 | 74.5 | 79.6 | 81.5 | 81.2 | 78.2 | 70.0 | 61.3 | 54.6 | 68.0 |
| AVERAGE | 52.2 | 55.2 | 61.6 | 67.5 | 74.7 | 79.8 | 81.6 | 81.4 | 78.0 | 69.5 | 61.3 | 54.7 | 68.1 |

### 2.1.3 Tides

The normal tidal range at Grand Isle, LA is diurnal and is from 1.5 to 2.0 feet from low to high tide. Further inland the extent of tidal range and area of influence are determined by the rainfall discharge exiting the drainage areas into the Gulf of Mexico, and by discharges in the Gulf Intracoastal Waterway originating in the Atchafalaya River. The tidal ranges become smaller when moving further inland. During a spring tidal cycle these ranges may be larger; during neap tidal cycle these ranges may be less.

### 2.1.4 Precipitation

Precipitation records are also available for Louisiana and published on the National Oceanic and Atmospheric Administration's (NOAA) National Climatic Data Center website (http-//www1.ncdc.noaa.gov/pub/orders/IPS-E94999DE-130D-4437-8BB1-312509AAD725.pdf).

Table 2 lists the stations with their period of record and available extremes for the same 40 year period that was used for the temperature data. The stations have 30-year monthly and annual normals. The average annual normal rainfall for these stations is 65.36 inches.

Table 3 lists the monthly and annual normals. The wettest month is July with an average monthly normal of 7.55 inches. February is the driest month averaging 4.30 inches.

**Table 2 - Precipitation Extremes**

PRECIPITATION EXTREMES

| Station | Period of Record (to 2010) | Maximum Monthly (in.) | Maximum Date | Minimum Monthly (in.) | Minimum Date | Greatest 1-Day | Greatest Date |
|---|---|---|---|---|---|---|---|
| Franklin 3NW | 1955-Date | 19.87 | Dec-09 | 0 | Nov-61 | 8.51 | 12/30/2010 |
| Galliano | 1968-Date | 21.35 | Sep-98 | 0.12 | Oct-78 | 9.9 | 5/30/1975 |
| Morgan City | 1905-Date | 23.04 | Jun-01 | 0 | Oct-11 | 15.55 | 4/16/1927 |

SOURCE: NCDC

**Table 3 – Monthly and Annual Normal Precipitation (Source- NCDC)**

| Station | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Franklin - 3NW | 5.43 | 3.92 | 4.73 | 5.09 | 4.92 | 7.06 | 7.37 | 7.76 | 5.85 | 3.72 | 4.46 | 4.82 | 65.13 |
| Galliano | 5.85 | 4.59 | 5.53 | 4.43 | 5.72 | 5.82 | 7.69 | 7.13 | 6.34 | 3.65 | 4.67 | 4.03 | 65.48 |
| Morgan City | 5.81 | 4.39 | 4.7 | 4.22 | 5.38 | 5.81 | 7.6 | 7.4 | 6.49 | 3.66 | 5.07 | 4.95 | 65.48 |
| AVERAGE | 5.70 | 4.30 | 4.99 | 4.58 | 5.34 | 6.23 | 7.55 | 7.43 | 6.23 | 3.68 | 4.73 | 4.60 | 65.36 |

Wind data taken at New Orleans Louis Armstrong Airport are typically used to describe the study area. This wind data is used because the locations experience similar kinds of events due to the close proximity of their geographic location on the Gulf Coast. Table 4 shows the average monthly and annual wind speeds over the period 1971-2000. The average velocity of the winds is 8.1 miles per hour over this period. Southeast winds predominate in the spring and summer. The prevailing winds of the fall and winter are from the northeast. Winter storms in the area have produced wind speeds of up to 47 miles per hour. The summer is often disturbed by tropical storms and hurricanes that produce the highest winds in the area. Maximum wind speeds observed (highest one-minute speed) since 1963 was 69 mph and was a result of Hurricane Betsy in September 1965.

**Table 4 - Average Monthly and Annual Wind Speeds**

| NEW ORLEANS LOUIS ARMSTRONG AIRPORT 1971 - 2000 | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANN |
| (mph) | (mph) | (mph) | (mph) | (mph) | (mph) | (mph) | (mph) | (mph) | (mph) | (mph) | (mph) | (mph) |
| 9.2 | 9.5 | 9.4 | 9.2 | 8.2 | 6.8 | 5.9 | 6.0 | 7.6 | 8.0 | 8.5 | 8.8 | 8.1 |

### 2.1.5 Stream Gaging Data

Stream gaging data was used from the 31 stations in the study area. Some stations are maintained through a cooperative agreement between the US Army Corps of Engineers (USACE) and the United States Geological Survey. The stations' period of record and available data types are shown in Table 5. The station locations are shown in Figure 2.

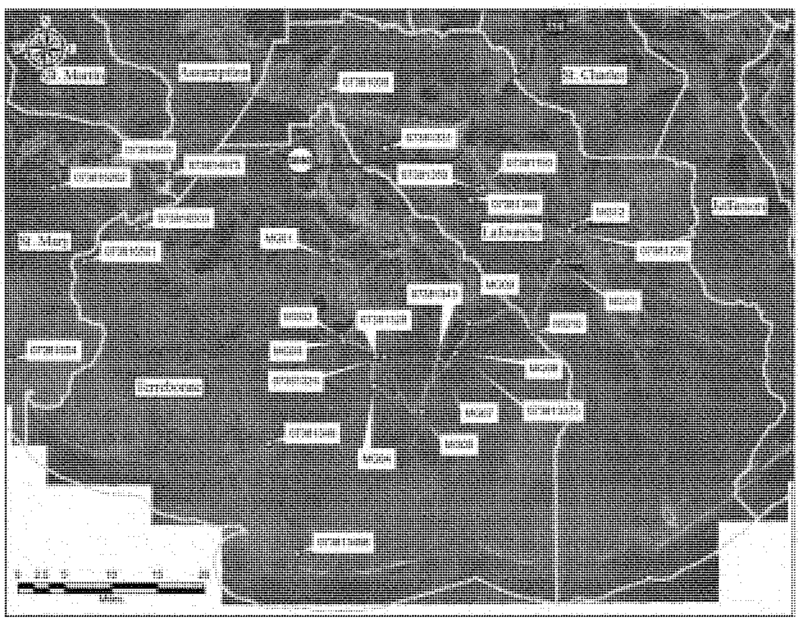


Figure 2 - Gage Station Locations

**Table 5 - Gage Station Information**

| Station ID | Station Name | Period | Type | Conversion of Stage to Elevation (NAVD88 2004.65,ft) | Source |
|---|---|---|---|---|---|
| MG01 | West Minor's Canal | 07/2004 - 04/2005<br>*<br>02/2004 - 04/2006<br>05/2004 - 04/2006 | Discharge<br>Stage<br>Salinity | -0.26 | USACE MVN |
| MG02 | Falgout Canal | 04/2005 - 10/2005<br>09/2004 - 10/2005<br>* | Stage<br>Salinity | -0.68 | USACE MVN |
| MG03 | Bayou Dularge | 09/2004 - 04/2005<br>07/2003 - 10/2005<br>09/2004 - 04/2005 | Velocity<br>Stage<br>Salinity | -0.68 | USACE MVN |
| MG04 | Bayou Grand Caillou | 10/2004 - 11/2004<br>10/2004 - 11/2004 | Stage<br>Salinity | -0.54 | USACE MVN |
| MG05 | Bayou Petit Caillou | 03/2004 - 06/2005<br>04/2004 - 06/2005 | Stage<br>Salinity | -0.4 | USACE MVN |
| MG07 | Bush Canal | 11/2004 - 09/2005 | Stage | -0.16 | USACE |

| Station ID | Station Name | Period | Type | Conversion of Stage to Elevation (NAVD88 2004.65,ft) | Source |
|---|---|---|---|---|---|
| | | | | | MVN |
| MG08 | Bayou Terrebonne | 10/2003 - 05/2005<br>04/2004 - 06/2005<br>* | Stage<br>Salinity | -0.16 | USACE<br>MVN |
| MG09 | Humble Canal | 05/2003 - 10/2005<br>04/2004 - 10/2005 | Stage<br>Salinity | -0.2 | USACE<br>MVN |
| MG10 | Bayou Pointe-aux-Chenes | 10/2003 - 02/2005<br>*<br>04/2004 - 03/2005 | Stage<br>Salinity | 0 | USACE<br>MVN |
| MG11 | Grand Bayou Canal | 05/2004 - 10/2005<br>05/2004 - 10/2005 | Stage<br>Salinity | 0 | USACE<br>MVN |
| MG12 | GIWW Larose | 12/2004 - 04/2005<br>06/2004 -05/2005<br>06/2004 - 05/2005 | Discharge<br>Stage<br>Salinity | 0 | USACE<br>MVN |
| - | Houma | 1971 to 2008 | Precipitation | - | NCDC<br>NOAA |
| - | Morgan City | 1996 to 2006 | Precipitation | - | NCDC<br>NOAA |
| 7381000 | Bayou Lafourche at Thibodaux, LA | 01/2004 - 10/2009 | Discharge/Stage | 0 | USGS |
| 7381150 | Bayou Lafourche at Lockport, LA | 10/2006 - 10/2009 | Stage | -3.793 | USGS |
| 7381235 | GIWW West of Bayou Lafourche at Larose, LA | 01/2004 - 10/2009 | Discharge/Stage | 0 | USGS |
| 7381324 | Bayou Grand Caillou at Dulac, LA | 01/2004 - 10/2009 | Discharge/Stage | 0.357 | USGS |
| 7381328 | Houma Navigation Canal at Dulac, LA | 01/2004 - 10/2009 | Discharge/Stage | 0.02 | USGS |
| 7381331 | GIWW at Houma, LA | 01/2004 - 10/2009 | Discharge/Stage | -0.712[1] | USGS |
| 73813375 | Bayou Terrebonne at Ctrl Str near Lapeyrouse, LA | 12/2001 - 11/2005 | Precipitation/Stage | 0 | USGS |
| 7381343 | B. Petit Caillou at Ctrl Str near Lapeyrouse, LA | 01/2004 - 10/2009 | Precipitation/Stage | 0 | USGS |
| 7381349 | Caillou Lake (Sister Lake) SW of Dulac, LA | 08/2008 - 10/2009 | Precipitation/Stage | 0 | USGS |
| 73813498 | Caillou Bay SW of Cocodrie, LA | 01/2004 - 09/2006 | Precipitation/Stage | N.C.F.[2] | USGS |
| 7381350 | Company Canal at Hwy 1 at Lockport, LA | 01/2004 - 10/2009 | Stage | -0.566[1] | USGS |

| Station ID | Station Name | Period | Type | Conversion of Stage to Elevation (NAVD88 2004.65,ft) | Source |
|---|---|---|---|---|---|
| 7381355 | Company Canal at Salt Barrier near Lockport, LA | 01/2004 - 10/2009 | Stage | -1.090[1] | USGS |
| 7381600 | Lower Atchafalaya River at Morgan City, LA | 01/2004 - 10/2009 | Discharge/Stage | -0.45 | USGS |
| 73816501 | Avoca Island Cutoff south of Morgan City, La. | 10/2008 - 10/2009 | Stage | N.C.F.[2] | USGS |
| 73816503 | Bayou Penchant S of Morgan City, LA | 01/2004 - 10/2009 | Discharge/Stage | 0 | USGS |
| 7381654 | Atchafalaya Bay at Eugene Island | 08/2006 - 10/2009 | Stage | N.C.F.[2] | USGS |
| 73816202 | GIWW at mile 103 S of Morgan City, LA | 01/2004 - 10/2009 | Stage | 0 | USGS |
| 73814675 | Bayou Boeuf at Railroad Bridge at Amelia, LA | 01/2004 - 03/2009 | Discharge/Stage | 0 | USGS |

* Three or more consecutive months missing from data.
** Data is sporadic.
Notes: 1. Datum based on OPUS measurements and it is not tied to any tidal epoch.
2. "N.C.F." in the above table corresponds to "No Conversion Factor" for converting the stage to an elevation.

### 2.1.6 Floods of Record

#### 2.1.6.1 Non-Tropical Events

The study area floods from tidal surges associated with hurricanes and tropical storms. Lower Atchafalaya River water enters the study area from the Avoca Island Cutoff Channel and GIWW. Heavy rainfall also affects the lower reach in the areas that are highly developed.

Some of the major historical floods caused by heavy rainfall or tides occurred in 1973, 1980, 1983, 1991, 2005 and 2011. Descriptions of significant events are described below.

**1973 Flood**- Flooding occurred throughout the eastern portion of the study area during the spring of 1973. Tidal flooding inundated the area below Highway 90 with the exception of the alluvial ridges of the Mississippi River, Bayou Lafourche, and many of the smaller streams that drain into the Gulf of Mexico. Peak stages recorded on May 27 include 11.16 feet NGVD at Wax Lake Outlet at Calumet and 6.27 feet NGVD at Lower

Atchafalaya River below Sweet Bay Lake. On May 28, flooding caused a high stage of 10.53 feet NGVD on the Lower Atchafalaya River at Morgan City.

**1980 Flood-** Heavy rains at the end of March and early April setup flooding which occurred over the entire study area during mid April. A maximum extreme was set at Bayou Black at Greenwood, 4.82 feet NGVD. One day rainfall totals on April 13 exceeded 9 inches at Morgan City (9.1) and 11 inches at Thibodaux (11.8).

**1983 Flood-** Heavy rains north of the study area produced this flood of record. In the Atchafalaya Basin Floodway System, peak stages from this event include 8.11 ft NGVD at Wax Lake Outlet at Calumet and 7.32 ft NGVD at Lower Atchafalaya River at Morgan City on June 6.

**1991 Flood-** Flooding occurred throughout the study area due to above normal rainfall during most of year. In the Houma Thibodaux Area during May 8-10, the three day totals for the two sites were 12.94 and 14.33 inches NGVD, respectively. The rainfall event set a maximum extreme event of 8.76 feet NGVD on Bayou Lafourche at Thibodaux gage on May 9. In addition to heavy rainfall, high tides in the Gulf of Mexico affected runoff.

#### 2.1.6.2 Tropical Events

Some of the major historical hurricanes that produced significant flooding within the study area are listed below in Table 6.

**Table 6 - Historical Hurricanes in Study Area**

| Year | Name | Dates | Category at Landfall |
|---|---|---|---|
| 1909 | Unnamed storm | September 18-21 | Category 3 |
| 1915 | Unnamed storm | September 25-October 1 | Category 4 |
| 1956 | Flossy | September 23-30 | Category 1 |
| 1957 | Audrey | June 26-27 | Category 4 |
| 1961 | Carla | September 10-12 | Category 5 |
| 1964 | Hilda | October 3-4 | Category 4 |
| 1965 | Betsy | September 9-10 | Category 4 |
| 1971 | Edith | September 16 | Category 1 |
| 1974 | Carmen | September 8 | Category 4 |
| 1985 | Danny | August 15 | Category 1 |
| 1985 | Juan | October 28-30 | Category 1 |
| 1992 | Andrew | August 24-27 | Category 5 |
| 2002 | Lili | October 3 | Category 1 |
| 2005 | Katrina | August 23-30 | Category 5 |

| Year | Name | Dates | Category at Landfall |
|---|---|---|---|
| 2005 | Rita | September 23-24 | Category 5 |
| 2008 | Gustav | September 2 | Category 2 |
| 2008 | Ike | September 12-13 | Category 2 |

**1909 Flood**- Wind speeds of 80 mph were reported for Thibodaux and near the mouth of Bayou Terrebonne, 40 miles south of Thibodaux as a tropical cyclone passed through the study area from September 19-20. The highest tides were experienced at the mouth of Bayou Terrebonne in Lafourche Parish, where an elevation of 15 feet above sea level was attained at Sea Breeze.

**1915 Flood**- Heavy rainfall, high winds, and extremely low barometric pressures from this hurricane from September 29 to October 2 caused headwater flooding along Bayou Lafourche where stages of 9 and 5 feet above sea level, respectively, were reported at Leeville and Golden Meadow. The United States Weather Bureau 5 minute sustained and extreme wind velocities for the 29th of September were 66 and 75 miles per hour at New Orleans. In Leeville, approximately 13 miles west of Grand Isle, only 1 of 100 houses remained standing as a result of this storm.

**1956 Flood**- Hurricane Flossy, during the period of September 21-30, was the cause of this flood. Tides reached 5 to 8 feet above normal along most of the southeastern coast. Rainfall during the storm was quite heavy. The heaviest occurred at Golden Meadow where 16.7 inches of rain was recorded.

**1957 Flood**-Heavy rainfall and Heavy winds associated with Hurricane Audrey, June 25-28, caused headwater flooding along the Louisiana coast. The storm set peak stages of 8.05 feet NGVD at Lower Atchafalaya River below Sweet Bay Lake, 6.81 feet NGVD at Atchafalaya Bay at Eugene Island, 8.52 feet and 7.35 feet NGVD respectively at Intracoastal Waterway at Wax Lake East and West on June 27. Maximum stages were also set along the coastline on this date and included 6.00 feet NGVD at Schooner Bayou and 8.12 feet NGVD at Leland Bowman Lock.

**1961 Flood**- Hurricane Carla raised tides 3 to 4 feet above normal along the entire coastline of Louisiana during the period of September 4-14. Rainfall associated with the hurricane amounted to 6.2 inches at Morgan City and 3.4 inches at Houma.

**1964 Flood**- Hurricane Hilda, during the period of October 3-5, caused extensive tidal and headwater flooding in the study area. Heavy rainfall north of the study area associated with hurricane ranged from 10.1 inches at New Roads to 8.9 inches at Baton Rouge.

**1965 Flood**- Hurricane Betsy damaged most of southeast Louisiana, specifically Lafourche and Terrebonne Parish. In Thibodaux, winds of 130 mph to 140 mph were reported.

**1971 Flood**- Hurricane Edith damaged made landfall in the western parishes of Louisiana as a Category 2. The storm impacted St. Mary Parish as a Category 1.

**1974 Flood**- Hurricane Carmen was responsible for this flood during September 5-9. The highest known storm tide, 11.64 feet NGVD occurred at Cocodrie in Terrebonne Parish. This stage was reportedly more than 10 feet above normal.

**1985 Flood**- Hurricane Danny, Category I, hurricane made landfall between Grand Chenier in Cameron Parish and Pecan Island in Vermillion. Storm surge values ranged from 5 to 8 feet across Iberia, St. Mary, and Vermillion parishes.

Hurricane Juan, during the period of October 28-30, caused massive flooding throughout the study area due to its prolonged 5-day stay along the Louisiana Coast. Tides were generally 3 to 6 feet above normal, and storm surges of 5 to 8 feet were reported in several coastal parishes. Rainfall amounts in the study area ranged from 5 to nearly 17 inches for this period.

**1992 Flood-** Hurricane Andrew, during the period August 24-27, set a new maximum extreme of 7.65 feet NGVD at Round Bayou at Deer Island and recorded 6.8 ft NGVD for the Lower Atchafalaya River at Morgan City in St. Mary parish. The Gulf Intracoastal Waterway at Wax Lake East Control Structure recorded a stage of 6.15 feet NGVD.

**2002 Flood-** Hurricane Lili major flooding event for Terrebonne Parish had over 1,000 structures flooded. Lili made landfall on the morning of October 3 near Intracoastal City, as a weakening category one hurricane. Wind gusts reaching 120 mph, coupled with over 6 inches of rainfall and a storm surge of 12 feet caused over $790 million in damage to Louisiana. A total of 237,000 people lost power, and oil rigs offshore were shut down for up to a week.

**2005 Flood-** The year, 2005, will be recorded in the annals of history as the "Year of the Storms." Never in history had Terrebonne Parish been declared a disaster area twice within a period of thirty days. But, on August 29, 2005, for Hurricane Katrina and again on September 24, 2005, for Hurricane Rita, the Parish was declared a federal disaster area by the President of the United States. Maximum stage experienced in the area ranged from about 2.8 to 3.2 feet for Katrina. Katrina pushed the water out to the Gulf in Terrebonne Parish. During the period of September 20-26, Rita flooded over 4,000 structures in Terrebonne Parish. Maximum stage experienced in the area for Rita ranged from about 3.6 to 8.6 feet.

Lafourche Parish was affected by three storms in 2005, including Hurricane Cindy in July, Hurricane Katrina in August and Hurricane Rita in September. By far the most dangerous of the three, Hurricane Katrina carried maximum sustained winds of 140 mph, with hurricane-force winds extending over 100 miles from the center of the storm. Storm surges reached 20 to 30 feet above normal tide levels and brought large battering waves. While these conditions did not occur at the location of the Morganza project, they represent the potential impacts a storm could impose on the project as the storm extended from New Orleans to the east along the Mississippi Gulf coast.

St. Mary Parish was one of the fortunate parishes that was not directly hit by Hurricane Katrina, which struck to the east, of Hurricane Rita, which passed west of the parish. Destructive storm surges spared St. Mary during Hurricane Katrina but hit the parish coastline as well as some inland areas through man-made canals during Hurricane Rita. The violent storm surged up to 15 feet as it moved towards the southern half of the parish, causing flooding in a localized area of the City of Franklin and in a widespread area of the parish south of U.S. Highway 90. Hurricane force winds of at least 75 mph from both Katrina and Rita also swept through St. Mary, causing wind damages.

**2008 Flood-** During the final days of August 2008, Hurricane Gustav entered the Gulf of Mexico. With an uncertain path and dire predictions, a state of emergency was declared on August 28 that included a mandatory evacuation of Terrebonne Parish. The parish was evacuated over a four day period. It was the largest and most successful evacuation in the region's history. Terrebonne Parish suffered a direct hit from the Category 2 hurricane at 10-30 a.m. on September 1st. Gustav was the largest hurricane to hit the parish since Hurricane Betsy in 1965. Maximum stage experienced in the area ranged from about 1.5 to 2.5 feet.

A little over a week after Hurricane Gustav made a direct hit, Hurricane Ike flooded the southern most areas of Terrebonne Parish. Hurricane Ike inundated 2,800 structures. High water marks were measured at 7.5 feet NAVD 29 near Highway 56 and 8.1 feet NAVD 29 just east of Highway 55. Terrebonne Parish constructed several non-federal levees that have performed well in prior storm events. However, the water from Hurricane Ike breached the Montegut Levee and overtopped the following levees- Madison Canal, 4-3B Pointe-aux-Chenes, 3-1A Susie Canal, 4-3C Isle De Jean Charles, 3-1B, 4-8 Montegut, 3-1B Extension Orange Street South, 5-1A Lower Little Caillou, 3-1C Shrimpers Row, 5-1B Upper Little Caillou, 3-2 Mayfield, 5-2 Boudreaux Canal, 4-1 Upper Pointe-aux-Chenes, 8-1 Lower Dularge, 4-2B Sara Road to Bush Canal, 8-2C Marmande North, 4-3A Middle Pointe-aux-Chenes, and 8-2D Falgout Canal North.

St. Mary parish was impacted by both Gustav and Ike. Surge values varied from 8-12 for Gustav and 4-5 feet for Ike. Lafourche Parish was hit with 100 mph winds and flooding was extensive south of Golden Meadow during Gustav.

**2011 Flood**- By noon on September 3, 2011, tropical storm Lee's center appeared to be headed ashore near Intracoastal City, about 100 miles west of Houma. Sustained winds were recorded at 60 mph, with gusts as high as 75 mph. The area was currently under a moderate drought until Lee dropped as much as 14 inches of rain in some areas. There were unconfirmed reports of flooded homes in the extreme low portions of Terrebonne parish, including Cocodrie, Isle de Jean Charles and Pointe-aux-Chenes.

Tidal surge peaked at about 6.5 feet above sea level at the Bayou Terrebonne floodgate in Montegut. This was the highest water level recorded in the parish. A normal tide is about 1.5 feet above sea level so the storm produced as much as 5 feet of increased tide into some communities.

### 2.1.7 Sea Level Change

#### 2.1.7.1 Background

The Army Corps of Engineers has developed guidelines on how future sea level rise is to be incorporated into project engineering efforts. The guidance, detailed in Engineering Circular (EC) 1165-2-212, *Sea-Level Change Considerations for Civil Works Programs*, follows findings from the National Research Council's 1987 report.

***Sea level change can cause a number of impacts in coastal and estuarine zones, including changes in shoreline erosion, inundation or exposure of low-lying coastal areas, changes in storm and flood damages, shifts in extent and distribution of wetlands and other coastal habitats, changes to groundwater levels, and alterations to salinity intrusion into estuaries and groundwater systems.***

***EC 1165-2-212***

EC 1165-2-212 discusses three potential future sea level scenarios based on historic, intermediate, or high sea level rise rates. Relative sea level rise is a combination of eustatic sea level rise (i.e., global sea level rise due to polar ice cap melting) and subsidence (i.e., sinking of land). It is well known that relative sea level rise can vary considerably with eustatic sea level rise in southern Louisiana. The relative sea level rise scenarios for the Morganza project are based on both EC 1165-2-212 and EC 1165-2-211 (which was issued in July 2009 and replaced by EC 1165-2-212 in October 2011).

##### 2.1.7.1.1 Historical Gage Data

The lowest rate is calculated through use of historical stage gage data. In case of our analysis, the gage data was based on the Leeville, LA gage (Figure 3). Gage data was available for a total of 43 years starting in 1957 and ending in 1999. A Leeville gage data scatter plot is given in Figure 4 on a monthly time scale. The width of scatter at any month is roughly 1.5 feet with a few outliers spread throughout the plot. Applying a linear trend to the data gives a yearly sea level rate of increase of approximately 7 millimeters per year. This is a relative sea level rise rate since subsidence is included in the gage readings.

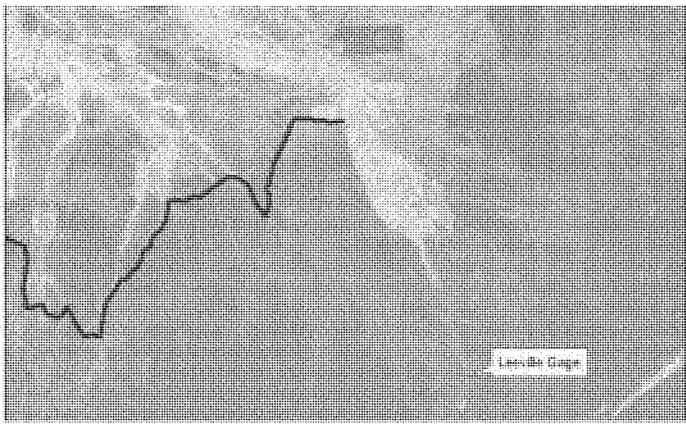


Figure 3 - Location of Leeville Stage Gage in reference to the MTG alignment

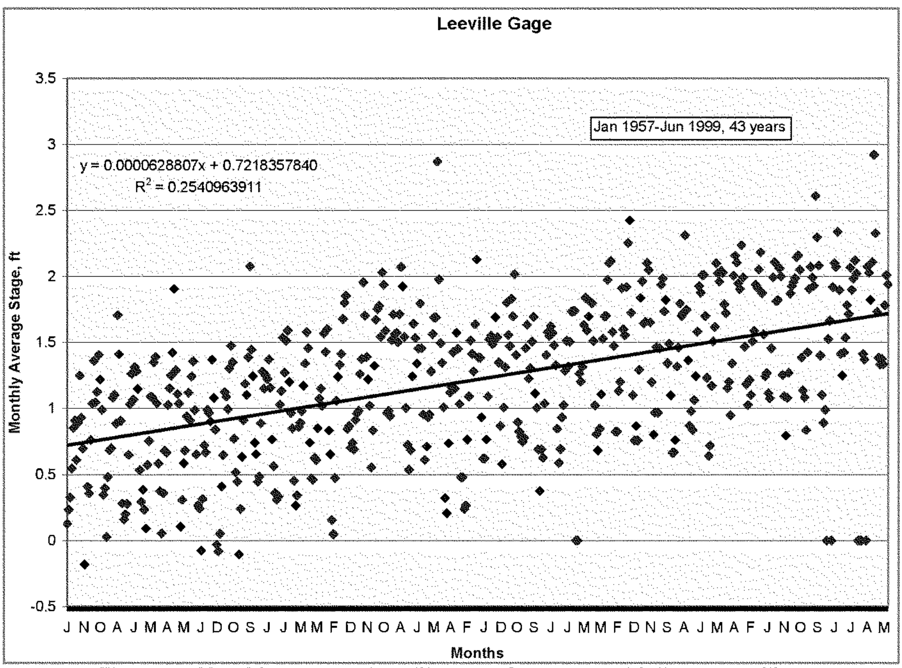



Figure 4 - Monthly Average Leeville gage data along with linear trendline

### 2.1.7.1.2 Estimating Future Change in Local Mean Sea Level

The EC discusses incorporation of accelerated global sea level rise scenarios. The two accelerated rates are given by NRC Curve I and NRC Curve III. A single equation is given in the EC to compute each of the projected rates of sea level rise. The equation units are meters.

$$E(t_2) - E(t_1) = 0.0017(t_2 - t_1) + b(t_2^2 - t_1^2),$$

where E corresponds to eustatic sea level rise, $t_1$ corresponds to the time between the project's construction date and year 1986, $t_2$ is the time between a future date at which one wants to estimate sea level rise and year 1986. The variable *b* is a coefficient dependent on the NRC Curve being followed. For Curve I and Curve III the values of *b* are 2.36E-5 and 1.005E-4, respectively. The value of 0.0017 in the equation corresponds to the historic global mean sea level change rate of 1.7 millimeters per year. Using the historic relative sea level rise of approximately 7 mm/year along with the equation given above, Figure 5 through Figure 7 give expected sea level rise values from year 2010 to 2085. The base year for completion of the MTG levee system is 2035. The future condition is year 2085.

Leeville gage 43 year period of record

| model year | | Historic trend | Historic trend | Subsidence rate Leeville historic rate mm/yr historic - 1.7 = | Subsidence rate | 0.5m @ 2100 NRC curve I acceleration factor: 0.00 | 1.5m @ 2100 NRC curve III acceleration factor: 0.00 |
|---|---|---|---|---|---|---|---|
| 2010 | | mm/yr 6.995 | | 5.295 | | new eustatic + subsidenc | |
| | year | mm | feet | mm | feet | feet | feet |
| MODEL | 2010 | 0 | 0.00 | 0 | 0.00 | 0.00 | 0.00 |
| | 2011 | 6.995 | 0.02 | 5.295 | 0.02 | 0.03 | 0.04 |
| | 2012 | 13.99 | 0.05 | 10.59 | 0.03 | 0.05 | 0.08 |
| | 2013 | 20.985 | 0.07 | 15.885 | 0.05 | 0.08 | 0.12 |
| | 2014 | 27.98 | 0.09 | 21.18 | 0.07 | 0.11 | 0.16 |
| | 2015 | 34.975 | 0.11 | 26.475 | 0.09 | 0.14 | 0.20 |
| | 2016 | 41.97 | 0.14 | 31.77 | 0.10 | 0.16 | 0.24 |
| | 2017 | 48.965 | 0.16 | 37.065 | 0.12 | 0.19 | 0.29 |
| | 2018 | 55.96 | 0.18 | 42.36 | 0.14 | 0.22 | 0.33 |
| | 2019 | 62.955 | 0.21 | 47.655 | 0.16 | 0.25 | 0.38 |
| | 2020 | 69.95 | 0.23 | 52.95 | 0.17 | 0.27 | 0.42 |
| | 2021 | 76.945 | 0.25 | 58.245 | 0.19 | 0.30 | 0.47 |
| | 2022 | 83.94 | 0.28 | 63.54 | 0.21 | 0.33 | 0.51 |
| | 2023 | 90.935 | 0.30 | 68.835 | 0.23 | 0.36 | 0.56 |
| | 2024 | 97.93 | 0.32 | 74.13 | 0.24 | 0.39 | 0.61 |
| | 2025 | 104.925 | 0.34 | 79.425 | 0.26 | 0.42 | 0.66 |
| | 2026 | 111.92 | 0.37 | 84.72 | 0.28 | 0.45 | 0.70 |
| | 2027 | 118.915 | 0.39 | 90.015 | 0.30 | 0.48 | 0.75 |
| | 2028 | 125.91 | 0.41 | 95.31 | 0.31 | 0.51 | 0.80 |
| | 2029 | 132.905 | 0.44 | 100.605 | 0.33 | 0.53 | 0.86 |
| | 2030 | 139.9 | 0.46 | 105.9 | 0.35 | 0.56 | 0.91 |
| | 2031 | 146.895 | 0.48 | 111.195 | 0.36 | 0.59 | 0.96 |
| | 2032 | 153.89 | 0.50 | 116.49 | 0.38 | 0.62 | 1.01 |

**Figure 5- Part (1) of sea level rise computations by year. Historic (yellow), Intermediate (teal), and High (blue) rates are computed**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 2033 | 160.885 | 0.53 | 121.785 | 0.40 | 0.65 | 1.07 |
| | 2034 | 167.88 | 0.55 | 127.08 | 0.42 | 0.68 | 1.12 |
| BASE | 2035 | 174.875 | 0.57 | 132.375 | 0.43 | 0.72 | 1.18 |
| | 2036 | 181.87 | 0.60 | 137.67 | 0.45 | 0.75 | 1.23 |
| | 2037 | 188.865 | 0.62 | 142.965 | 0.47 | 0.78 | 1.29 |
| | 2038 | 195.86 | 0.64 | 148.26 | 0.49 | 0.81 | 1.34 |
| | 2039 | 202.855 | 0.67 | 153.555 | 0.50 | 0.84 | 1.40 |
| | 2040 | 209.85 | 0.69 | 158.85 | 0.52 | 0.87 | 1.46 |
| | 2041 | 216.845 | 0.71 | 164.145 | 0.54 | 0.90 | 1.52 |
| | 2042 | 223.84 | 0.73 | 169.44 | 0.56 | 0.93 | 1.58 |
| | 2043 | 230.835 | 0.76 | 174.735 | 0.57 | 0.96 | 1.64 |
| | 2044 | 237.83 | 0.78 | 180.03 | 0.59 | 1.00 | 1.70 |
| | 2045 | 244.825 | 0.80 | 185.325 | 0.61 | 1.03 | 1.76 |
| | 2046 | 251.82 | 0.83 | 190.62 | 0.63 | 1.06 | 1.82 |
| | 2047 | 258.815 | 0.85 | 195.915 | 0.64 | 1.09 | 1.89 |
| | 2048 | 265.81 | 0.87 | 201.21 | 0.66 | 1.13 | 1.95 |
| | 2049 | 272.805 | 0.90 | 206.505 | 0.68 | 1.16 | 2.01 |
| | 2050 | 279.8 | 0.92 | 211.8 | 0.69 | 1.19 | 2.08 |
| | 2051 | 286.795 | 0.94 | 217.095 | 0.71 | 1.22 | 2.14 |
| | 2053 | 293.79 | 0.96 | 222.39 | 0.73 | 1.27 | 2.26 |
| | 2054 | 300.785 | 0.99 | 227.685 | 0.75 | 1.31 | 2.33 |
| | 2055 | 307.78 | 1.01 | 232.98 | 0.76 | 1.34 | 2.40 |
| | 2056 | 314.775 | 1.03 | 238.275 | 0.78 | 1.37 | 2.46 |
| | 2057 | 321.77 | 1.06 | 243.57 | 0.80 | 1.41 | 2.53 |
| | 2058 | 328.765 | 1.08 | 248.865 | 0.82 | 1.44 | 2.60 |
| | 2059 | 335.76 | 1.10 | 254.16 | 0.83 | 1.48 | 2.67 |
| MODEL | 2060 | 342.755 | 1.12 | 259.455 | 0.85 | 1.51 | 2.75 |
| | 2061 | 349.75 | 1.15 | 264.75 | 0.87 | 1.54 | 2.82 |
| | 2062 | 356.745 | 1.17 | 270.045 | 0.89 | 1.58 | 2.89 |
| | 2063 | 363.74 | 1.19 | 275.34 | 0.90 | 1.61 | 2.96 |
| | 2064 | 370.735 | 1.22 | 280.635 | 0.92 | 1.65 | 3.04 |
| | 2065 | 377.73 | 1.24 | 285.93 | 0.94 | 1.68 | 3.11 |
| | 2066 | 384.725 | 1.26 | 291.225 | 0.96 | 1.72 | 3.19 |
| | 2067 | 391.72 | 1.29 | 296.52 | 0.97 | 1.75 | 3.26 |
| | 2068 | 398.715 | 1.31 | 301.815 | 0.99 | 1.79 | 3.34 |
| | 2069 | 405.71 | 1.33 | 307.11 | 1.01 | 1.83 | 3.42 |
| | 2070 | 412.705 | 1.35 | 312.405 | 1.02 | 1.86 | 3.50 |
| | 2071 | 419.7 | 1.38 | 317.7 | 1.04 | 1.90 | 3.57 |

**Figure 6 - Part (2) of sea level rise computations by year. Historic (yellow), Intermediate (teal), and High (blue) rates are computed**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 2072 | 426.695 | 1.40 | 322.995 | 1.06 | 1.93 | 3.65 |
| | 2073 | 433.69 | 1.42 | 328.29 | 1.08 | 1.97 | 3.73 |
| | 2074 | 440.685 | 1.45 | 333.585 | 1.09 | 2.01 | 3.81 |
| | 2075 | 447.68 | 1.47 | 338.88 | 1.11 | 2.04 | 3.90 |
| | 2076 | 454.675 | 1.49 | 344.175 | 1.13 | 2.08 | 3.98 |
| | 2077 | 461.67 | 1.51 | 349.47 | 1.15 | 2.12 | 4.06 |
| | 2078 | 468.665 | 1.54 | 354.765 | 1.16 | 2.15 | 4.14 |
| | 2079 | 475.66 | 1.56 | 360.06 | 1.18 | 2.19 | 4.23 |
| | 2080 | 482.655 | 1.58 | 365.355 | 1.20 | 2.23 | 4.31 |
| | 2081 | 489.65 | 1.61 | 370.65 | 1.22 | 2.27 | 4.40 |
| | 2082 | 496.645 | 1.63 | 375.945 | 1.23 | 2.30 | 4.48 |
| | 2083 | 503.64 | 1.65 | 381.24 | 1.25 | 2.34 | 4.57 |
| | 2084 | 510.635 | 1.68 | 386.535 | 1.27 | 2.38 | 4.66 |
| FUTURE | 2085 | 517.63 | 1.70 | 391.83 | 1.29 | 2.42 | 4.75 |

**Figure 7 - Part (3) of sea level rise computations by year. Historic (yellow), Intermediate (teal), and High (blue) rates are computed**

From the above information, the base and future condition associated sea level rise values are 0.72 feet and 2.42 feet, respectively, for the intermediate rate of rise and 1.18 feet and 4.75 feet, respectively, for the high rate of rise.

### 2.1.7.2 Project Model Rates

Before incorporating the findings of EC-1165-2-211 and EC-1165-2-212 into the project, a few sea level rise scenarios had already been modeled according to the work of Kevin Knuuti used in Louisiana Coastal Protection and Restoration (LACPR). Knuuti's work is based on Intergovernmental Panel on Climate Change Fourth Assessment Report published in 2007. Table 7 provides modeled rates of sea level rise in the last column which were done prior to the EC publication. The high rate of sea level rise (3.2 ft) was for a condition 50 years from year 2010 which would have been year 2060.

Table 8 summarizes all modeled rates as well as the latest rates established through the EC. Note inclusion of the old future condition of 2060 along with the updated new base and future condition. Rate 1 and rate 2 correspond to intermediate and high rates, respectively.

**Table 7 - Breakdown of eustatic and subsidence rates used to compute historic and high rates of sea level rise modeled**

| | Eustatic Sea Level Rise - ft per 50 years | Source | Subsidence - ft per 50 years | Source | Total - ft per 50 years |
|---|---|---|---|---|---|
| MTG Scenario 1 (historic) | 0.66 | ERDC Knuuti | 0.5 | MVN Geology for project area | 1.15 |
| MTG Scenario 2 (high rate) | 2.0 | ERDC Knuuti | 1.2 | ERDC Knuuti | 3.2 |

**Table 8 - Summary of all sea level rise rates established for the project.**

| Morganza to Gulf SLR Rates (ft) Relative to Year 2010 (existing) | | | | | | |
|---|---|---|---|---|---|---|
| | | | | Modeled | | |
| Year | Historic | Rate 1 | Rate 2 | Low | High 1 | High 2 |
| 2035 | 0.57 | 0.72 | 1.18 | | | |
| 2060 | 1.12 | 1.51 | 2.75 | | 1.15 | 3.2 |
| 2085 | 1.70 | 2.42 | 4.75 | | | 5.0 |

Note: The old future condition year (2060) is also included.

## 2.2 WATERSHED CHARACTERISTICS

### 2.2.1 Basin Delineation

The project area is located south of Houma, LA near the southern coast of Louisiana. The study area includes portions of Terrebonne and Lafourche Parishes and consists primarily of waterways, lakes, and marsh areas. The primary inflows to the system are the Atchafalaya River and the Wax Lake Outlet with lesser inflows from Bayou Lafourche, the Gulf Intracoastal Waterway (GIWW), Bayou Boeuf, and additional drainage channels. The tidal signal for the area is from the Gulf of Mexico, which makes it a diurnal, micro-tidal system (~ 2 ft spring tide range).

The total drainage area within the study area is about 1891 square miles (mi$^2$). The area east of Louisiana State Highway 311 drains predominately from north to south, while the area west of the highway drains predominately from east to west. There are several watercourses within the study area. Many of the watercourses are interconnected and have extremely low grade, resulting in a complex drainage system. The major watercourses in the study area include the Gulf Intercoastal Waterway (GIWW), Bayou Terrebonne, Bayou Lafourche, Bayou Black, Bayou Petit Caillou, Houma Navigation Canal (HNC), Bayou Grand Caillou, and Bayou Dularge. The overland elevation within the study area ranges from 0 to 14 ft North American Vertical Datum (NAVD) 1988 (epoch 2004.65). Specific subbasin information can be found in Section 2.6.2.5.2 of this report.

## 2.3 ADCIRC AND STWAVE MODELING

### 2.3.1 Background

Numerical models were used to simulate surge and wave response in the project area. This section will give a brief summary of the hydrodynamic models used for hurricane simulation and how the modeling effort relates to the project. Statistical probabilities will be discussed in the modeling section as well as several other sections of the report. Table 9 provides main Annual Exceedance Probabilities (AEP) discussed in this report as well as each corresponding return period.

**Table 9 - Relation of common frequencies with return periods**

| | Frequency with Corresponding Return Period | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Frequency (%) | 50 | 20 | 10 | 4 | 2.86 | 2 | 1.3 | 1 | 0.5 | 0.2 |
| Return (yrs) | 2 | 5 | 10 | 25 | 35 | 50 | 75 | 100 | 200 | 500 |

Hydrodynamic models were needed to define statistical probabilities for specified locations over the project area. Storm surge and wave statistics are normally developed through use of 304 synthetic hurricane storms where each storm is defined by a track and parameters (forward speed, size, orientation to coast, etc.). The need for such a large number of synthetic storms is in part due to a lack of historical hurricanes hitting the gulf coast region. A total of 304 storms are used to fully cover the range of statistical probabilities needed. In some cases a subset of the 304 storms can be used to define statistical probabilities for a project if the storms not used are determined to be of no statistical significance. In other words, if a given statistical surge probability value established for a given point in the project area is equal to the same value whether running a subset of storms or the full set of storms then storms outside of the subset are defined as statistically insignificant. Subsets are mainly selected through comparing storm tracks with project location. Storm tracks far away from the project area are less likely to have a significant effect on the model results. In regards to the MTG project, analyses indicate that only 115 storms of the 304 would be statistically significant to the project area. Only 115 storms were simulated for the project. The subset of storms was created by experts at the Army Corps Engineer Research and Development Center (ERDC).

Various models were used to simulate ocean circulation, offshore waves, near-shore waves, and inland surge. Ocean circulation was modeled with the planetary boundary layer model (PBL). The model generates a time series of wind and pressure fields for each specific storm and reads directly to ADCIRC. The surge model, ADCIRC, develops offshore surge based on these wind and pressure fields. The surge model ADCIRC is a two dimensional finite-element model that runs on a large unstructured grid domain (Luettich et al. 1992, Westerink et al. 1993, Luettich and Westerink 2004). The grid covers the entire Gulf of Mexico as well as much of the Atlantic Ocean. The advantage of an unstructured grid is that it allows for higher resolution at user defined locations instead of having to increase resolution throughout the entire grid. The grid resolution ranged from meters around the project area to tens of kilometers in the Atlantic Ocean. Running in parallel with ADCIRC is the offshore wave model (WAM). The wave model computes directional wave spectra that will be further used by the near shore wave model STWAVE. The near shore wave model computes wave fields and radiation stresses that are read back into ADCIRC. The wave model STWAVE is a steady state model able to compute wave heights and periods based on, among other forces, a given surge field. There are 5 rectangular grids associated with STWAVE where all grids combined cover the entire Louisiana Gulf of Mexico coastline. Sensitivity analysis indicated STWAVE half-plane mode was sufficient to solve for the wave components. Both ADCIRC and STWAVE were run in a "coupled" fashion to solve for still water elevation (SWE) and wave characteristics.

### 2.3.2 ERDC Studies

ERDC was tasked with performing all modeling efforts for the project. Each of the project alternatives were modeled on the 2007 ADCIRC mesh sl15v6f containing approximately 2.2 million nodes. Modifications were made to this main mesh depending on whether with or without project conditions were being modeled. For without project conditions, no project levees were included in the model except for high ground that already existed in the area. The main sl15v6f mesh already included raised features of significance. The Larose to Golden Meadow levee was not considered in place for MTG without project conditions, however existing high ground along the Larose to Golden Meadow alignment was in the mesh since it already existed (Figure 8). For with-project conditions, the MTG authorized alignment was applied to the grid. Full levee boundaries associated with the Larose to Golden Meadow project were also included. Both the height of MTG and Larose levees were set to non-overtop (i.e., 20 meters high) (Figure 9). Another with-project alignment termed the multiple lines of defense alignment was modeled but was not considered a viable alternative after a short review. All raised features in the without project mesh were also included in the with-project mesh. Both mesh figures shown below have been filtered to a smaller set of points so as to have increased clarity of elevation values. In regards to STWAVE, all five rectangular grids were used (Cialone et al., 2010). The ADCIRC model does contain the Barrier Alignment, but is modeled as non-overtopping.

For all 115 synthetic storms the resulting surge and wave simulation results are available at every node on the grid. A small set of points from the entire nodal mesh were used to represent the model results. The subset of points surrounded the project area. A total of 320 points defined as the MTG points were specified by the USACE New Orleans District (MVN). A map of the points is shown in Figure 10. Statistical frequencies ranging from 0.2% to 2.0% chance exceedance were developed at each of these MTG points. Each of the 115 storms produced a maximum SWE, significant wave height (Hs), and mean wave period (Tm). The statistical analysis used each of the maximum values at a given location to produce event frequencies. Given some points will be "submerged" more times than others over the suite of storms a threshold was set for the number of times (i.e., storms) a point must be submerged in order to calculate a frequency at that location. The methodology used to develop the probability is termed joint probability method with optimum sampling. Refer to Resio (2007) for a more in-depth look at the methodology used to develop statistical probabilities of synthetic storms.

**Figure 8 - Without Project raised features in mesh around project area. Elevations are in meters**

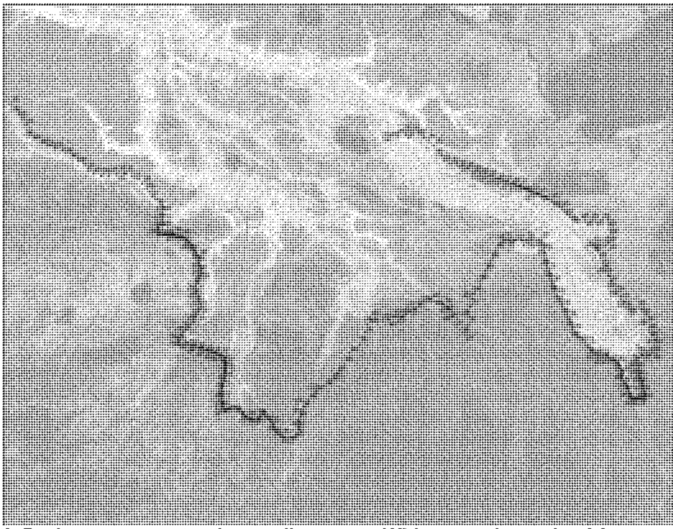


**Figure 9 - With Project non-overtop levee alignment. Without project raised features are included in the with-project mesh. Elevations are in meters**

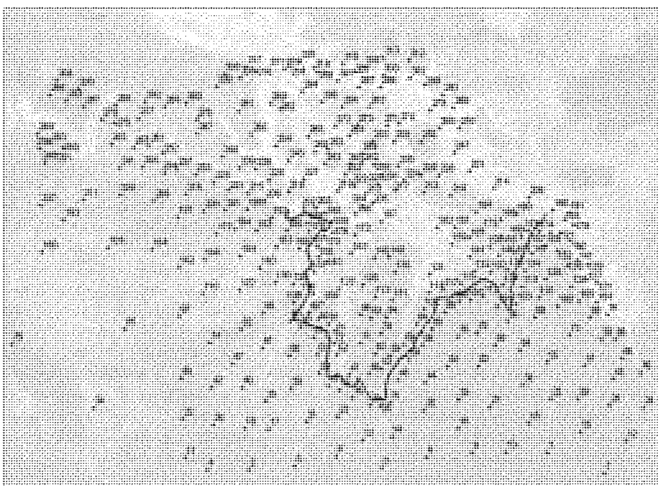


**Figure 10 - Map of 320 Morganza nodal points used in the design effort along with the approximate alignment of the MTG Alignment**

As of spring of 2009, ERDC had completed all modeling alternatives under the original base and future year conditions. The alternatives modeled along with corresponding sea level rise (SLR) values are as follows-

Without Project
Base 2010 - No SLR (full suite 115 storms)
Future 2060 - 1.15 feet SLR (full suite 115 storms)
Future 2060 - 3.2 feet SLR (sensitivity analysis 12 storms)

With-Project - Authorized Alignment
Future 2060 - 1.15 feet SLR (full suite 115 storms)
Future 2060 - 3.2 feet SLR ( sensitivity analysis 12 storms)

The 1.15 and 3.2 feet SLR values are intermediate and high approximations for year 2060. When the word "rate" is mentioned in this report it refers to the summation of rise from the current year to the given year. For example, 1.15 feet of rise would be the total rise from year 2010 to year 2060. The 3.2 feet SLR data are a result of a sensitivity analysis done ERDC. The analysis was completed to avoid having to run all 115 storms. Only the above mentioned sea level rise conditions were modeled since 2010 and 2060 were at the time considered base and future conditions, respectively. Also note the future condition rate of 3.2 ft will not be found in Figure 4. Discussion in section 2.1.8.2 notes the value was established through the work of Kevin Knuuti. This was completed before the SLR circular was published.

In July of 2009 SLR Engineering Circular 1165-2-211 was released to the New Orleans District. The SLR circular called for three rates of SLR to be incorporated into all future condition planning formulation and engineering designs. The three rates of SLR were defined as a historical rate, an intermediate rate, and a high rate. The intermediate and high rates of SLR were computed through equations defined in the circular. Since release of the circular and modification of base and future years to 2035 and 2085, three new rates of SLR have been established. The historic rates of SLR were established through a 43 year period of record from the Leesville gage in the MTG project area. All rates include eustatic SLR as well as localized subsidence.
Table 8 provides the new base and future conditions, the SLR rates established under the new conditions, as well as the SLR rates modeled under the old future condition year.

With the modeled SLR rates shown in the table above all historic, intermediate, and high SLR data could be interpolated. Any data corresponding to a SLR rate below 1.15 feet would use existing condition as well as 1.15 feet data to interpolate. The 4.75 feet SLR condition could not be interpolated since the 3.2 feet SLR condition was the highest scenario run. To establish the 4.75 feet statistical results ERDC ran one more set of 115 storms for with and without project conditions at a SLR of 5 feet. The model was run with a slightly higher SLR to account for any possible changes to project SLR rates in the future. This completed the modeling simulations for the project. ERDC's final report contains a more detailed description of the entire modeling efforts and can be furnished upon request. Also the future condition sensitivity analysis report used to define the 3.2 feet SLR results can be furnished upon request.

## 2.4 RISK AND RELIABILITY ANALYSIS

The MTG Hurricane and Storm Damage Risk Reduction project is the first coastal project in Louisiana to incorporate a risk-based analysis for a double levee system containing both local levees and a future project levees. The purpose of this work is to analyze the performance of these two levee systems individually and together as a double levee system, against the influence of storm surge, wave overtopping and rainfall.

A risk based approach is required for all flood risk reduction studies by Engineering Regulation., ER 1105-2-101, Paragraph 7.a

> ***"All flood risk management studies will adopt risk analysis as described herein. The risk analysis approach and results shall be documented in the principal decision document used for recommending authorization and/or construction."***

Uncertainty and variability are intrinsic and important in water resources planning and design. Risk and uncertainty arise from measurement errors and from the underlying variability of complex natural, social, and economic situations. If the analyst is uncertain because the data are imperfect or the analytical tools crude, the plan is subject to measurement errors. The MTG project covers an extremely large area, with a wide variety of coastal and inland hydraulic and hydrologic data. Much of this data has to be adjusted to account large changes for sea level rise in this coastal region.

If the randomness of the data can be described by some probability distribution, based on a historical data base that is applicable to the future, then distributions can be described or approximated by objective techniques. If there is no such historical data base, the probability distribution of random future events can be described subjectively, based upon the best available insight and judgment. The degree of risk and uncertainty generally differs among various aspects of a project.

Reliability analysis is that part of the risk study that leads to an evaluation of the conditional probability of failure (i.e., reliability) of the levee systems and components when they are exposed to the loads of a hurricane. The reliability analysis for MTG had three steps-

1. Specify the components constituting the local levee system and the future project levee system.
2. Define the failure modes of each levee reach.
3. Assign conditional probabilities to the failure states for given water elevations caused by hurricane conditions.

### 2.4.1 Objective

The purpose of the hydraulic analysis for this project was to do a preliminary investigation to determine potential methods of protecting the study area from damaging storm surges resulting from tropical events. Objectives for this project were identified as follows-

- Evaluate the existing condition, which only considers the local levee performance against various storm surges, resulting from tropical events.

- Evaluate the various project conditions, which consider two project levee heights for three different future year conditions as a result of the estimate relative sea level rise.

The existing condition model simulations for this project were called the 2010 run. The three future year project conditions are the base year 2035 run, which is when construction of the project levee system will be complete to 2035 design elevations, the 2085 run, which is the year when the project is 50 years old, and finally the 2024 run, which is a year in the middle of project construction. At the year 2024 the partially built levee is considered to provide at least some risk reduction to the study area thus generating a benefit before project completion. The basic difference in these project conditions are the change in estimated future sea level rise, which becomes an important factor in coastal areas such as this.

The project levee alternatives, as stated above, have included the performance of the local levees in addition to the project levees. The combination of the two levee systems makes the stage-damage computations for this study very complex. The process of developing frequency curves from the modeling results and applying these frequency curves to the economic analysis became an iterative process with multiple flood damage model run results needing to be combined to provide a true assessment of the damages in the study area. The local and project levees were represented in the economic analysis by fragility curves.

### 2.4.2 Reliability Analysis

The purpose of this risk and reliability analysis was to determine the reliability of the existing local levees in the study area. A reliability analysis was to give credit to the local levees by determining the probability of failure of the existing levees as a function of the floodwater elevation. The USACE Engineer Technical Letter(ETL) 1110-2-556, *Risk-Based Analysis on Geotechnical Engineering for Support of Planning Studies*, dated 28 May 1999 (Reference 2), was used as guidance. This guidance expired on 30 June 2004 and was rescinded on 4 MAR 2009. The “credit to existing levees” analysis was after the ETL was rescinded. No other guidance that has replaced this ETL; consequently, it is still the most appropriate document to use as guidance.

The reliability criteria that were considered for the analysis were elevation, geotechnical conditions, history of levee performance, and water elevations. The analysis was conducted using engineering judgment based on available data. Levee stability analysis was performed by district geotechnical engineers. Probabilities of failure were assigned to various water elevations, below the top of the levee, based on the factors of safety determined in the stability analysis. A levee failure methodology was devised by hydraulic engineers to determine when given water elevations would cause levees to fail by overtopping. This resulted in fragility curves for each reach by mode of failure.

#### 2.4.2.1 Levee Breach Methodology

In order to assess the performance of the local levees, a worst case combination (highest stage, lowest levee elevation, worst material composition) was used to construct fragility curves for the non-uniform local levee system. This was not a localized worst case location but a representative worst case reach of levee (lowest and weakest as compared to other reaches) that will also experience the maximum loading on the system. This was developed for all local levees in the study area on a reach-by-reach basis. The reaches distinguish changes in the geometry and/or soil-makeup of the levees.

The levee failures were associated with two principal failure modes-

(1) Levee or levee foundation failure.
(2) Levee erosion caused by overtopping.

This approach represents a simplified analysis to yield generic conditional probability of failure vs. water surface elevation with respect to top of levee. The fragility curves reflect a qualitative evaluation of the major geotechnical aspects of levee integrity.

#### 2.4.2.2 Local Levees

##### 2.4.2.2.1 Local Levee Descriptions

The MTG hurricane and storm surge reduction project study area has existing local levees that are protecting areas of their communities from tidal influences from the Gulf of Mexico. These levees have been designed and constructed by the communities and are not a part of the Corps' federal or non-federal levee programs. An evaluation is necessary to determine the reliability of the existing levees as required by Policy Guidance Letter No. 26, *Benefit Determination Involving Existing Levees*, dated 23 December 1991 (Reference 1).

The local levees constructed by the communities in the study area vary in elevations, compositions, top width, and side slopes and are scattered throughout the study area. There was little or no levee design documentation available for all the local levees, therefore geometric and engineering material properties of the local levees were determined from aerial photographs, GIS overlays, available geotechnical data, extensive interviews with levee district personnel, and best engineering judgment. A table of local levees and the elevations of the top of levee is shown in Table 12.

#### 2.4.2.2.2 Stability Analysis

Stability analysis was performed on the local levees based on the information gather as described in the previous paragraph. This analysis was performed by Geotechnical Engineers and is described in detail in the Geotechnical section of this report. The results the stability analysis revealed that the local levee systems probability of failure due to stability or under seepage was relatively low for still water elevations reaching to the top of the levee.

#### 2.4.2.2.3 Surface Erosion

The purpose of the performance mode "surface erosion" is to assess the potential for the local levee to be eroded by the wave action and potential free flow. The overtopping rate at which the local levees (1) begin to erode, and (2) will experience catastrophic failure will be calculated. The height of water that equates to the overtopping rate will then be determined. The ETL 1110-2-556 (Reference 2) outlines a procedure to estimate the probability of failure due to erosion. This procedure was followed for the "credit to existing levee" analysis.

##### 2.4.2.2.3.1 Erosion Analysis

The minimum average system elevation is 3ft for Levees 1-5 and 11BW11, and a maximum of 10ft for Levee EAST RIDGES - Reach J1. Levee slopes ranged from 1-10 to 1-3.

The overtopping rate at which the levee begins to erode is estimated to be 0.10 cfs/ft. The basis for defining 0.1 cfs/ft as the start of levee erosion is per HSDRRS guidelines. Erosion is expected beyond the 0.1 cfs/ft 90% non-exceedance value associated with levee design. The value at which catastrophic failure of the levee will occur is estimated to be 2.0 cfs/ft.

The corresponding surge to the overtopping rates of 0.10 and 1.00 cfs/ft were calculated via the Van der Meer Equation (EQ 1 and EQ2). As a sensitivity analysis, the surge at overtopping rate 1.50 cfs/ft was also taken and can be found in Table 11. The difference in surge between overtopping rate of 1.00 cfs/ft and 1.50 cfs/ft was usually less than 0.5ft.

**MORGANZA TO THE GULF OF MEXICO, LOUISIANA PAC
ENGINEERING APPENDIX**

EQ 1- $$\frac{q}{\sqrt{gH_{mo}^{3}}} = \frac{0.067}{\sqrt{\tan\alpha}}\gamma_b\xi_0 \exp\left(-4.3\frac{h_k}{H_{mo}}\frac{1}{\xi_0\gamma_b\gamma_f\gamma_\beta\gamma_v}\right)$$

With a maximum-

EQ 2- $$\frac{q}{\sqrt{gH_{mo}^{3}}} = 0.2\exp\left(-2.3\frac{h_k}{H_{mo}}\frac{1}{\gamma_f\gamma_\beta}\right)$$

where

q - wave overtopping discharge
g - gravitational acceleration
$H_{m0}$ - significant wave height
$\xi_0$ - breaker parameter = $\tan\alpha / \sqrt{s_0}$
$s_0$ - wave steepness = $2\pi Hm0 / (gT^2_{m-1,0})$
$\tan\alpha$ - levee slope
$h_k$ - freeboard of levee above still water level
$\gamma$ - coefficients for berm (b), roughness (f), angle of incidence ($\beta$), vertical wall (v)

In order to determine the reliability of the local levees, historical data was used to investigate the levee performance during past flooding events where the levees experienced significant loading. The historical surge data was used in conjunction with reported levee damage and compared to the calculated surge that represents overtopping failure. If the storm surge known to cause damage was lower than the calculated surge for overtopping, then the calculated value was adjusted down to the observed value to determine the final adjusted critical surge value. The critical surge values calculated using the Van der Meer overtopping equation were always greater than the surge observed during the storms. In the past four years these levees have experienced significant loading due to two hurricanes that both occurred in 2008. Hurricanes Gustav (August 2008) and Ike (September 2008) produced storm surge elevations that reached the local levee alignment in this study area. The hurricane modeling of these two storms which produced hindcast plots showing the stages produced against the local levees can be furnished upon request. The levees that failed during Ike were 5-1B, 8-1, and East Ridges North. In all other reaches the calculated critical surge level will be used.
Table **10** displays adjustments that were made on this principle.

**Table 10 - Adjustments made to calculated surge due to known levee failure**

| System | Name | Levee Elev. (ft.) | Calculated Surge for Overtop 1.0 (cfs/ft) | Ike Observed Surge (ft) | Gustav Observed Surge (ft) | Adjusted Value (ft) |
|---|---|---|---|---|---|---|
| 13 | EAST RIDGES-North/Montegut | 7 | 7.24 | 5.00 | 3.20 | 5.00 |
| 14 | 8-1S | 4 | 4.39 | 5.70 | 4.10 | 4.39 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 15 | 5-1B | 6 | 6.41 | 5.70 | 0.00 | 5.70 |

2.4.2.2.3.2 **Overtopping Rates**

The surge found with an overtopping rate 0.10 cfs/ft ranged between 3.87 and 9.27ft. The surge found with an overtopping rate 1.00 cfs/ft ranged between 4.39 and 9.98ft. The surge found with an overtopping rate 1.50 cfs/ft ranged between 4.57 and 10.61ft. Results for all levees can be found in Table 11.

**Table 11 - Erosion failure heights for local levees**

| | | | | | | Surge (ft) for Overtopping of- | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| System | Name | Min System Elv (ft) | Levee Slope | Crown Width (ft) | Material | Surge for 0.1 (cfs/ft) | Assoc. 0.1 Wave Height (ft) | Surge for 1.0 (cfs/ft) | Assoc. 1.0 Wave Height (ft) | Surge for 1.5 (cfs/ft) | Assoc. 1.5 Wave Height (ft) |
| 0 | BGC4 and HNC8 | - | - | - | - | - | - | - | - | - | - |
| 1 | MARSH - CENTRAL | - | - | - | - | - | - | - | - | - | - |
| 2 | BT5 | - | - | - | - | - | - | - | - | - | - |
| 3 | MARSH - EAST | - | - | - | - | - | - | - | - | - | - |
| 4 | HOUMA - SOUTHEAST | - | - | - | - | - | - | - | - | - | - |
| 5 | MARSH - SOUTHWEST | - | - | - | - | - | - | - | - | - | - |
| 6 | HNC0 | - | - | - | - | - | - | - | - | - | - |
| 7 | NORTH - EAST | - | - | - | - | - | - | - | - | - | - |
| 8 | LBB5 | - | - | - | - | - | - | - | - | - | - |
| 9 | BL89 | 5 | 0.33 | 8 - 10 | sidecast | 4.80 | 1.47 | 5.37 | 1.65 | 5.54 | 1.70 |
| 10 | TRS PROJECT | - | - | - | - | - | - | - | - | - | - |
| 11 | BL1-BL7 | - | - | - | - | - | - | - | - | - | - |
| 12 | UNDEVELOPED - NORTHWEST | - | - | - | - | - | - | - | - | - | - |
| 13 | EAST RIDGES - Reach J1 | 10 | 0.10 | 50 | MVN P&S | 9.27 | 2.85 | 9.98 | 3.06 | 10.61 | 3.26 |
| 13 | EAST RIDGES - Reach J3 | 6 | 0.33 | 8-10 | sidecast | 5.74 | 1.76 | 6.41 | 1.97 | 6.67 | 2.05 |

**MORGANZA TO THE GULF OF MEXICO, LOUISIANA PAC**
**ENGINEERING APPENDIX**

| | | | | | | Surge (ft) for Overtopping of- | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| System | Name | Min System Elv (ft) | Levee Slope | Crown Width (ft) | Material | Surge for 0.1 (cfs/ft) | Assoc. 0.1 Wave Height (ft) | Surge for 1.0 (cfs/ft) | Assoc. 1.0 Wave Height (ft) | Surge for 1.5 (cfs/ft) | Assoc. 1.5 Wave Height (ft) |
| 13 | EAST RIDGES-North/Montegut | 7 | 0.33 | 10-12 | sidecast | 5.00* | 2.05 | 5.00* | 2.22 | 7.54 | 2.31 |
| 14 | 8-1S | 4 | 0.20 | 8 - 10 | sidecast | 3.87 | 1.19 | 4.39 | 1.35 | 4.57 | 1.40 |
| 15 | PETITE CALLOU | 6 | 0.25 | 10 - 12 | - | 5.74 | 1.76 | 6.41 | 1.97 | 6.54 | 2.01 |
| | 5-1A | 6 | 0.25 | 10 - 12 | Spec for 5-1A/5-1B | 5.74 | 1.76 | 6.41 | 1.97 | 6.54 | 2.01 |
| | 5-1B | 6 | 0.25 | 10 - 12 | Spec for 5-1A / 5-1B | 5.70* | 1.76 | 5.70* | 1.97 | 6.54 | 2.01 |
| 16 | 3-1C | 6 | 0.33 | 8-10 | sidecast | 5.74 | 1.76 | 6.41 | 1.97 | 6.67 | 2.05 |
| 17 | 3-1B | 9.5 | 0.33 | 10 | MVN P&S | 8.81 | 2.70 | 9.63 | 2.95 | 9.98 | 3.06 |
| 18 | 8-2C | 6 | 0.33 | 8-10 | sidecast | 5.74 | 1.76 | 6.41 | 1.97 | 6.67 | 2.05 |
| 18 | 8-2D | 6 | 0.33 | 8-10 | sidecast | 5.74 | 1.76 | 6.41 | 1.97 | 6.67 | 2.05 |
| 19 | D-36 | 9.5 | 0.33 | 10 | MVN P&S | 8.81 | 2.70 | 9.63 | 2.95 | 9.98 | 3.06 |
| 20 | RIDGE SOUTH (1) | - | - | - | - | - | - | - | - | - | - |
| 21 | RIDGE SOUTH (2) | - | - | - | - | - | - | - | - | - | - |
| 22 | SLB PROJECT | 6 | 0.33 | 8-10 | sidecast | 5.74 | 1.76 | 6.41 | 1.97 | 6.67 | 2.05 |
| | 11BE6-W | 6 | 0.33 | 8-10 | sidecast | 5.74 | 1.76 | 6.41 | 1.97 | 6.67 | 2.05 |
| | 11BW79 | 6 | 0.33 | 8-10 | sidecast | 5.74 | 1.76 | 6.41 | 1.97 | 6.67 | 2.05 |
| 23 | RIDGE WEST | - | - | - | - | - | - | - | - | - | - |

| | | | | | | Surge (ft) for Overtopping of- | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| System | Name | Min System Elv (ft) | Levee Slope | Crown Width (ft) | Material | Surge for 0.1 (cfs/ft) | Assoc. 0.1 Wave Height (ft) | Surge for 1.0 (cfs/ft) | Assoc. 1.0 Wave Height (ft) | Surge for 1.5 (cfs/ft) | Assoc. 1.5 Wave Height (ft) |
| | (2) | | | | | | | | | | |
| 24 | RIDGE WEST (1) | 4 | 0.33 | 8 | sidecast | 4.39 | 1.35 | 4.48 | 1.37 | 4.57 | 1.40 |
| 25 | D-30 and D-48 | 4 | 0.33 | 6-8 | sidecast | 4.39 | 1.35 | 4.48 | 1.37 | 4.57 | 1.40 |
| 25 | D-30 | 4 | 0.33 | 6-8 | sidecast | 4.39 | 1.35 | 4.48 | 1.37 | 4.57 | 1.40 |
| 25 | D-48 | 4 | 0.33 | 6-8 | sidecast | 4.39 | 1.35 | 4.48 | 1.37 | 4.57 | 1.40 |
| 26 | BPC5 | - | - | - | - | - | - | - | - | - | - |
| 27 | NWM - NORTH | 8 | 0.33 | 8 | sidecast | 7.54 | 2.31 | 8.18 | 2.51 | 8.44 | 2.59 |
| 28 | D-62 | 6 | 0.33 | 8-10 | sidecast | 5.74 | 1.76 | 6.41 | 1.97 | 6.67 | 2.05 |
| 29 | D-10 | 6 | 0.33 | 8-10 | sidecast | 5.74 | 1.76 | 6.41 | 1.97 | 6.67 | 2.05 |
| 30 | MARSH HNC 1 | - | - | - | - | - | - | - | - | - | - |

***Adjusted value due to observed failure during Hurricane Ike.**

### 2.4.2.2.4 Fragility Curves

The performance of the local levee system is defined in the FDA model through a fragility curve. A fragility curve gives the probability of levee failure associated with a given rate of overtopping. The primary mode of levee failure is erosion where the magnitude of erosive forces is dependent upon exterior water elevations. Fragility curves were based on four overtopping rates.

The stability analysis results along with the results from the erosion analysis were used to develop the fragility curves for the all the local levees. Since the stability analysis revealed that a stability analysis had a very low probably of occurring the major failure mode of the local levees would be due to erosion from wave overtopping. The water elevations associated with overtopping rates of 1 cubic feet per second per linear foot of levee were given a probability of failure of 95%. The water elevations associated with overtopping rates of 0.1 cfs/ft were given a probability of failure of 5%. These two points along with the low probabilities associated with the stability analysis were used to develop the fragility curves.

The reliability assessments that were performed for individual levee reaches resulted in fragility curves for each reach by mode of failure. The process of how the hydraulic results were used to develop the stage damage relationships, considering the reliability of the local levees is detailed in the next section of this report.

**Table 12 - Local levee heights and probability of failure water elevations**

| Economic Reach | HEC-FDA Index | System | Probability of Failure | | | | Top of Levee |
|---|---|---|---|---|---|---|---|
| | | | 0 | 0.1 | 0.45 | 0.95 | |
| **D-16S** | **379** | D-16S | 2 | 3 | 3.52 | 3.72 | 4 |
| **BL89** | **298** | BL89 | 2 | 3.8 | 4.4 | 4.65 | 5 |
| **D-01** | **367** | EAST RIDGES - Reach J1 | 2 | 7.5 | 8.8 | 9.3 | 10 |
| **PAC1** | **709** | EAST RIDGES - Reach J1 | 2 | 7.5 | 8.8 | 9.3 | 10 |
| **SL3** | **718** | EAST RIDGES - Reach J1 | 2 | 7.5 | 8.8 | 9.3 | 10 |
| **D-61** | **487** | EAST RIDGES - Reach J3 | 2 | 4.5 | 5.28 | 5.58 | 6 |
| **D-61-B** | **490** | EAST RIDGES - Reach J3 | 2 | 4.5 | 5.28 | 5.58 | 6 |
| **BT4-SA** | **334** | EAST RIDGES-North/Montegut | 2 | 5.3 | 6.16 | 6.51 | 7 |
| **4-1S** | **133** | EAST RIDGES-North/Montegut | 2 | 5.3 | 6.16 | 6.51 | 7 |
| **D-25** | **406** | EAST RIDGES-North/Montegut | 2 | 5.3 | 6.16 | 6.51 | 7 |
| **8-1N** | **166** | 8-1S/RIDGE WEST (1) | 2 | 3 | 3.52 | 3.72 | 4 |
| **8-1N-B** | **169** | 8-1S/RIDGE WEST (1) | 2 | 3 | 3.52 | 3.72 | 4 |
| **8-1S-B** | **175** | 8-1S/RIDGE WEST (1) | 2 | 3 | 3.52 | 3.72 | 4 |
| **BPC3** | **307** | PETITE CALLOU | 2 | 4.5 | 5.28 | 5.58 | 6 |
| **BPC4** | **310** | PETITE CALLOU | 2 | 4.5 | 5.28 | 5.58 | 6 |
| **4-2C** | **145** | PETITE CALLOU | 2 | 4.5 | 5.28 | 5.58 | 6 |
| **4-2B** | **142** | PETITE CALLOU | 2 | 4.5 | 5.28 | 5.58 | 6 |
| **4MGT** | **151** | PETITE CALLOU | 2 | 4.5 | 5.28 | 5.58 | 6 |
| **BT4** | **331** | PETITE CALLOU | 2 | 4.5 | 5.28 | 5.58 | 6 |
| **D-56** | **481** | PETITE CALLOU | 2 | 4.5 | 5.28 | 5.58 | 6 |
| **4-2A** | **139** | PETITE CALLOU | 2 | 4.5 | 5.28 | 5.58 | 6 |
| **LBC1** | **670** | LBC1 | 2 | 4.5 | 5.28 | 5.58 | 6 |
| **LBC2** | **673** | LBC2 | 2 | 4.5 | 5.28 | 5.58 | 6 |
| **5-1A** | **154** | 5-1A | 2 | 4.5 | 5.28 | 5.58 | 6 |
| **5-1B** | **157** | 5-1B | 2 | 4.5 | 5.28 | 5.58 | 6 |
| **3-1C** | **127** | 3-1C | 2 | 4.5 | 5.28 | 5.58 | 6 |
| **3-1B** | **124** | 3-1B | 2 | 7.1 | 8.36 | 8.835 | 9.5 |
| **8-2C** | **178** | 8-2C | 2 | 4.5 | 5.28 | 5.58 | 6 |

MORGANZA TO THE GULF OF MEXICO, LOUISIANA PAC
ENGINEERING APPENDIX

| Economic Reach | HEC-FDA Index | System | Probability of Failure | | | | Top of Levee |
|---|---|---|---|---|---|---|---|
| | | | 0 | 0.1 | 0.45 | 0.95 | |
| 8-2D | 181 | 8-2D | 2 | 4.5 | 5.28 | 5.58 | 6 |
| D-36 | 436 | D-36 | 2 | 7.1 | 8.36 | 8.835 | 9.5 |
| 11BE6-W | 25 | 11BE6-W | 2 | 4.5 | 5.28 | 5.58 | 6 |
| 11BW79 | 64 | 11BW79 | 2 | 4.5 | 5.28 | 5.58 | 6 |
| D-30 | 421 | D-30 | 2 | 3 | 3.52 | 3.72 | 4 |
| D-48 | 466 | D-48 | 2 | 3 | 3.52 | 3.72 | 4 |
| 9-1BMIDE | 196 | NWM - NORTH | 2 | 6 | 7.04 | 7.44 | 8 |
| 9-1AMID | 187 | NWM - NORTH | 2 | 6 | 7.04 | 7.44 | 8 |
| 9-1AE | 184 | NWM - NORTH | 2 | 6 | 7.04 | 7.44 | 8 |
| 9-1AW | 190 | NWM - NORTH | 2 | 6 | 7.04 | 7.44 | 8 |
| 9-1BMIDW | 199 | NWM - NORTH | 2 | 6 | 7.04 | 7.44 | 8 |
| 9-1BW | 202 | NWM - NORTH | 2 | 6 | 7.04 | 7.44 | 8 |
| D-62-B | 496 | D-62-B | 2 | 4.5 | 5.28 | 5.58 | 6 |
| D10 | 373 | D-10 | 2 | 4.5 | 5.28 | 5.58 | 6 |
| BL2 | 280 | BL2 | 2 | 4.5 | 5.28 | 5.58 | 6 |
| BL3 | 283 | BL3 | 2 | 4.5 | 5.28 | 5.58 | 6 |
| BL4 | 286 | BL4 | 2 | 3.8 | 4.4 | 4.65 | 5 |
| BL5 | 289 | BL5 | 2 | 3.8 | 4.4 | 4.65 | 5 |
| BL6 | 292 | BL6 | 2 | 3.8 | 4.4 | 4.65 | 5 |
| 1-7_N3-4 | 85 | 1-7_N3-4 | 2 | 4.1 | 4.84 | 5.115 | 5.5 |
| 1-7_N4-7 | 88 | 1-7_N4-7 | 2 | 4.1 | 4.84 | 5.115 | 5.5 |
| 1-7_N7-10 | 91 | 1-7_N7-10 | 2 | 4.1 | 4.84 | 5.115 | 5.5 |
| 1-7-N10-13 | 94 | 1-7-N10-13 | 2 | 4.1 | 4.84 | 5.115 | 5.5 |
| 1-7N13-16 | 97 | 1-7N13-16 | 2 | 4.1 | 4.84 | 5.115 | 5.5 |
| 1-7N16-17 | 100 | 1-7N16-17 | 2 | 4.1 | 4.84 | 5.115 | 5.5 |
| 1-7N17-24 | 103 | 1-7N17-24 | 2 | 4.1 | 4.84 | 5.115 | 5.5 |
| 1-7N24-28 | 106 | 1-7N24-28 | 2 | 4.1 | 4.84 | 5.115 | 5.5 |
| D-29 | 418 | D-29 | 2 | 4.9 | 5.72 | 6.045 | 6.5 |
| 11BW79-W7 | 67 | 11BW79-W7 | 2 | 4.1 | 4.84 | 5.115 | 5.5 |
| 11BW5 | 58 | 11BW5 | 2 | 4.1 | 4.84 | 5.115 | 5.5 |
| 11BW6 | 61 | 11BW6 | 2 | 4.1 | 4.84 | 5.115 | 5.5 |
| 1-1AB | 1 | 1-1AB | 2 | 3.8 | 4.4 | 4.65 | 5 |
| 1-1AN | 4 | 1-1AN | 2 | 3.8 | 4.4 | 4.65 | 5 |
| 1-3 | 79 | 1-3 | 2 | 4.9 | 5.72 | 6.045 | 6.5 |
| 1-2S | 76 | 1-2S | 2 | 3 | 3.52 | 3.72 | 4 |

| Economic Reach | HEC-FDA Index | System | Probability of Failure | | | | Top of Levee |
|---|---|---|---|---|---|---|---|
| | | | 0 | 0.1 | 0.45 | 0.95 | |
| **1-5** | **82** | 1-5 | 2 | 2.3 | 2.64 | 2.79 | 3 |
| **4-2** | **136** | 4-2 | 2 | 3 | 3.52 | 3.72 | 4 |
| **4-1N** | **130** | 4-1N | 2 | 3 | 3.52 | 3.72 | 4 |
| **BL7** | **295** | BL7 | 2 | 4.5 | 5.28 | 5.58 | 6 |
| **11BW11** | **40** | 11BW11 | 2 | 2.3 | 2.64 | 2.79 | 3 |
| **11BE4** | **16** | 11BE4 | 2 | 4.5 | 5.28 | 5.58 | 6 |
| **4-7** | **148** | 4-7 | 2 | 4.5 | 5.28 | 5.58 | 6 |
| **11BE5** | **19** | 11BE5 | 2 | 3 | 3.52 | 3.72 | 4 |
| **6-1B1** | **160** | 6-1B1 | 2 | 4.5 | 5.28 | 5.58 | 6 |
| **6-1B1-B** | **163** | 6-1B1 | 2 | 4.5 | 5.28 | 5.58 | 6 |
| **D-53** | **478** | D-53 | 2 | 3.8 | 4.4 | 4.65 | 5 |
| **D-60** | **484** | D-60 | 2 | 4.5 | 5.28 | 5.58 | 6 |
| **D-64** | **499** | D-64 | 2 | 3.8 | 4.4 | 4.65 | 5 |
| **E2-LF** | **517** | E2-LF | 2 | 4 | 4.7 | 5 | 5.4 |
| **E2-LF-B** | **520** | E2-LF | 2 | 4 | 4.7 | 5 | 5.4 |

### 2.4.2.3 Project Levees

The MTG project study project levees will be designed to reduce risk in the study area from storm surge and tidal influences from the Gulf of Mexico. Even though the project levees are designed and engineered to withstand the conditions chosen by the project, a risk and reliability analysis is required to be performed on these levees. The project levees will endure atypical conditions and have to perform differently than other levees in a normal river system. This is primarily due to their continuous exposure to water on both sides of the levees. Additional issues associated with levees include tidal fluctuation, wave run-up; poor foundation conditions (organic soils).

The project levees vary in elevations, based on the alignment and the required risk reduction needed at various locations, based on the hurricane modeling results.

#### 2.4.2.3.1 Stability Analysis

Stability analysis was performed on the project levees as part of the levee design. This analysis was performed by Geotechnical Engineers and is described in detail in the Geotechnical section of this report.

The results the stability analysis revealed that the local levee systems probability of failure due to stability or under seepage was relatively low for still water elevations reaching to the top of the levee and that the major factor contributing to any failure would be due to erosion by wave overtopping flows.

#### 2.4.2.3.2 Surface Erosion

The erosion analysis performed on the project levees, was done so as part of the levee design. The process is similar to what was done for the local levees with the exception that the designers had much more information about the project levees. The erosion failure heights for the project levees were determined by allowable rated of wave overtopping flows on the levees. The allowable overtopping rates were developed as actual weir flow heights. These weir flow heights had to be converted to actual water surface elevations. The failure probabilities associated with the failure heights were used to construct the fragility cures for the project levees.

#### 2.4.2.3.3 Fragility Curves

The stability analysis results and the results from the erosion analysis were used to develop the fragility curves for the all the project levees. The stability analysis revealed a geotechnical stability failure had a very low probably of occurring, the major failure mode for the project levees would be due to erosion from wave overtopping and/or weir flow. The water elevations associated with various overtopping rates were associated with a probability of failure to construct fragility curves for both the local and federal levees.

This methodology involved combining the stability analysis of the levees with a wave overtopping assessment that identified the stage where a critical overtopping rate fails the levee. The percentage of probability on the fragility curve at the critical stage and above was adjusted to 100% failure if exceeded. This would then combine the probability of failure for other modes of failure below the critical stage with 100% erosion failure above critical stage.

The without-project HEC-FDA model includes fragility curves that describe the reliability of the local levees. These fragility curves were developed using limited available data, stability analyses, and erosion evaluation. Wave overtopping was not considered; if the local levee does not fail, no damages are computed by the HEC-FDA model, even though wave overtopping could result in without-project damages. These assumptions resulted in overstating the performance of the local levee system and thus reduced the without-project damages that were used to compute project benefits.

The economic analysis performed for the with-project conditions represent the Federal levee performance by a single point fragility curve that has a zero percent probability of failure until a wave overtopping rate of 2 cfs/ft is reached, at which time, failure is considered likely. For all events where the wave overtopping is less than 2 cfs/ft, no damages are computed by the HEC-FDA model. The failure point chosen on the Federal levee would overstate residual damages and therefore understate benefits.

Recent full scale wave overtopping simulation research at Colorado State University (CSU) and simulation research projects on levees were performed to determine the need for armoring. This specific analysis forms the basis for the assumed performance of the proposed Federal grass-covered earthen levees. The upper estimate in the CSU tests was 2.0 cfs/ft. Levees could fail if armoring is not present and overtopping is greater than 2.0 cfs/ft. With the likelihood more certain, the failure probability for 2.0 cfs/ft was set at 95 percent.

A sensitivity analysis was performed on an economic reach for the with-project Federal levee with three test cases. Test Case A has a typical fragility curve developed from geotechnical and hydraulic analyses, Test Case B is the single point failure with the 100 percent probability at a surge elevation that results in 2 cfs/ft wave overtopping, and Test Case C is a single point failure with the 100 percent probability surge elevation at the top of levee. The sensitivity analysis demonstrated that the single point failure is a proxy for a typical fragility curve that meets the intent of the ER 1105-2-101 to address risk and obtain economic consequences. The with-project economic analysis using a single point fragility curve with a failure point at 2 cfs/ft wave overtopping understates the performance of the levee, calculating higher residual damages and therefore understating the benefit-cost ratio.

In the HEC-FDA model, once the wave overtopping reaches 2 cfs/ft, the Federal levees fail and interior stage becomes the without-project stage and residual damages are computed. A breach analysis for the with-project Federal levee demonstrated the interior stage with a breach is likely to be lower than the exterior stage and the without-project stage; the interior/exterior relationships used in the Federal levee analysis therefore understates the performance of the levee again understating the benefit-cost ratio.

In reviewing each of these assumptions, the USACE Risk Management Center concluded that the methodology used in this study resulted in underestimating the without-project damages. The analysis performed on the with-project conditions understated the performance of the Federal levees as well as overstated the residual damages due to the interior/exterior relationships used in the economic model.

### 2.4.3 Approach to Compute Project Benefits

The stage frequency curves developed from external surge stages are used in the Flood Damage Analysis (FDA) Model to test the performance of the local levees for the existing condition. The existing and local levee systems are represented in FDA by constructing fragility curves. A portion of the external/surge volume would become the overtopping wave volume in the with-project condition. A representative stage frequency for wave overtopping will be constructed and used to evaluate the without local levee condition as well. The wave overtopping stage frequency would be constructed assuming no failure of the project surge levee (i.e. assume wave overtopping only through the full range of frequencies so as not to double count damages).

In order to assess the 3% AEP levee project conditions in FDA two flood damage simulations needed to be performed. The first run used same without project external/surge stages for stage frequency curve, and then evaluated the proposed 3% AEP project levee by constructing fragility curves in FDA. Second run used overtopping of 3% AEP levee to generate stage frequency curves to capture the overtopping wave volume between the project and local levees, then evaluated local levees by using the fragility curves in FDA. These two runs were combined outside of FDA to determine the damages reduced by the 3% AEP alternative including the existing local levees. Assuming that a portion of the external surge volume has been transformed into internal overtopping wave volume (and results in the internal stage frequency loading) then the local levee assessment essentially becomes an interior drainage type of analysis. The combined benefits of both project and local levees would be:

- Without Project EAD – With Project Levee EAD = Project Levee Benefit using surge stage frequency and project design fragility, plus
- Without Local Levee EAD – With Local Levee EAD = Local Levee Benefit using wave overtopping stage frequency and local levee fragility.

The 1% AEP levee project conditions were assessed by using the external/surge stages for stage frequency curve. Since 1% AEP levee meets HSDRRS Criteria, it is logical to assume levee holds back water all the way to top for this case. Given the height/resiliency of 1% AEP levee, the relatively low volume of overtopping and the tremendous storage areas inside the levee, it's reasonable to assume that damages reduced by local levees are not significant. Therefore it was decided not to do second HEC-FDA run for local levees inside the 1% AEP proposed levee.

### 2.4.4 Benefits During Construction Analysis

The benefits during construction (BDC) analysis will determine the maximum AEP of corresponding surge and wave parameters that a given levee will be able to withstand in year 2024. The 2024 benefit analysis has been conducted with the single point failure elevation in lieu of the fragility curve in the same manner as the 2035 and 2085 with project economic analyses. The use of a single-point of failure as a proxy for the Federal fragility curve meets the intent of ER 1105-2-101 to address risk and obtain economic consequences. This section describes how the single point failure elevation is determined for the BDC analysis. The BDC analysis is performed on the Morganza to the Gulf authorized alignment. Consistent with the 2035 and 2085 with project analyses, the maximum overtopping rate that can be withstood by a levee with grass is approximately 2.0 cfs/ft. To determine the single point failure elevation, the AEP associated with failure needs to be determined; this is the AEP that slightly exceeds the

2.0 cfs/ft overtopping rate. This single point approach is valid because consequences associated with the fragility curve prior to 2.0 cfs/lf overtopping are negligible. A single point elevation was selected because it provided a timely method in representing the levee performance using a conservative approach. Levee performance associated with this method will not overestimate project benefits.

The analysis uses appropriate 2024 levee parameters to determine level of overtopping. Only one reach for the 1% and 3% AEP levee elevations were used. Reaches I3 and H3 were used for 3% AEP and 1% AEP conditions, respectively. Associated levee elevation and geometries are given in Table 13.

**Table 13 - Summary of Levee data used to analyze benefits during construction**

| Return (yr) | Reach | Levee Slope | Berm Toe (ft) | Berm Slope | Berm Toe (ft) | Berm Slope | Berm Top (ft) | Levee Slope | Levee Crest at year 2024 (ft) |
|---|---|---|---|---|---|---|---|---|---|
| 35 | I3 | -- | -- | 1 on 6 | 3.2 | 1 on 12 | 8.1 | 1 on 6 | 14.1 |
| 100 | H3 | 1 on 3 | 4.5 | 1 on 30 | 6.7 | 1 on 15 | 8.9 | 1 on 6 | 15.7 |

Both H3 and I3 sub reaches fall into the same main reach used in other levee design efforts. Reaches H3, I1, I2, I3, J1, J2, and J3 will be used to do the entire analysis. See Figure 11 to view the map of where these reaches are located in the system. The modeled alignment follows the northern most yellow line on the west and the yellow segment alignment on the east.

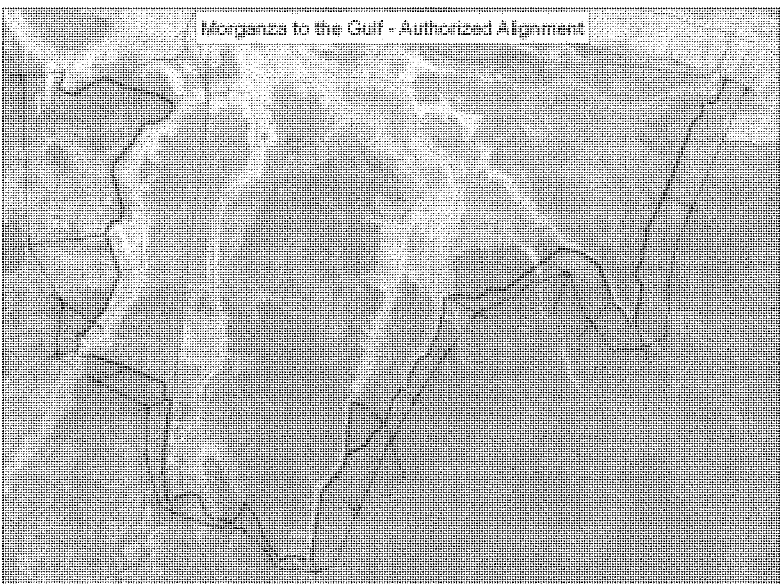



**Figure 11 - Map of Morganza to Gulf Authorized Alignment showing Reach H3, I1, I2, I3, J1, J2, J3**

The overall task was to determine a single probability. A range of probabilities was used to identify the specific probability associated with failure. In each case, the probability calculated for the partially constructed 1% AEP and 3% AEP levees will be lower than a 1% AEP and 3% AEP, respectively. If the given 1% AEP and 3% AEP design parameters were applied to the partially constructed 2024 levee the overtopping would most likely exceed the 2.0 cfs/ft limit and would definitely exceed the design overtopping limits of 0.01 and 0.1 cfs/ft at the 50% and 90% confidence limits, respectively. Overtopping was calculated for a range of probabilities below the 1% AEP and 3% AEP, respectively. For year 2024 the low SLR rate was 0.39 ft. This SLR rate was used to interpolate for 2024 condition data using existing (0 ft. SLR) and 0.57 ft. SLR data already available. All corresponding 2024 design data are given in Table 14. With the data established for a range of 2024 probabilities the next step was to determine berm factors for each of the scenarios. PC-Overslag as well as an excel sheet was used to develop all berm factors. An example output is given in Figure 12 through Figure 14 for calculating the overtopping for the 1.8% AEP corresponding to the partial 1% AEP levee elevation. The q50 overtopping rate was used to determine the probability event at which failure of the partial levee would occur. From the calculations, at approximately a 1.8% AEP event, the partially constructed 1% AEP levee will fail catastrophically whereas at approximately a 2.3% AEP event, the partially constructed 3% AEP levee will fail catastrophically. See Figure 15 for an example an overtopping scenario using 1.8% AEP boundary conditions.

The failure probabilities developed above have been rounded down to the nearest AEP used in the FDA model; all FDA model runs performed for the study use the same eight AEPs. To be conservative, the partial 1% AEP levee elevation will fail at a 2% AEP event, while the partial 3% AEP levee elevation will fail at a 4% AEP event. Refer to Table 14 through Table 17 for a summary of the results. The step-wise procedure for levee design is described in section 2.6.1.

**MORGANZA TO THE GULF OF MEXICO, LOUISIANA PAC ENGINEERING APPENDIX**

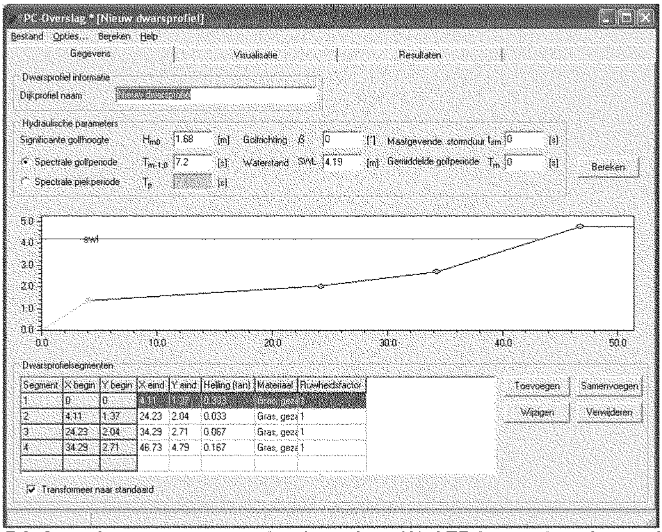



**Figure 12 - PC-Overslag geometry section based on 1% AEP levee elevation and 1.8% AEP boundary conditions**

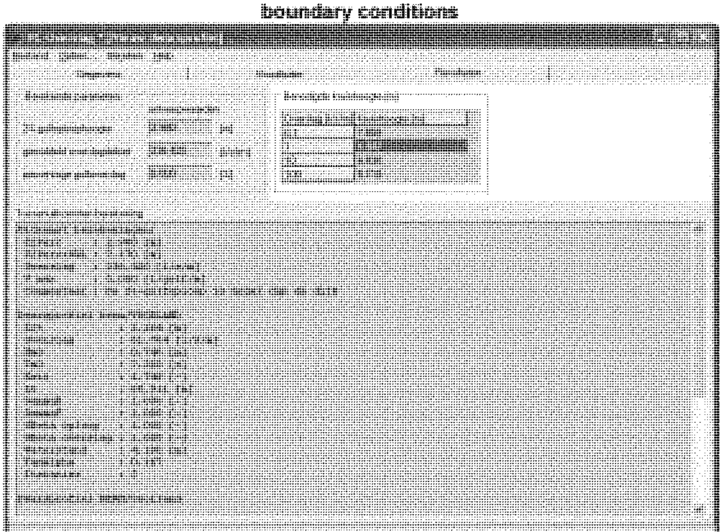


**Figure 13 - PC-Overslag output corresponding to 1% AEP levee elevation and 1.8% AEP boundary conditions**

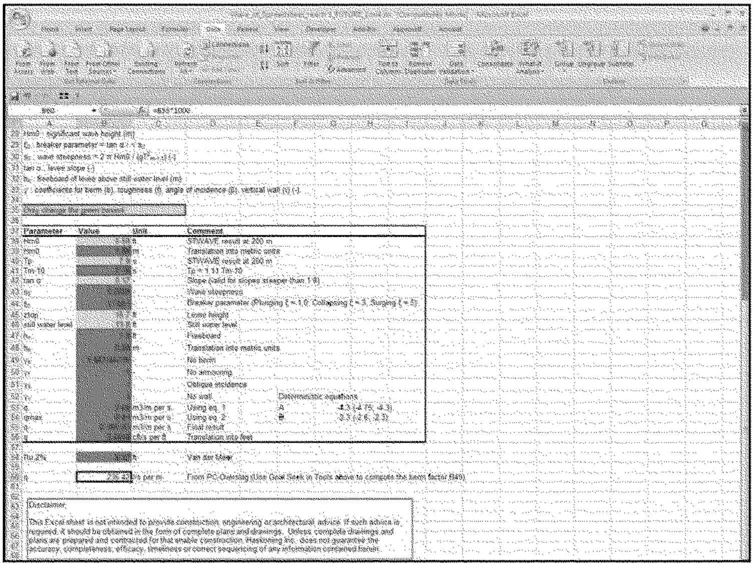


**Figure 14 - Excel sheet to find berm factor (gamma b) using 1.8% AEP surge and wave parameters with 1% AEP**

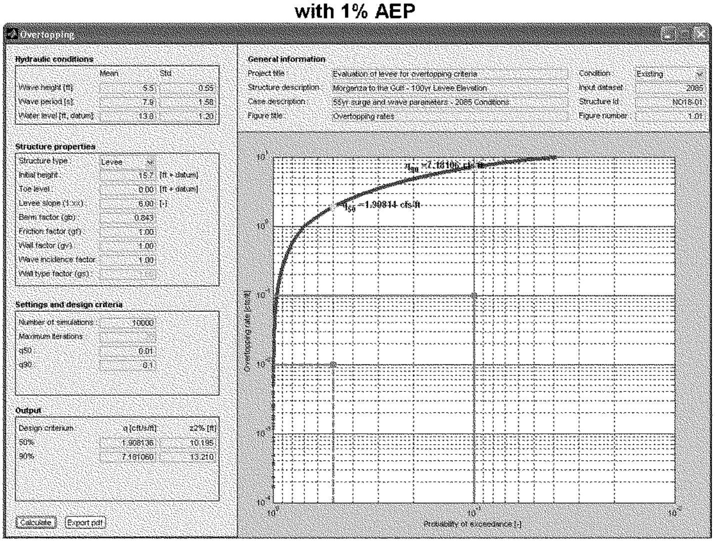



**Figure 15 - Matlab overtopping output using 1.8% AEP surge and wave parameters with corresponding 1% AEP. 50 percent confidence overtopping (q50) is approximately 1.90 cfs/ft**

Table 14 - First part of excel sheet showing all "trial and error" probabilities corresponding to 1% AEP

| Reach | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | Top of [illegible] | Top of [illegible] | Top of [illegible] | Top of [illegible] | Top of [illegible] | Top of [illegible] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |

Table 15 - Second part of excel sheet showing all "trial and error" probabilities corresponding to 1% AEP

| Top of [illegible] | Top of [illegible] | Slope 1 [illegible] | Slope 2 [illegible] | Slope 3 [illegible] | Slope 4 [illegible] | x1 | x2 | x3 | x4 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | | | [illegible] | | | |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | | | [illegible] | | | |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | | | [illegible] | | | |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | | | [illegible] | | | |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | | | [illegible] | | 56 | 50 |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | | |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | | |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | | |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | | |

**Table 16 - First part of excel sheet showing all "trial and error" probabilities corresponding to 3% AEP**

| Reach | RETURN | Surge (ft) | Surge (m) | Surge Stdev (ft) | Surge Stdev (m) | Hs (ft) | Hs (m) | Hs StDev (ft) | Hs StDev (m) | Tp (s) | Tp StDev (s) | Tp (s) | Top of Berm (ft) | Top of Berm (m) | Top of Berm (ft) | Top of Berm (m) | Top of Levee (ft) | Top of Levee (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [illegible] | 10 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| | 15 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| | 20 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| | 25 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| | 30 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| | 35 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| | 40 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| | 45 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |

**Table 17 - Second part of excel sheet showing all "trial and error" probabilities corresponding to 3% AEP**

| Slope 1 (Slope Levee) | Slope 2 (Berm) | Slope 3 (Slope Levee) | x1 | x2 | x3 | q (cfs per ft) | qb (Berms) | FINAL LEVEE HT | q60 - Overtopping | CORRESPONDING TO 2.0 CFS/FT OVERTOPPING (yrs) | Final return blended for Benefits during Construction |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | 12 | 6 | 5.85 | 23.77 | 54.75 | 0.000 | N/A | 54.7 | N/A | | |
| 6 | 12 | 6 | 5.85 | 23.77 | 54.75 | 0.034 | N/A | 54.7 | N/A | | |
| 6 | 12 | 6 | 5.85 | 23.77 | 54.75 | 0.667 | 0.969 | 54.7 | 0.002 | | |
| 6 | 12 | 6 | 5.85 | 23.77 | 54.75 | 4.335 | 0.875 | 54.7 | 0.039 | 43 | 25 |
| 6 | 12 | 6 | 5.85 | 23.77 | 54.75 | 18.961 | 0.872 | 54.7 | 0.146 | | |
| 6 | 12 | 6 | 5.85 | 23.77 | 54.75 | 54.472 | 0.867 | 54.7 | 0.384 | | |
| 6 | 12 | 6 | 5.85 | 23.77 | 54.75 | 134.480 | 0.866 | 54.7 | 1.109 | | |
| 6 | 12 | 6 | 5.85 | 23.77 | 54.75 | 356.715 | 0.950 | 54.7 | 2.488 | | |

### 2.4.5 Results and Conclusions

The performance of the existing MTG levees and the lack of reported distress for the past flood events indicates that they have provided some reliable means against flooding. In general, the results of the reliability of local levees analysis tend to show this, as expected. However, the existing levees, for the most part, have not been tested with flood waters in the range on those being used for the design. Therefore, the analyses performed show a wide range of reliabilities from high to low due to uncertainties associated with performance at maximum floodwater and variations in geometry and levee height.

The results of the "credit to existing levees" analysis indicate a wide range of probability of failure of the levees. With the flood water at the top of the levee, the probability of failure is greater than 95%. In general, analysis indicates that the performance of the local levees, in most instances, is controlled by the erodability of the levee. This is what is generally thought to be the case when clay levees are constructed on clay foundations. The stability of the levee is controlled by the strength of the levee material and also the foundation material.

Due to the "discontinuities" of many of these levees, flood water could flank these levees through adjacent lower spots. In addition, some portions of the levees themselves are lower. These "discontinuities" were incorporated into the relationship of the probability of failure to flood elevation. If the flood water elevation was higher than the "discontinuity", then the probability of failure of the levee reach was taken to be 100%.

## 2.5 FREQUENCY

### 2.5.1 Introduction

The New Orleans District's Economics Branch uses stage-frequency curves to compute surge-related damages throughout the study area for both "with" and "without" the project in place. Project benefits are based on the difference between the with- and without-project damages and are factored into the benefit cost analysis. To satisfy this need, both with- and without-project stage-frequency curves have been constructed by the Hydraulics & Hydrology (H&H) Branch. For more details, see the Economics Appendix, specifically "Engineering Inputs to the HEC-FDA Model."

Economics Branch calculated stage-damage relationships based on storage areas (SA) established through the interior modeling. The Morganza study area has been divided into 276 sub-areas or reaches (Figure 16). Of the 276 reaches, 264 were determined to be at risk from storm surge. Of the 264 reaches at risk, structures were present in 234 reaches. Hydraulic connectivity information for each storage area will be provided in

Section 2.6.3 and Section 2.6.4. Rainfall was not included in the overall stage frequency curves. The curve development relied on data provided through surge modeling for the upper portion of the curve and gage data for the lower portion of the curve. Composite stage frequency curves were developed for each of these storage areas. All elevations are given in vertical datum NAVD88 epoch 2004.65 unless otherwise stated. All elevations associate with results or input to analyses are given in vertical datum NAVD88 epoch 2004.65 unless otherwise stated. The frequency development only used the intermediate sea level rise case to calculate the BCR.

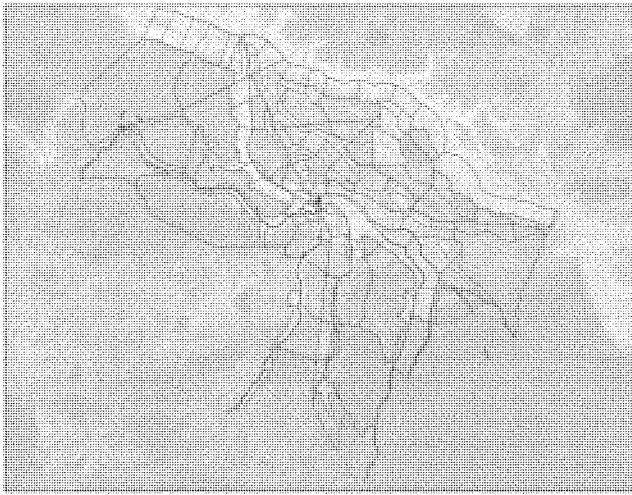


**Figure 16 - Map of storage areas (HEC-FDA reaches) delineated for the interior hydrologic model**

### 2.5.2 Established Risk reduction and Data Sources

Two levels of risk reduction were established for the MTG project:

- 3% Annual Exceedance Probability Storm Surge Risk Reduction System (3% AEP Alternative)
- 1% Annual Exceedance Probability Storm Surge Risk Reduction System (1% AEP Alternative)

The two levels are to be compared through economic analysis to determine which is more cost effective. The originally authorized level of risk reduction was deemed 1% risk reduction prior to Hurricane Katrina. After Hurricane Katrina new design criteria was established. The design elevations associated with the old level of risk reduction were compared against new 1% elevations developed from the new criteria. Results indicated that the old elevations were closer to a 2.86% (35 year) level of risk reduction based on current criteria. Thus, the old 1% level is represented as the 3% AEP Alternative for short throughout the report. In comparison, a new actual 1% AEP post

Hurricane Katrina level of risk reduction will also be included in the analysis.

The economic frequency analysis was performed over existing, base and future conditions. Base and Future conditions correspond to years 2035 and 2085, respectively. All exterior surge and wave modeling for the project was performed by ERDC. Both ADCIRC and STWAVE were used to develop surge and near shore waves, respectively (Cialone et. al., 2010). Detailed information on the modeling effort is given in ERDC's Final Modeling Report. All STWAVE modeling was done in half plane mode.

Table 8 shows all conditions established for the project along with the conditions modeled. A total of 115 synthetic storms were run for existing, 1.15 ft sea level rise (SLR), and 5.0 ft SLR project conditions. A 12 storm sensitivity analysis was done for the 3.2 ft SLR. ERDC computed all statistical values for frequencies of 2% and lower. Historic, rate 1 (intermediate), and rate 2 (high) SLR rates were based on sea level rise formulations derived from Army Corps Engineering Circular 1165-2-211. SLR rates 1 and 2 will be referred to as intermediate and high SLR rates, respectively. Initially, designs were developed for each of the three sea level rise rates for base and future conditions in accordance with the engineering circular. However, the economic cost-benefit analysis was based on only the results associated with the intermediate rate. The main MTG Post Authorization Change Report includes a narrative explanation on how costs and benefits will increase or decrease if the historic or high sea level rise rates became reality. With the modeled SLR scenarios the intermediate rates were interpolated for base and future years.

Two main data sources were used to develop the frequency curves. The sources are as follows.

- ADCIRC Data
  - grid nodes over the project area (surface)
  - 320 MTG point set

- Stage Gage Data

The MTG point data is a subset of 320 nodes from the full ADCIRC nodal data set. Both of these data sources are available for with and without project conditions. The 320 points were selected so that they represented the entire project area (Figure 10). Gage data will be discussed under the without project section of the report.

### 2.5.3 Without Project

#### 2.5.3.1 Existing Conditions

For without project conditions surge response was much greater on the interior than for with-project conditions. Response was available in storage areas as far inland as surge would propagate. As the frequency of event decreased water propagated further inland.

The same was true in going from existing to future conditions since water elevation increases at a minimum of proportional to the SLR increase. The frequencies established in this and future condition analyses discussed in this report correspond with the specified frequencies chosen for inclusion in the HEC-FDA economic program. HEC-FDA is the main software used by Economic Branch to calculate stage damage relationships. Eight frequencies were selected for the economic analysis including 0.2%, 0.5%, 1%, 2%, 4%, 10%, 20%, and 99.99%. Without project conditions was established first. Still water elevation (SWE) values were available in each storage area over the 0.2% to 2% frequency range. All ADCIRC grid node values lying within each storage area were used to develop the top end of the without project storage area frequency curves. Using all nodal points in each storage area provided a more accurate final representation of each storage area surge elevation. The process for selecting a single representative SWE for each storage area is given below using a 1% frequency event.

1. Map all SWE data available for 1% frequency over project storage areas
2. Determine which storage areas have at least 1 SWE value within
3. Calculate the mean and standard deviation of all values within each SA
4. Take the maximum value in each SA if the coefficient of variation of standard deviation/mean is less than 0.15.
5. If ratio is greater than 0.15, use LIDAR data to manually select a representative SWE.
6. Represent all storage areas that are dry (no surge) with -777.

The limit of 0.15 in step 4 was used as a measure of data scatter. Storage areas with calculated coefficient of variation of less than 0.15 signified a rather minor difference between maximum and minimum values. If larger than 0.15 the difference was rather significant. The limit of 0.15 cannot be found in HSDRRS guidelines since the value was only created as a reference for this analysis. For in depth information regarding HSDRRS criteria, see the *Hurricane and Storm Damage Reduction System Design Guidelines (Interim), New Orleans District, Engineering Division, October 2007.*

Data was summarized for each storage area and respective frequency. Storage area connectivity was reviewed to ensure realistic frequency values were used. For example, frequency values between northern and southern storage areas should have a smooth transition. Also, a check was performed on individual frequency curves to ensure SWE decreased as frequency of event increased. Surge model results were heavily relied upon to complete this task. In some cases engineering judgment had to be used to define a representative value for a storage area. Most of these cases were for either storage areas in the northern reaches of the project where wetting and drying of ADCIRC model nodes occurred sporadically. In some cases, the highest SWE was in a channel within the storage area. Such values were in many instances not consistent with surge elevations over land in the same storage areas. Keeping the highest value would have over inflated structural damages. Instead, the maximum SWE value was manually set to a lower value based on elevations over the entire storage area.

Still water elevations (SWE) were manually set to a lower elevation based on knowledge of all SWE throughout the storage area. Selecting a lower SWE value was dependent upon the specific storage area being analyzed. One example included in the report was when the maximum SWE was found to be in a channel within the storage area. In this case the SWE was lowered to be more consistent with overland surge in that storage area. Wetting and drying of areas from storm to storm also caused some higher than expected statistical results. Such a case was also grounds for setting to a lower SWE which was again dependent upon overland surge in the storage area.

#### 2.5.3.2 Develop Stage Frequency data

Frequency curve development given in the previous section was based on ADCIRC model results for 0.2% through 2% frequencies. To complete the lower part of the frequency curve (i.e., 4% through 50%) another data source had to be used. FEMA data were initially used to obtain 10% frequency values. However, there were known issues with the FEMA data including ground truthing concerns. Use of the FEMA data meant incorporation of a Dokka data adjustment (Cialone et al, 2010) as well as justification on why the data was used when there were notable reservations concerning the FEMA data. Upon further evaluation and discussion, gage data was found to better represent the entire range of high frequency events. Gage data did not need a Dokka data adjustment. Six gage sites were available within the area, but all were lacking decent records except for the gage near Houma, LA and the gage near Leeville, LA (Figure 18). Frequency analysis was done on the Houma and Leeville gages. Both gages resulted in very similar frequency values so only the gage at the Gulf Intracoastal Water Way Houma was used. A summarization of frequency values established through the gage analysis is given in Table 19.

Due to the hydraulic modeling limitations for events with smaller probability of exceedance (50%, 20%, 10%, and 5% AEP events), these events lower on the stage-frequency curves were developed using gage data and a statistical distribution. The Weibull distribution was selected based on the experience and expertise of senior coastal engineers in the MVN H&H branch. The historical gage data was obtained from the USACE Water Management Section and USGS websites. The gage data was converted to NAVD88 2004.65 using the best available conversions from the USACE MVN Surveys Section. The results of the lower stage frequency curves are presented in Table 18.

Figure 17 illustrates the results of the lower stage frequency curves.

The following gages were included in this stage-frequency exercise-

- Houma Canal at Dulac
- Bayou Lafourche at Golden Meadow Floodgate N
- Bayou Lafourche at Golden Meadow Floodgate S
- Intracoastal Water Way at Houma

- Bayou Petit Calliou North of Cocodrie
- Bayou Lafourche at Leeville

**Table 18 - Lower Stage Frequency Curve Results**

| Frequency (%) | 50 | 20 | 10 | 5 | 2 |
|---|---|---|---|---|---|
| **Houma Canal at Dulac** | 2.7 | 5.10 | 5.90 | - | - |
| **Bayou Lafourche at Golden Meadow Floodgate N** | 2.40 | 3.10 | 3.40 | 3.50 | - |
| **Bayou Lafourche at Golden Meadow Floodgate S** | 2.6 | 3.50 | 5.90 | 7.20 | - |
| **Intracoastal Water Way at Houma** | 1.80 | 2.70 | 3.00 | 3.80 | 4.20 |
| **Bayou Petit Calliou North of Cocodrie** | 1.20 | 3.20 | 6.80 | 8.40 | - |
| **Bayou Lafourche at Leeville** | 1.40 | 2.30 | 3.90 | 4.00 | - |

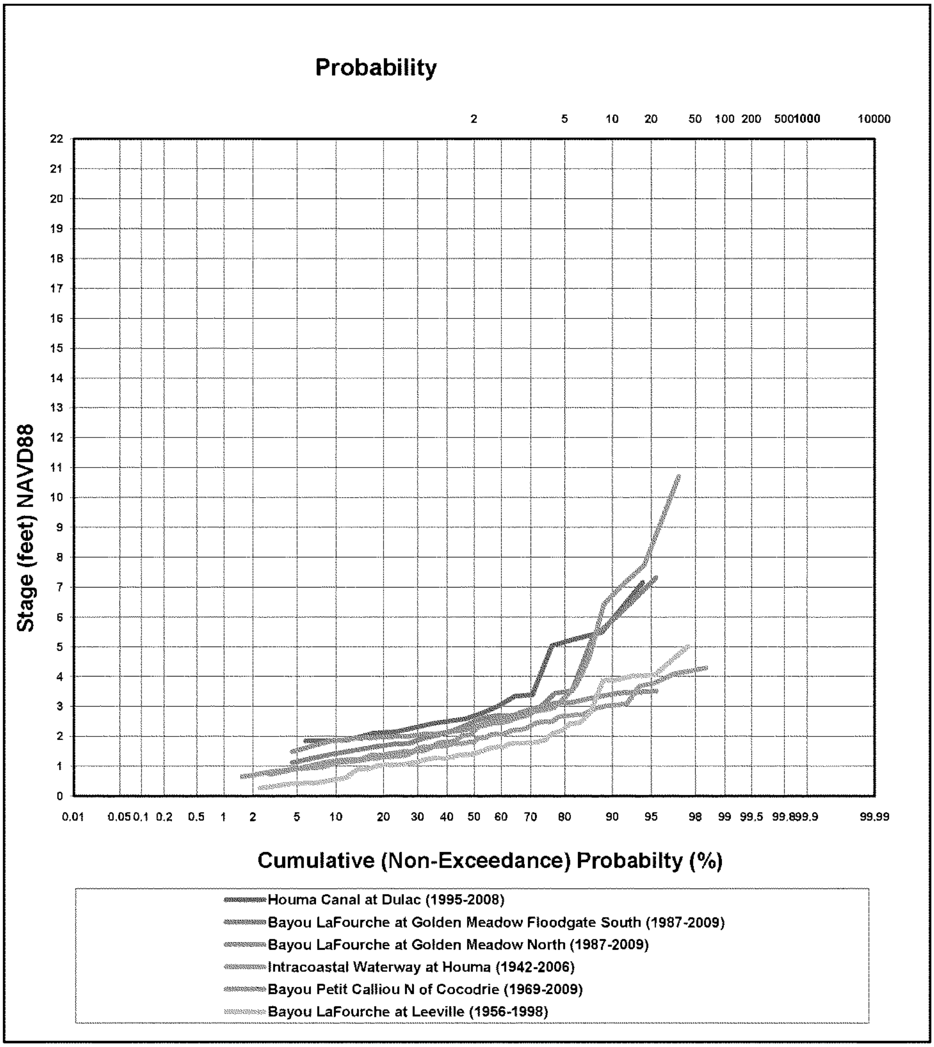



**Figure 17 - Lower Stage Frequency Curve Results**

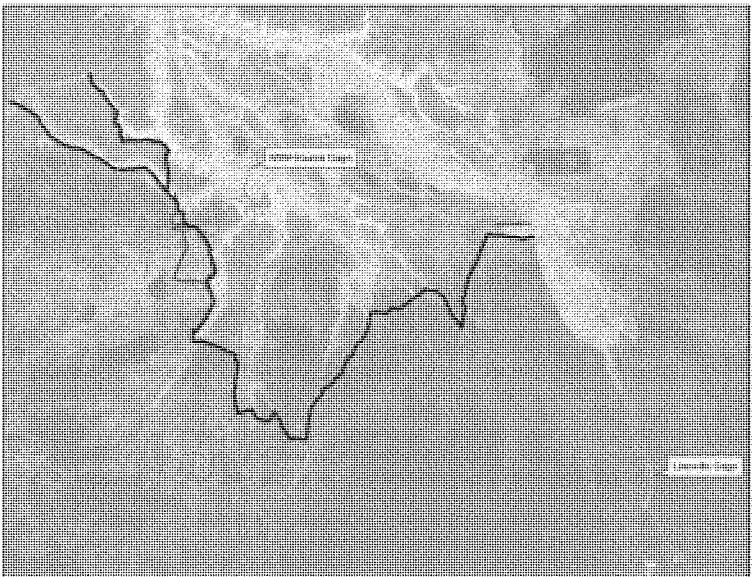


**Figure 18 - Map of Leesville and GIWW Houma Stage Gages along with MTG Authorized Levee Alignment**

**Table 19 - Stage frequencies established through gage analysis**

| Frequency (%) | 50 | 20 | 10 |
|---|---|---|---|
| Return Period (yrs) | 2 | 5 | 10 |
| Intracoastal Water Way at Houma | 1.9 | 2.3 | 3.1 |

After completion of the gage frequency analysis, a methodology had to be developed to translate these results onto each storage area frequency curve. The most straight forward method was to apply each frequency value directly to each storage area frequency curve. A basic curve was established for all storage areas based on this method. A check was performed on all storage area curves and modifications were made to the 10% through 50% values based on the following main guidelines-

- Frequency values will agree with hydraulic connectivity
- Any adjustment to gage frequency values will be lower than the initial gage value.
- The curve will be smoothed as much as possible with no significant shifts unless a physical boundary is present.
- Frequency values lower than the minimum ground elevation will be labeled as dry.

In case of a value on a given frequency curve being dry the higher frequency events were also labeled as dry. In addition to the frequency values already mentioned, two additional frequencies needed inclusion on the curves based on the frequencies defined through the economic branch damage analysis. Logarithmic interpolation was performed to compute 0.5% and 4% frequency values. The 10% and 2% values were used to interpolate the 4% frequency while the 1% and 0.2% values were used to define the 0.5% frequency value. For scenarios where either the 10% or 1% value was dry the ground elevation as well as topography was reviewed to make a judgment on whether the 0.5% or 4% frequency value was dry or wet. The final frequency curves for existing, base, and future conditions for each storage area can be furnished upon request.

After adjusting each curve, final quality checks were made on a bigger scale by visualizing storage area frequency values on a map. Every frequency value on each curve had to make sense in light of the entire system. Economic Branch contributed a significant amount of time and effort to assist in the final development of the curves. High frequency surge values might be lowered in such cases where the economic damage analysis showed costs significantly higher than would be expected. In other cases, economic damages at a given frequency event were compared to the same frequency of adjacent storage areas for correlation. If values looked abnormal they were checked and lowered if the high value could not be justified.

#### 2.5.3.3 Base & Future conditions

Base and future condition frequency curves were to be developed by the same method as used for existing without project conditions. Refer back to Table 8 for the sea level rise scenarios that were modeled. Only 0 ft SLR (2010), 1.15 ft SLR (2060), and 5.0 ft SLR (2085) data sets were available to develop base and future conditions. The equivalent intermediate SLR values associated with base and future conditions were 0.72 ft and 2.42 ft., respectively. As mentioned earlier, only the intermediate rate of SLR is important for the stage damage relationship. Refer to EC1165-2-211, dated July 2009, for more information on the three sea level rise rates established for base and future conditions.

Base and future conditions were established after first understanding the model runs. A simple logarithmic interpolation could not be done without first translating the model run data into appropriate intermediate rates of SLR. The 1.15 ft SLR model run corresponds to a year 2060 condition while the 5 ft SLR model run corresponds to a year 2085 condition. Table 20 gives the conversion of each model run to intermediate SLR rates so interpolation could be performed. The translation value shown in the table is equal to the difference between the modeled value and true intermediate value given in Table 8. Taking year 2035 for an example, the intermediate rate is equal to 0.72 ft. The existing condition data as well as modeled 2060 intermediate data needed to be established for interpolating to 2035 intermediate conditions. A translation value of 0.36 ft was added to 2060 SWE values to arrive at intermediate conditions.

Using the actual intermediate SLR values, interpolation for base condition was performed over all nodal points within the project area. Interpolation for the 2035 intermediate SLR value of 0.72 ft could be done using existing condition and 2060 intermediate data. The 2085 intermediate SLR value was established by simply subtracting the translation value in Table 20 from the values associated with the 5.0 ft SLR model results. Interpolation was done spatially over the entire project area. In case of 2035 conditions, the first step was to ensure points for existing and 1.15 ft. SLR data were matched to the same geographic location. This ensured interpolation would be done over the same location. With points geographically matched for base condition, interpolated values were computed at 0.2%, 1%, and 2% frequencies. The same frequencies were also established for intermediate future conditions. At this point all point values were developed for base and future condition analysis. The same step wise process used for development of without project existing condition curve data was used for without project base and future conditions.

Similar to the methodology used to represent the higher frequency events, gage data was used for future conditions after adding a given amount of elevation to account for base and future condition sea level rise. To establish base condition gage data the intermediate SLR rate of 0.72 ft. was added to each of the existing condition gage frequency values. For future conditions, the rate of 2.42 ft. was applied to the existing condition gage values. It's known that sometimes sea level rise does not correlate 1-1 with increase in surge. Without modeling of each specific SLR rate a good approximation was to follow a 1-1 relationship for 2035 and 2085 data development. Table 21 gives a summary of the approximated base and future condition gage values. All methods have been discussed for development of all based and future condition without project frequency curves.

**Table 20 - Translation of modeled data to intermediate SLR data**

| Year | Modeled SLR (ft) | Translation | Final Intermediate SLR (ft) |
|---|---|---|---|
| 2010 | 0 | -- | -- |
| 2035 | -- | -- | 0.72 |
| 2060 | 1.15 | 0.36 | 1.51 |
| 2085 | 5 | -2.58 | 2.42 |

**Table 21 - High frequency values developed for Base (2035) and Future (2085) conditions**

| Year | Sea Level Rise (ft) | Gage Frequency Values (ft) | | |
|---|---|---|---|---|
| | | 10% | 20% | 50% |
| 2010 | 0 | 3.1 | 2.3 | 1.9 |
| 2035 | 0.72 | 3.8 | 3.0 | 2.6 |
| 2085 | 2.42 | 5.5 | 4.7 | 4.3 |

### 2.5.4 With Project – Levee Overtopping

Stage damage relationships also needed to be established for with project conditions. However, a different approach was taken to build with-project frequency curves. Focusing on the propagation of surge, the intent of with-project conditions was to create a barrier to stop surge from inundating populated areas. Thus, surge would be factored into the interior storage area frequency curves through levee failure as a direct result of overtopping. An exception to this statement would be the limited number of storage areas that lie outside of risk reduction. For with-project conditions the storage areas outside of the project would be developed in the same manner as the without project frequency curves. Only base and future condition curves were established in this analysis. The intermediate rate of SLR was used for base and future condition with project analysis.

Overtopping was calculated for base and future years based on the 1% and 3% AEP alternatives. A simplified approach was used to calculate overtopping since no modeling was done to simulate levee deterioration during an overtopping event. The approach assumed multiple SWE frequencies as boundary conditions over each levee level of risk reduction. Table 22 shows the boundary conditions applied for each level of risk reduction. All boundary conditions are based on frequencies above the given level of risk reduction in order to produce overtopping. The eight economic frequencies discussed in Section 3.1 were considered when determining frequencies expected to produce overtopping for each level of risk reduction.

**Table 22 - Summary of boundary condition frequencies applied to each level of risk reduction for base and future conditions**

| Level of Protection | Exterior Boundary Conditions | | | |
|---|---|---|---|---|
| | 2% | 1% | 0.5% | 0.2% |
| 2.86% (35 yr) | X | X | X | X |
| 1% (100 yr) | | | X | X |

### 2.5.4.1 Storm selection

SWE boundary frequencies have now been selected to be applied to each level of risk reduction. The points used to define those SWE frequencies were based on the MTG 320 point set. The points chosen were the same SWE points used in base and future condition design efforts. A list of the points used at each reach is given in Table 23. Overtopping was computed for each levee elevation and boundary frequency. Base 2035 condition with 1% levee elevation over reach K, L will be used in the example step-wise procedure. Applied as boundary condition to the 1% levee elevation will be 0.2% frequency data. The procedure is given as-

- Determine the 2035 SWE value corresponding to a 0.2% frequency at reach K, L point 174.
- Select a storm out of the 115 storms for with project conditions by searching for a storm that produced a peak surge at point 174 nearest to the 0.2% SWE value.
- Extract the storm surge hydrograph for the given storm at point 174.
- Use a Van der Meer overtopping spreadsheet to compute overtopping flow rate (TAW, 2002).

Before the above procedure could be performed, storm maximum values had to be developed for 2035 and 2085 conditions. There were no model runs specifically performed for 2035 or 2085 intermediate SLR conditions so interpolation was necessary. Interpolation was done for base and future SLR cases at each of the 320 MTG points. As in previous interpolations the existing, 1.15ft SLR, and 5.0ft SLR storm data sets were used. After the interpolated maximum storm values were computed the above procedure was followed to select storms for all frequencies corresponding to 1% and 2.86% level of risk reductions. In most cases, maximum storm elevations selected had values within 0.50 ft. of the actual frequency SWE value. An example of this is given in Table 24.

**Table 23 - Reaches with corresponding point from the MTG 320 point set**

| Reach | Overtopping Points | |
|---|---|---|
| | Surge | Wave |
| K, L | 174 | 103 |
| H3, I1, I2, I3, J1, J2, J3 | 96 | 96 |
| H2 | 45 | 31 |
| G1, G2, G3, H1 | 36 | 36 |
| E2, E1, F2, F1 | 83 | 90 |
| B | 90 | 90 |
| B2 | 90 | 90 |
| A-South | 90 | 90 |
| A-North | 208 | 208 |

**Table 24 - Reach K, L data corresponding 0.2% SWE value for 2035 conditions to a given storm**

| 2035 Conditions | | | | |
|---|---|---|---|---|
| Reach | SWE Point | 0.2% SWE (ft) | Closest Storm | Storm SWE (ft) |
| K, L | 174 | 21.8 | 8 | 22.28 |

### 2.5.4.2 Overtopping – fragility curves

Using the extracted storm hydrographs overtopping was developed. Overtopping rates in cfs/ft were used as a key indication of expected levee performance. As mentioned previously, an overtopping rate of 2.0 cfs/ft was considered as the failure rate. Besides the catastrophic failure rate other probabilities of failure needed to be defined for the stage damage relationship. A fragility curve was the best way to define a levee based on its ability to withstand overtopping. A fragility curve plots overtopping in cfs/ft versus probability of levee failure for a given levee reach. A number of overtopping rates must be developed to provide a range of probabilities from near 0% to near 100% failure. Five points were to be established on the fragility curve. The rates included 0.1, 0.5, 1.0, 1.5, and 2.0 cfs/ft. The lowest overtopping rate of 0.1 cfs/ft corresponded to the allowable design rate while the 2.0 cfs/ft corresponded to catastrophic failure.

Overtopping rates were established through an overtopping spreadsheet that utilizes the Van der Meer overtopping equation. Main inputs to the spreadsheet include Top of Levee, SWE, Hs, Tm, and a storm hydrograph. The statistical surge and wave data were based on the reach and frequency being analyzed. Storm hydrographs were extracted from existing surge runs in front of a given levee reach and frequency. This means a different storm hydrograph was used for each levee reach and frequency. The storm hydrograph was normalized to the input SWE so as to produce a peak of the storm hydrograph equal to the input SWE. The same was done for Hs and Tm where the input values corresponded to the same time on the hydrograph as the input SWE. The hydrograph had a time-step of 15 minutes. At each time-step the free flow and wave flow was calculated. An example of spreadsheet and overtopping hydrograph for a given levee reach are given in Figure 19 and Figure 20, respectively.

Plots of SWE versus overtopping rate were produced for each reach and frequency. For the 1% AEP, the 0.5% and 0.2% AEP boundary conditions were applied. For the 3% AEP, 2%, 1%, 0.5%, and 0.2% AEP boundary conditions were applied. SWE corresponding to the five main overtopping rates needed for the fragility curve were established through these plots. Figure 21 gives an example of one of the SWE versus overtopping plots along with an arrow approximating the appropriate SWE. SWE values were provided to the nearest tenth. If all plotted curves for a given reach did not fall near each other the minimum SWE needed to reach a specific overtopping rate was taken as the representative value. For example, if a SWE of 17.5 ft corresponded to a 2.0 cfs/ft limit for the 0.5% AEP curve and 17.2 ft SWE for the 0.2% AEP curve then the value that governs is the 17.2 ft SWE. Also, in cases where a 2.0 cfs/ft overtopping rate was not reached it was approximated. We expect little failure risk when a considerable height of free board exists on the levee. The risk is expected to increase at a much more dramatic rate as the water level rises and freeboard lessens. As SWE increases the risk will asymptotically approach catastrophic failure. All top of levee information was provided by the project management team (Table 25). These values are not the same as the levee design elevations provided by H&H. Subsidence and lift schedules were taken into account to develop the final top of levee elevations used in this analysis.

**Table 25 - Top of levee values corresponding to each condition for 3% and 1% levels of risk reduction**

| 3% AEP Alternative | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Reach** | **2024 Actual** | **2035 Actual (before lift)** | **2024 to 2035 Average Actual** | **2024 Top of Levee for HEC-FDA** | **2035 Top of Levee for HEC-FDA** | **2085 Top of Levee for HEC-FDA** | **Basis for 2035** |
| Barrier/A | 10.7 | 10.5 | 10.6 | 10.5 | 12.5 | 13.0 | 2070 |
| B | 13.8 | 12.8 | 13.3 | 13.0 | 12.5 | 13.5 | 2050 |
| E | 16.0 | 14.0 | 15.0 | 15.0 | 16.5 | 15.5 | 2035, 2085 |
| F | 15.0 | 14.5 | 14.8 | 14.5 | 15.0 | 15.5 | 2065 |
| G | 17.5 | 17.0 | 17.3 | 17.0 | 17.0 | 17.5 | 2050 |
| H | 19.0 | 18.3 | 18.6 | 18.5 | 20.5 | 20.0 | 2035, 2085 |
| I | 19.7 | 19.0 | 19.4 | 19.0 | 19.0 | 20.0 | 2045 |
| J | 20.5 | 18.5 | 19.5 | 19.5 | 19.5 | 20.0 | 2070 |
| K | 17.5 | 16.0 | 16.8 | 16.5 | 18.0 | 17.5 | 2035, 2085 |
| L | 17.5 | 18.3 | 17.9 | 17.5 | 18.0 | 17.5 | 2035, 2085 |

| 1% AEP Alternative | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Reach** | **2024 Actual** | **2035 Actual (before lift)** | **2024 to 2035 Average Actual** | **2024 Top of Levee for HEC-FDA** | **2035 Top of Levee for HEC-FDA** | **2085 Top of Levee for HEC-FDA** | **Basis for 2035 Value** |
| Barrier/A | 16.7 | 15.8 | 16.3 | 16.0 | 19.0 | 20.5 | Around 2068 |
| B | 16.0 | 19.4 | 17.7 | 17.5 | 19.0 | 20.5 | 2055 |
| E | 16.0 | 14.0 | 15.0 | 15.0 | 22.0 | 23.5 | 2045 |
| F | 16.0 | 14.0 | 15.0 | 15.0 | 23.0 | 23.5 | 2060 |
| G | 19.2 | 18.0 | 18.6 | 18.5 | 24.0 | 24.0 | 2035, 2085 |
| H | 18.2 | 24.8 | 21.5 | 21.5 | 24.5 | 26.5 | 2045 |
| I | 19.6 | 24.8 | 22.2 | 22.0 | 24.5 | 26.5 | 2045 |
| J | 19.5 | 25.8 | 22.7 | 22.5 | 25.0 | 26.5 | 2055 |
| K | 18.5 | 24.4 | 21.5 | 21.5 | 24.0 | 25.5 | 2050 |
| L | 18.5 | 24.0 | 21.3 | 21.0 | 23.0 | 25.5 | 2045 |

Notes:

2024 value based on straight average of 2024 and 2035 predicted elevations.

2035 value based on "average" of predicted elevations between 2035 and 2085 using one of two methods:

1. If “Basis for 2035 Value” is a single year, it means elev. based on point immediately before last lift (completely settled levee) rounded to the nearest half foot.
2. If “Basis for 2035 Value” has multiple years, means elevation is based on average along settlement curve between those two years.

2085 value based on predicted elevation at 2085 (similar to final design elevation).

Table 25 shows the "top of levee" elevations used in the 2024, 2035, and 2085 HEC-FDA models for the risk-based economic benefits analysis. The "top of levee" elevations are based on predicted crown elevations and lift schedules from USACE, MVN, Geotechnical Branch. In order to maintain the levee crown at or above the base year (2035) and future year (2085) design elevations while accounting for levee settlement and relative sea level rise, levees would be constructed in multiple lifts over the construction period of approximately 2015 to 2070. Both the design elevations and constructed "top of levee" elevations vary by levee reach. Design elevations vary by levee reach because of surge and wave differences due to storm path, wind speeds and direction, etc. Because of the long construction schedule, not all reaches will achieve the design level of risk reduction at the same time. By 2024, there will be a "closed system" with first-lift levees and structures in place but the "top of levee" elevations may be above or below the design elevations depending on the reach. By 2035, all "top of levee" elevations will be at or above the 2035 base design elevation, and by 2085 all "top of levee" elevations would be at the 2085 future design elevations.

The last step of the process was assigning each of the five overtopping rates to specific probabilities of failure. This final plot was created for base and future conditions and each levee reach. Figure 22 gives a plot of overtopping versus probability of failure. The rate of 2.0 cfs/ft was given a failure probability of 95%. Statistically a failure probability cannot reach 100% because there is always a small amount of uncertainty. Probabilities for the 0.5 and 1.5 cfs/ft rates were arrived at by smoothing out the curve knowing that the curve should be more S-shaped than linear with inflection at the 1.0 cfs/ft probability. The rationale for assigning probabilities is subjective to the engineer, their prior experience, and the conditions present for the levee under study. Geotechnical engineers and risk analysis experts were consulted during the development of these fragility curves. The inflection points based on overtopping rates were determined as a result of levee overtopping erosion tests performed at Colorado State University for other post-Katrina MVN levee designs. Reading from the curve we note the 0.5 and 1.5 overtopping rates are equal to 6% and 85% probability of failure, respectively. Final summary tables are given in Table 26 through Table 29

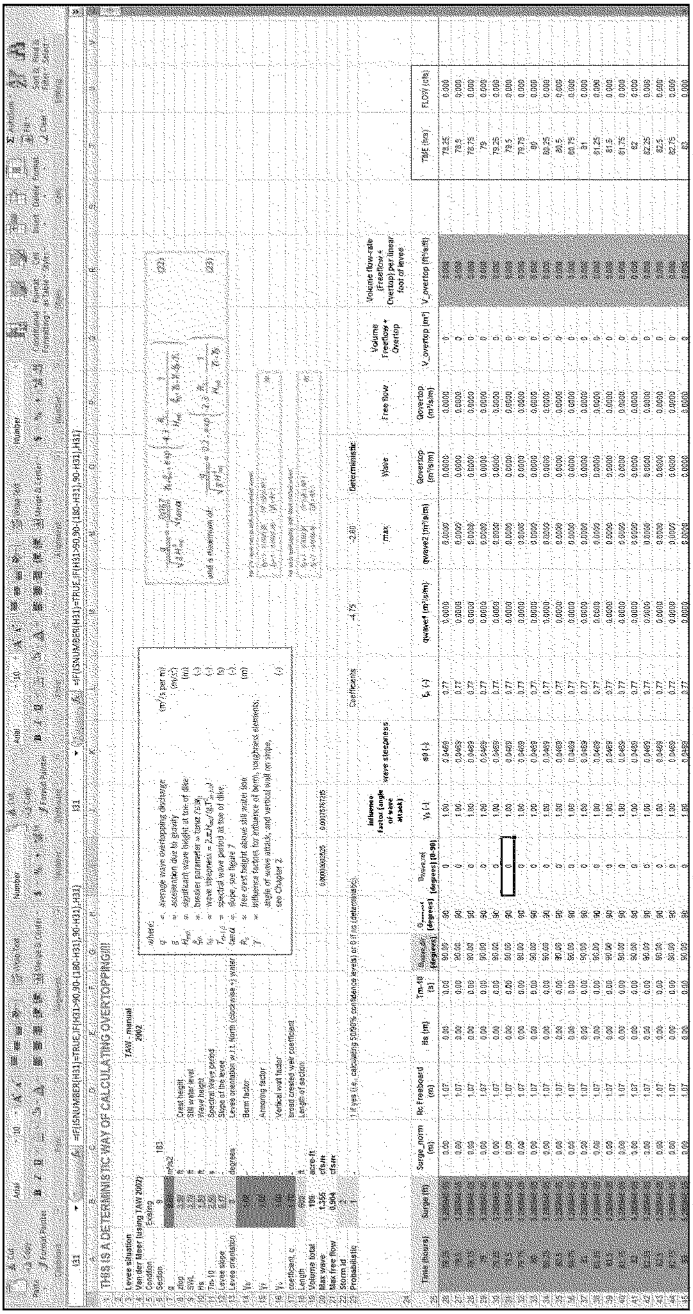


Figure 19 - Example of overtopping spreadsheet used to calculate overtopping rates. Neon green cells indicate changeable inputs.

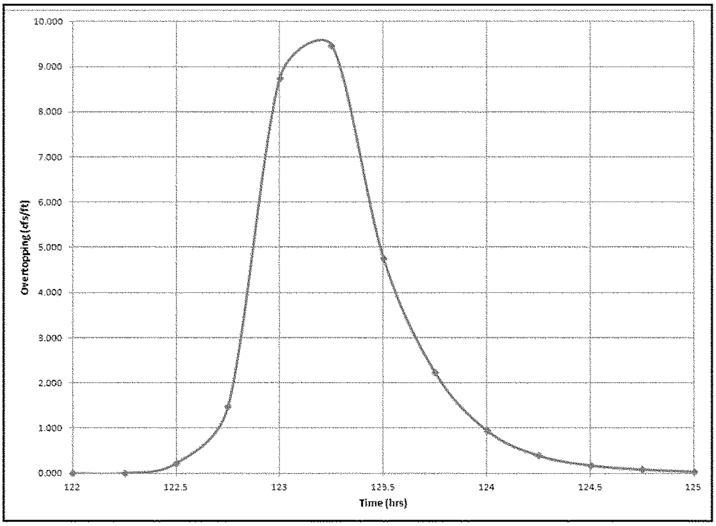



**Figure 20 - Example hydrograph of time versus overtopping rate**

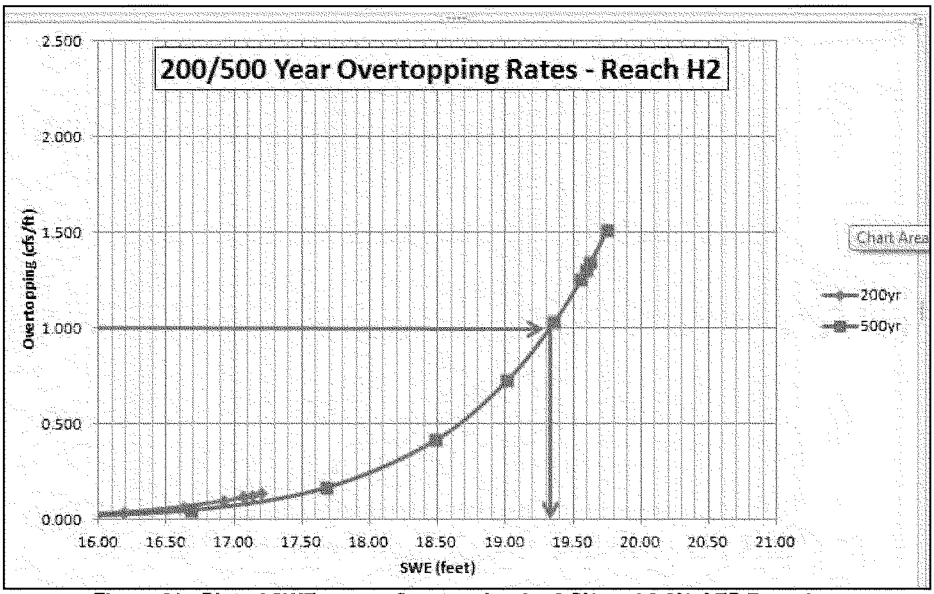



**Figure 21 - Plot of SWE versus Overtopping for 0.5% and 0.2% AEP Boundary Conditions over Reach H2.**
**In this example, the 2.0 cfs/ft rate had to be approximated**

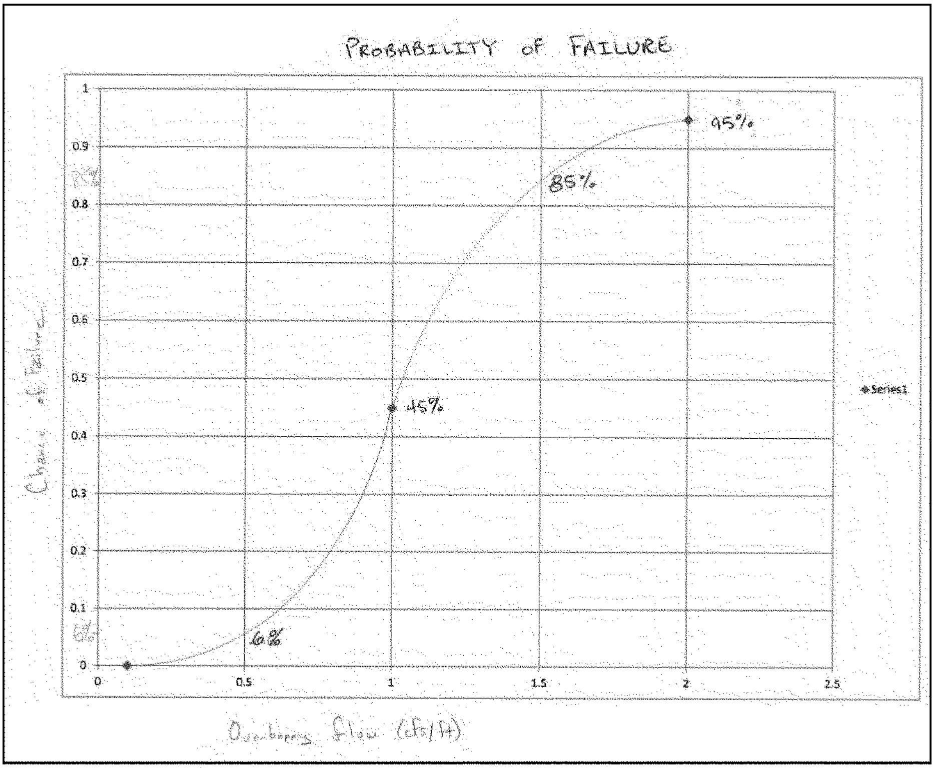



Figure 22 - Plot of overtopping versus probability of failure

**Table 26 - Fragility curve data for year 2035, 3% AEP**

| 2035 | 35 yr levee | Overtopping Rate (cfs/ft) | | | | |
|---|---|---|---|---|---|---|
| | | 0.01 | 0.5 | 1.0 | 1.5 | 2.0 |
| | | Probability of Failure | | | | |
| TOL | Reach | 0.004 | 0.06 | 0.45 | 0.85 | 0.95 |
| 12.5 | A | 7.1 | 9.5 | 10.0 | 10.3 | 10.5 |
| 12.5 | B | 9.1 | 9.7 | 10.2 | 10.5 | 10.8 |
| 16.5 | E | 11.4 | 13.2 | 13.7 | 14.0 | 14.2 |
| 15.0 | F | 11.4 | 12.1 | 12.7 | 13.0 | 13.3 |
| 17.0 | G | 11.4 | 12.2 | 12.6 | 12.9 | 13.1 |
| 20.5 | H | 12.5 | 14.9 | 15.5 | 15.9 | 16.2 |
| 19.0 | I | 12.5 | 13.9 | 14.5 | 14.9 | 15.1 |
| 19.5 | J | 12.5 | 14.3 | 14.8 | 15.2 | 15.5 |
| 18.0 | K | 11.8 | 14.0 | 14.5 | 14.8 | 15.1 |
| 18.0 | L | 11.8 | 13.9 | 14.5 | 14.8 | 15.1 |

**Table 27 - Fragility curve data for year 2035, 1% AEP**

| 2035 | 100 yr levee | Overtopping Rate (cfs/ft) | | | | |
|---|---|---|---|---|---|---|
| | | 0.01 | 0.5 | 1.0 | 1.5 | 2.0 |
| | | Probability of Failure | | | | |
| TOL | Reach | 0.004 | 0.06 | 0.45 | 0.85 | 0.95 |
| 19.0 | A | 10.4 | 14.7 | 15.3 | 15.7 | 15.9 |
| 19.0 | B | 12.4 | 15.6 | 16.1 | 16.4 | 16.5 |
| 22.0 | E | 15.2 | 18.8 | 19.3 | 19.6 | 19.8 |
| 23.0 | F | 15.2 | 19.6 | 20.1 | 20.4 | 20.6 |
| 24.0 | G | 14.8 | 18.1 | 19.0 | 19.3 | 19.5 |
| 24.5 | H | 16.3 | 19.1 | 19.7 | 20.2 | 20.5 |
| 24.5 | I | 16.3 | 19.1 | 19.7 | 20.2 | 20.5 |
| 25.0 | J | 16.3 | 19.4 | 20.2 | 20.6 | 20.9 |
| 24.0 | K | 16.1 | 20.1 | 20.5 | 20.8 | 21.0 |
| 23.0 | L | 16.1 | 19.4 | 20.0 | 20.2 | 20.3 |

**Table 28 - Fragility curve data for year 2085, 3% AEP**

| 2085 | 35 yr levee | Overtopping Rate (cfs/ft) | | | | |
|---|---|---|---|---|---|---|
| | | 0.01 | 0.5 | 1.0 | 1.5 | 2.0 |
| | | Probability of Failure | | | | |
| TOL | Reach | 0.004 | 0.06 | 0.45 | 0.85 | 0.95 |
| 13.0 | A | 9.8 | 10.5 | 10.8 | 11.0 | 11.2 |
| 13.5 | B | 10.7 | 10.8 | 11.1 | 11.2 | 11.4 |
| 15.5 | E | 12.5 | 12.6 | 12.9 | 13.1 | 13.5 |
| 15.5 | F | 12.5 | 12.6 | 12.9 | 13.1 | 13.5 |
| 17.5 | G | 12.5 | 12.6 | 13.1 | 13.4 | 13.6 |
| 20.0 | H | 13.9 | 14.4 | 15.1 | 15.5 | 15.8 |
| 20.0 | I | 14.0 | 14.4 | 15.1 | 15.5 | 15.8 |
| 20.0 | J | 14.0 | 14.4 | 15.1 | 15.5 | 15.8 |
| 17.5 | K | 13.1 | 13.5 | 13.9 | 14.1 | 14.4 |
| 17.5 | L | 13.1 | 13.5 | 13.9 | 14.1 | 14.4 |

**Table 29 - Fragility curve data for year 2085, 1% AEP**

| 2085 | 100 yr levee | Overtopping Rate (cfs/ft) | | | | |
|---|---|---|---|---|---|---|
| | | 0.01 | 0.5 | 1.0 | 1.5 | 2.0 |
| | | Probability of Failure | | | | |
| TOL | Reach | 0.004 | 0.06 | 0.45 | 0.85 | 0.95 |
| 20.5 | A | 13.7 | 17.3 | 17.8 | 18.1 | 18.3 |
| 20.5 | B | 14.2 | 16.6 | 17.1 | 17.4 | 17.7 |
| 23.5 | E | 16.6 | 19.7 | 20.2 | 20.6 | 20.8 |
| 23.5 | F | 16.6 | 19.7 | 20.2 | 20.6 | 20.8 |
| 24.0 | G | 16.2 | 18.0 | 18.9 | 19.3 | 19.6 |
| 26.5 | H | 17.8 | 20.2 | 21.2 | 21.6 | 21.8 |
| 26.5 | I | 17.8 | 20.1 | 21.2 | 21.6 | 21.8 |
| 26.5 | J | 17.8 | 20.2 | 21.2 | 21.6 | 21.8 |
| 25.5 | K | 17.7 | 20.3 | 20.9 | 21.4 | 21.8 |
| 25.5 | L | 17.7 | 20.3 | 20.9 | 21.4 | 21.8 |

After the above analysis was completed, a sensitivity analysis was performed on an economic reach for the with-project Federal levee with three test cases. Test Case A has a typical fragility curve developed from geotechnical and hydraulic analyses, Test Case B is the single point failure with the 100 percent probability at a surge elevation that results in 2 cfs/ft wave overtopping, and Test Case C is a single point failure with the 100 percent probability surge elevation at the top of levee. The sensitivity analysis demonstrated that the single point failure is a proxy for a typical fragility curve that meets the intent of the ER 1105-2-101 to address risk and obtain economic consequences. Based on this analysis, Case B, the single point failure elevation at the 2 cfs/ft wave overtopping was used for the project evaluation. See Section 2.4.2.3.3 for further discussion.

#### 2.5.4.3 Benefits during construction - year 2024

In addition to the with project analysis for base and future years a separate analysis looked into possible benefits obtained by having the levee in place before reaching a final levee elevation in year 2035. By year 2024 the levee system would be in place and would offer a moderate amount of risk reduction however limited that may be. Both the 1% and 3% AEP were included in this investigation. As discussed previously, input data used for base and future condition levee design was used as boundary conditions for the with project overtopping analysis. For 2024 conditions the existing condition and 2035 year data were used to interpolate SWE, Hs, and **T**m for 2024 conditions. The 2024 levee elevations used for 1% and 3% AEP are given in Table 25 also. Overtopping results were translated to fragility curves through the same process done for base and future years. Fragility curve information is summarized in Table 30 and Table 31.

**Table 30 - Fragility curve data for year 2024, 3% AEP**

| 2024 | 35 yr levee | Overtopping Rate | | | | |
|---|---|---|---|---|---|---|
| | | 0.01 | 0.5 | 1.0 | 1.5 | 2.0 |
| | | Probability of Failure | | | | |
| TOL | Reach | 0.004 | 0.06 | 0.45 | 0.85 | 0.95 |
| 10.5 | A | 6.2 | 8.6 | 9.0 | 9.2 | 9.4 |
| 13.0 | B | 8.7 | 10.0 | 10.5 | 10.9 | 11.1 |
| 15.0 | E | 11.1 | 11.7 | 12.3 | 12.9 | 13.2 |
| 14.5 | F | 11.1 | 11.8 | 12.4 | 12.7 | 13.0 |
| 17.0 | G | 11.1 | 12.0 | 12.4 | 12.7 | 12.9 |
| 18.5 | H | 12.2 | 13.6 | 14.2 | 14.5 | 14.8 |
| 19.0 | I | 12.2 | 13.7 | 14.3 | 14.7 | 14.9 |
| 19.5 | J | 12.2 | 14.1 | 14.6 | 15.0 | 15.3 |
| 16.5 | K | 11.3 | 12.9 | 13.4 | 13.7 | 14.0 |
| 17.5 | L | 11.3 | 13.6 | 14.1 | 14.5 | 14.7 |

**Table 31 - Fragility curve data for year 2024, 1% AEP**

| 2024 | 100 yr levee | Overtopping Rate (cfs/ft) | | | | |
|---|---|---|---|---|---|---|
| | | 0.01 | 0.5 | 1.0 | 1.5 | 2.0 |
| | | Probability of Failure | | | | |
| TOL | Reach | 0.004 | 0.06 | 0.45 | 0.85 | 0.95 |
| 16.0 | A | 9.3 | 12.3 | 13.1 | 13.4 | 13.6 |
| 17.5 | B | 11.9 | 14.4 | 15.0 | 15.2 | 15.5 |
| 15.0 | E | 14.9 | 11.8 | 12.5 | 13.0 | 13.3 |
| 15.0 | F | 14.9 | 11.9 | 12.5 | 12.9 | 13.2 |
| 18.5 | G | 14.6 | 13.0 | 13.8 | 14.2 | 14.5 |
| 21.5 | H | 16.0 | 15.8 | 16.4 | 16.8 | 17.2 |
| 22.0 | I | 16.0 | 16.9 | 17.5 | 17.9 | 18.2 |
| 22.5 | J | 16.0 | 17.2 | 17.8 | 18.2 | 18.5 |
| 21.5 | K | 15.6 | 16.5 | 17.0 | 17.5 | 17.8 |
| 21.0 | L | 15.6 | 16.2 | 16.6 | 17.0 | 17.3 |

#### 2.5.4.4 Storage Areas Outside Risk Reduction Area

A limited number of storage areas were totally outside of the leveed area and others were hydraulically separated into two sections due to levee placement. Table 32 provides a list of storage areas lying at least partially outside the leveed area.

**Table 32 - Storage areas outside leveed area**

| Storage Areas Outside Protection | | | | | |
|---|---|---|---|---|---|
| 6-1B1 | BB8 | D-16N | D-35 | E1-LF | GW18 |
| 8-1N | BD1 | D1A | D-45 | E2 | |
| 8-1S | BDL4 | D-25 | D-61 | HNC10 | |
| A1 | BPC5 | D-34N | D-62 | HNC9 | |
| BB7 | BT5 | D-34S | E1 | E2-LF | |

The storage areas could not be associated with a fragility curve since they were outside of a levee. Instead, with project frequency curves for base and future conditions were created for these storage areas as done for without project conditions. Refer to the methodology established in Section 2.5.3.2 for without project condition frequency curve development.

## 2.6 HYDRAULIC DESIGN

Design criteria established for levee and structure design has evolved since Hurricane Katrina. Much of the methodology used for analyzing statistical storm frequency in the southeastern part of Louisiana has changed significantly. Overtopping criteria defined for levee and structure design has also changed. The study initiated prior to 2005, therefore many of the results established previous to the new design criteria were reviewed. The design effort in this report was separated into two main sections.

- 1% Annual Exceedance Probability Storm Surge Risk Reduction System (1% AEP Alternative)
- 3% Annual Exceedance Probability Storm Surge Risk Reduction System (3% AEP Alternative)

The 1% AEP Alternative will calculate levee and structure designs based on the latest design criteria. The 3% AEP Alternative refers to the level of risk reduction authorized by congress prior to the establishment of the latest design criteria. Both alternatives were based on the same levee alignment (Figure 23). Levee and structure design calculations will be performed for both 1% AEP Alternative and 3% AEP Alternative scenarios. The designs will then be evaluated and compared. The most suitable alternative will be selected for further study. All background design plots for levees, structures, and wave loads are given in can be furnished upon request.

### 2.6.1 1% AEP Storm Surge Risk Reduction System Levee Designs

Levee designs were established for each with project condition based on statistical results from the hydrodynamic modeling effort. All designs were performed by engineers in the USACE MVN Hydraulics & Hydrologic Branch. The alignment was broken into hydraulic reaches based on surge and wave response in front of the alignment. Sub reaches that have similar surge elevations are kept in the same main reach while corners and turns in the alignment sometimes indicated a need for starting a new reach. The hydraulic reaches stayed consistent throughout all levee designs (Figure 23). The reaches are as follows-

1. Reach K, L
2. Reach H3, I1, I2, I3, J1, J2, J1, J3
3. Reach H2
4. Reach G1, G2, G3, H1
5. Reach E2, E1, F2, F1
6. Reach B
7. Reach B2
8. Reach A South of GIWW
9. Reach A North of GIWW

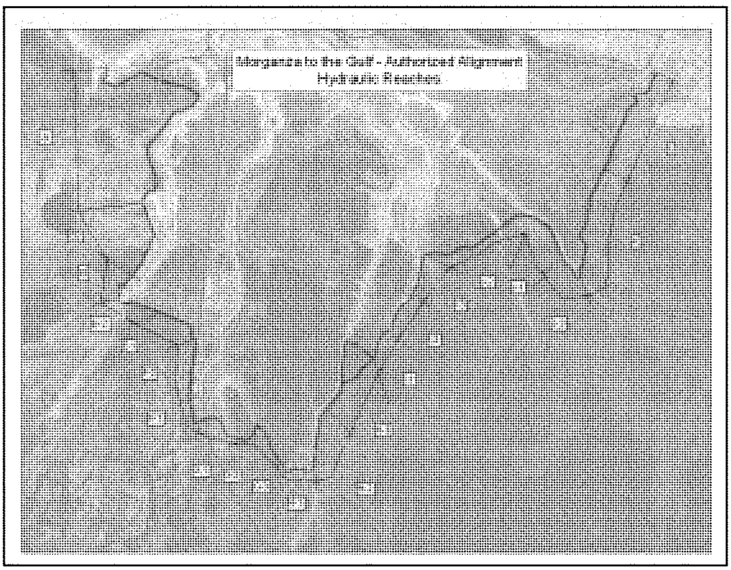


**Figure 23 - Hydraulic Reaches associated with the MTG Authorized Alignment**

Reach A is not the end of the authorized alignment. Referring back to Figure 23, the levee continues along the high ridge west of Reach A until tying into higher ground. The section west of Reach A will be considered later in this report. The same hydraulic reaches were used in both the 1% AEP Alternative and 3% AEP Aternative analyses to keep all designs comparable. The design procedure applied is common to all levee designs performed by USACE MVN Hydraulics & Hydrologic Branch. A step-wise procedure will now be given for levee design.

1. Choose a hydraulic reach to perform a levee design. For an example, Reach E will be used.
2. Determine which of the 320 points are in front of Reach E and find the point with maximum surge elevation as well as the point with maximum Hs and Tm. In most cases the surge and wave points are the same; however they can be different if maximums do not occur at the same point over the reach.
3. Note the standard deviations associated with SWE, Hs, and Tm.
4. If a berm will be added to the flood-side of the levee then a berm factor will need to be calculated. If no berm will be included skip to step 7.
5. Use the Dutch-originating software PC-Overslag to calculate a linear overtopping rate, q, corresponding to various possible geometries for the levee. The value of q is calculated in liters per second per meter and cannot exceed 1.5 l/s per meter (0.1 cfs/ft) as per HSDRRS guidelines, for example, Figure 24 and Figure 25.
6. Take the calculated q with surge and wave parameters and proceed to a customized excel sheet with automated calculations from the Dutch TAW manual. The TAW manual has equations related to wave run-up and overtopping associated with dikes. The excel sheet will calculate a berm factor for a given geometry (Figure 26).
7. Run a probabilistic Monte Carlo simulation using surge and wave parameters along with corresponding berm factor and geometry details. The probabilistic calculations produce 50% and 90% confidence overtopping rates q50 and q90, respectively, based on the Van der Meer overtopping equation. Use 10,000 iterations for the Monte Carlo simulations (Figure 27).
8. Check the q50 and q90 values. According to HSDRRS guidelines, the q50 cannot exceed 0.01 cfs/ft and the q90 cannot exceed 0.1 cfs/ft. When all criteria is satisfied the ending levee elevation is the final design elevation.
9. Iterations are sometimes needed to produce the most efficient levee elevation. If the overtopping rates are too low then decrease the levee height by 0.5 feet. If overtopping is too high increase by 0.5 feet until criteria is met.

As outlined in the New Orleans Hurricane Protection Manual the Monte Carlo Analysis described in the procedure above is executed as follows-

1. Draw a random number between 0 and 1 to set the exceedance probability p.

2. Compute the water elevation from a normal distribution using the mean 1% surge elevation and standard deviation as parameters and with an exceedance probability p.
3. Draw a random number between 0 and 1 to set the exceedance probability p.
4. Compute the wave height and wave period from a normal distribution using the mean 1% wave height/wave period and the associated standard deviation and with an exceedance probability p.
5. Repeat step 3 and 4 for the three overtopping coefficients independently.
6. Compute the overtopping rate for these hydraulic parameters and overtopping coefficients determined in step 2, 4, and 5.
7. Repeat steps 1-5 a large number of times (i.e., N=10000)
8. Compute the 50% and 90% confidence limit of the overtopping rate (i.e., q50 q90)

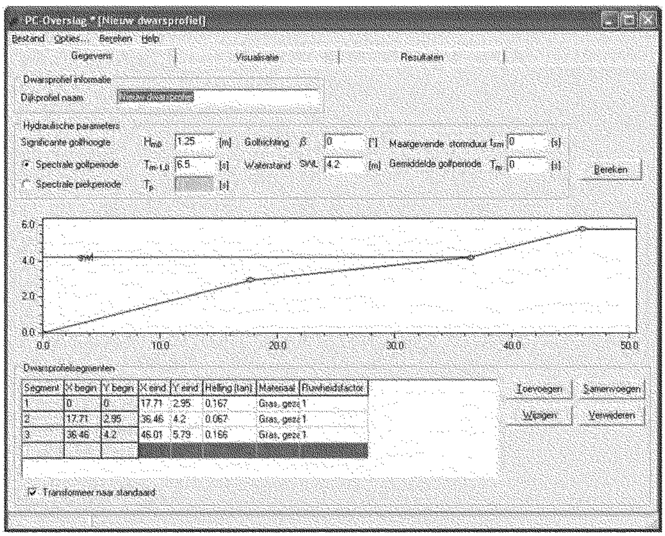



**Figure 24 - Example of PC-Overslag input screen. Levee geometry information is shown along with surge and wave values**

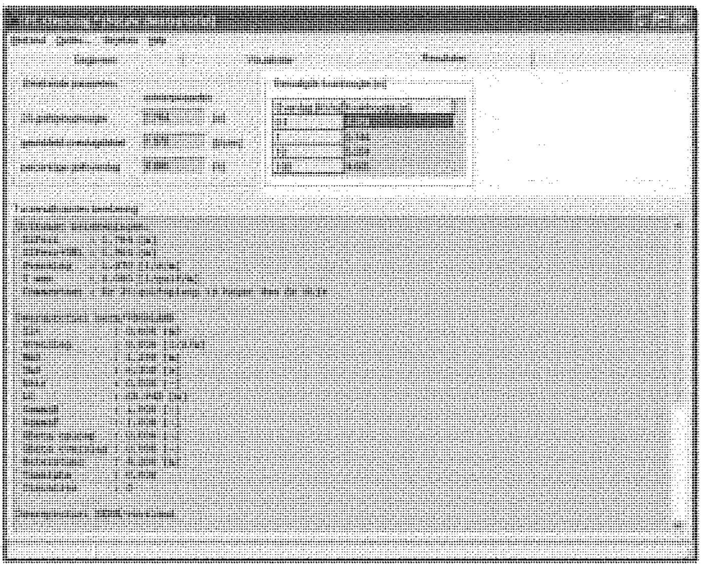


Figure 25 - Example of PC-Overslag result screen

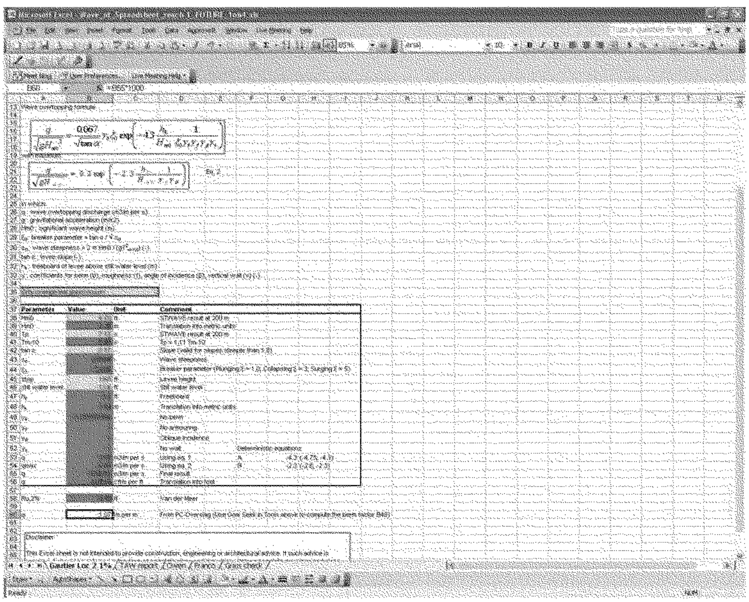


Figure 26 - Example of TAW Manual berm factor calculation sheet

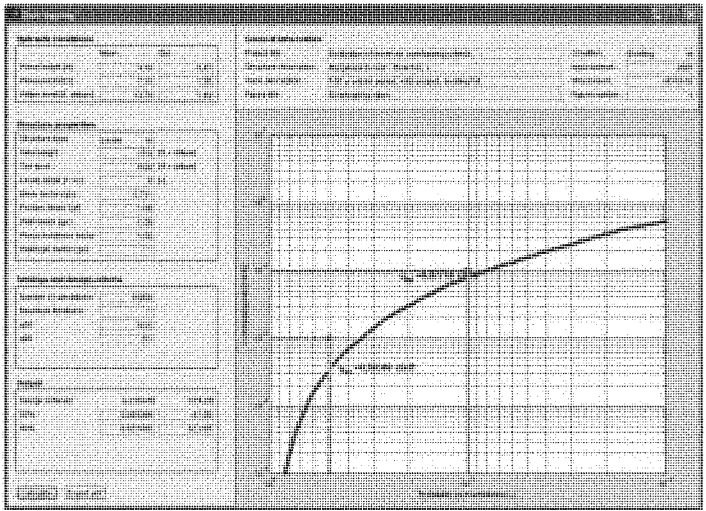


**Figure 27 - Example of the Matlab overtopping script used to compute levee design elevation**

### 2.6.1.1 Authorized Alignment

#### 2.6.1.1.1 Existing Conditions

In addition to existing condition 1% chance exceedance designs, 1.33% and 2.0% (75 and 50 year, respectively) designs were also completed at request of the project management team. Existing condition design values for each frequency are provided in Table 33, Table 34, and Table 35. The values in the tables were taken directly from ERDC's statistical computations. The standard deviations for Hs and Tm are 10% and 20% of their respective values. In addition to the stepwise procedure given above, more detailed levee design methodology is provided in the HSDRRS Design Elevation Report (U.S. Army Corps, 2010). The final existing condition designs for all percent chance exceedance events are given in Table 36, Table 37, and Table 38.

## Table 33 - 1% AEP Existing Condition frequency design characteristics

| 1% Exceedance | Surge J-Point | Wave J-Point | Surge Elevation (ft) | | 90% Surge Elevation (ft) | Significant Wave Height (ft) | | Period (s) | |
|---|---|---|---|---|---|---|---|---|---|
| Reach | | | mean | std | | mean | std | mean | std |
| | | | | | | | | | |
| K, L | 174 | 103 | 14.94 | 1.52 | 16.9 | 4.5 | 0.45 | 6.7 | 1.34 |
| H3, I1, I2, I3, J2, J1, J3 | 96 | 96 | 15.58 | 1.36 | 17.3 | 6.4 | 0.64 | 7.1 | 1.42 |
| H2 | 45 | 31 | 14.6 | 1.17 | 16.1 | 6.2 | 0.62 | 7.9 | 1.58 |
| G1, G2, G3, H1 | 36 | 28 | 14.28 | 1.13 | 15.7 | 5.9 | 0.59 | 8.1 | 1.62 |
| F2, F1 | 41 | 41 | 13.78 | 1.11 | 15.2 | 6.1 | 0.61 | 7.2 | 1.44 |
| E2, E1 | 83 | 83 | 14.63 | 1.29 | 16.3 | 4.8 | 0.48 | 6 | 1.20 |
| B | 90 | 90 | 11.4 | 0.99 | 12.7 | 3.2 | 0.32 | 7.1 | 1.42 |
| B2 | 116 | 129 | 10.12 | 1.03 | 11.4 | 2.6 | 0.26 | 4.5 | 0.90 |
| A-North of GIWW | 183 | 183 | 8.04 | 0.99 | 9.3 | 2.5 | 0.25 | 5 | 1.00 |
| A-South of GIWW | 180 | 140 | 9.26 | 1.09 | 10.7 | 3.2 | 0.32 | 5.7 | 1.14 |

## Table 34 - 1.33% Existing Condition frequency design characteristics

| 1.33% Exceedance | Surge J-Point | Wave J-Point | Surge Elevation (ft) | | 90% Surge Elevation (ft) | Significant Wave Height (ft) | | Period (s) | |
|---|---|---|---|---|---|---|---|---|---|
| Reach | | | mean | std | | mean | std | mean | std |
| | | | | | | | | | |
| K, L | 174 | 103 | 13.78 | 1.44 | 15.6 | 4.1 | 0.41 | 6.5 | 1.30 |
| H3, I1, I2, I3, J2, J1, J3 | 96 | 96 | 14.52 | 1.28 | 16.2 | 5.8 | 0.58 | 7.1 | 1.42 |
| H2 | 45 | 31 | 13.63 | 1.11 | 15.1 | 5.8 | 0.58 | 7.8 | 1.56 |
| G1, G2, G3, H1 | 36 | 28 | 13.3 | 1.07 | 14.7 | 5.4 | 0.54 | 8 | 1.60 |
| F2, F1 | 41 | 41 | 12.85 | 1.05 | 14.2 | 5.6 | 0.56 | 7.2 | 1.44 |
| E2, E1 | 83 | 83 | 13.55 | 1.22 | 15.1 | 4.3 | 0.43 | 5.8 | 1.16 |
| B | 90 | 90 | 10.49 | 0.93 | 11.7 | 2.7 | 0.27 | 7.1 | 1.42 |
| B2 | 116 | 129 | 9.14 | 0.97 | 10.4 | 2.2 | 0.22 | 4.2 | 0.84 |
| A-North of GIWW | 183 | 183 | 7.22 | 0.94 | 8.4 | 2.1 | 0.21 | 4.8 | 0.96 |
| A-South of GIWW | 180 | 140 | 8.33 | 1.03 | 9.6 | 2.8 | 0.28 | 5.5 | 1.10 |

## Table 35 - 2% Existing Condition frequency design characteristics

| 2% Exceedance | Surge J-Point | Wave J-Point | Surge Elevation (ft) | | 90% Surge Elevation (ft) | Significant Wave Height (ft) | | Period (s) | |
|---|---|---|---|---|---|---|---|---|---|
| Reach | | | mean | std | | mean | std | mean | std |
| | | | | | | | | | |
| K, L | 174 | 103 | 12.1 | 1.32 | 13.8 | 3.5 | 0.35 | 6.3 | 1.26 |
| H3, I1, I2, I3, J2, J1, J3 | 96 | 96 | 12.94 | 1.18 | 14.5 | 5 | 0.50 | 7 | 1.40 |
| H2 | 45 | 31 | 12.18 | 1.02 | 13.5 | 5 | 0.50 | 7.8 | 1.56 |
| G1, G2, G3, H1 | 36 | 28 | 11.82 | 0.98 | 13.1 | 4.6 | 0.46 | 7.9 | 1.58 |
| F2, F1 | 41 | 41 | 11.42 | 0.97 | 12.7 | 4.7 | 0.47 | 7 | 1.40 |
| E2, E1 | 83 | 83 | 11.92 | 1.12 | 13.4 | 3.7 | 0.37 | 5.5 | 1.10 |
| B | 90 | 90 | 9.05 | 0.86 | 10.2 | 2 | 0.20 | 7 | 1.40 |
| B2 | 116 | 129 | 7.62 | 0.89 | 8.8 | 1.5 | 0.15 | 3.8 | 0.76 |
| A-North of GIWW | 183 | 183 | 5.99 | 0.86 | 7.1 | 1.6 | 0.16 | 4.5 | 0.90 |
| A-South of GIWW | 180 | 140 | 6.9 | 0.94 | 8.1 | 2.1 | 0.21 | 5.2 | 1.04 |

## Table 36 - MTG 1% Existing Condition designs

| 1% Existing Condition Levee Designs | Top of Levee | Levee Slope | Top of Berm | Berm Slope | Toe of Berm | Levee Slope | 0.2 % Exceedence Stage Elevation |
|---|---|---|---|---|---|---|---|
| K, L | 26.5 | 1:4 | | | | | 20.7 |
| | 21.5 | 1:8 | | | | | |
| | 21.5 | 1:6 | 15 | 1:15 | 8 | 1:6 | |
| H3, I1, I2, I3, J2, J1, J3 | 30.5 | 1:4 | | | | | 20.7 |
| | 23.5 | 1:8 | | | | | |
| | 23.0 | 1:6 | 16 | 1:15 | 11.5 | 1:6 | |
| H2 | 30.0 | 1:4 | | | | | 19 |
| | 23.0 | 1:8 | | | | | |
| | 22.5 | 1:6 | 15 | 1:15 | 8.5 | 1:6 | |
| G1, G2, G3, H1 | 29.0 | 1:4 | | | | | 18.5 |
| | 23.0 | 1:8 | | | | | |
| | 22.0 | 1:6 | 14.5 | 1:15 | 8.5 | 1:6 | |
| F2, F1 | 27.5 | 1:4 | | | | | 17.9 |
| | 21.5 | 1:8 | | | | | |
| | 21.5 | 1:6 | 14 | 1:15 | 8 | 1:6 | |
| E2, E1 | 26.0 | 1:4 | | | | | 19.5 |
| | 20.5 | 1:8 | | | | | |
| | 21.0 | 1:6 | 15 | 1:15 | 10 | 1:6 | |
| B | 19.5 | 1:4 | | | | | 15.1 |
| | 17.0 | 1:8 | | | | | |
| | 16.0 | 1:6 | 11.5 | 1:15 | 8.5 | 1:6 | |
| B2 | 15.5 | 1:4 | | | | | 14.0 |
| | 14.0 | 1:8 | | | | | |
| | 14.0 | 1:6 | 10.5 | 1:15 | 7.5 | 1:6 | |
| A-North of GIWW | 13.5 | 1:4 | | | | | 11.8 |
| | 13.0 | 1:5 | | | | | |
| | 12.5 | 1:6 | | | | | |
| | 12.0 | 1:8 | | | | | |
| | 12.0 | 1:6 | 8 | 1:15 | 4.5 | 1:6 | |
| A-South of GIWW | 17.0 | 1:4 | | | | | 13.3 |
| | 14.0 | 1:8 | | | | | |
| | 13.5 | 1:6 | 9.5 | 1:15 | 6 | 1:6 | |

## Table 37 - MTG 1.33% Existing Condition designs

| 1.33% Existing Condition Levee Designs | Top of Levee | Levee Slope | Top of Berm | Berm Slope | Toe of Berm | Levee Slope | 0.2% Exceedence Surge Elevation |
|---|---|---|---|---|---|---|---|
| K, L | 20 | 1:8 | | | | | n/a |
| | 19.5 | 1:6 | 14 | 1:15 | 10 | 1:6 | |
| H3, I1, I2, I3, J2, J1, J3 | 22 | 1:8 | | | | | n/a |
| | 22 | 1:6 | 14.5 | 1:15 | 9 | 1:6 | |
| H2 | 21.5 | 1:8 | | | | | n/a |
| | 21 | 1:6 | 14 | 1:15 | 8 | 1:6 | |
| G1, G2, G3, H1 | 21.5 | 1:8 | | | | | n/a |
| | 20 | 1:6 | 13.5 | 1:15 | 8 | 1:6 | |
| F2, F1 | 20 | 1:8 | | | | | n/a |
| | 20 | 1:6 | 13 | 1:15 | 7.5 | 1:6 | |
| E2, E1 | 19 | 1:8 | | | | | n/a |
| | 19 | 1:6 | 14 | 1:15 | 9.5 | 1:6 | |
| B | 15.5 | 1:8 | | | | | n/a |
| | 14.5 | 1:6 | 10.5 | 1:15 | 8 | 1:6 | |
| B2 | 12 | 1:8 | | | | | n/a |
| | 12 | 1:6 | 9.5 | 1:15 | 7 | 1:6 | |
| A-North of GIWW | 10.5 | 1:8 | | | | | n/a |
| | 10 | 1:6 | 7.5 | 1:15 | 5.5 | 1:6 | |
| A-South of GIWW | 12.5 | 1:8 | | | | | n/a |
| | 12 | 1:6 | 8.5 | 1:15 | 5.5 | 1:6 | |

## Table 38- MTG 2% Existing Condition designs

| 2% Existing Condition Levee Designs | Top of Levee | Levee Slope | Top of Berm | Berm Slope | Toe of Berm | Levee Slope | 0.2% Exceedence Surge Elevation |
|---|---|---|---|---|---|---|---|
| K, L | 17.5 | 1:8 | | | | | |
| | 17 | 1:6 | 12.5 | 1:15 | 8 | 1:6 | n/a |
| H3, I1, I2, I3, J2, J1, J3 | 20 | 1:8 | | | | | |
| | 18.5 | 1:6 | 14 | 1:15 | 8 | 1:6 | n/a |
| H2 | 18.5 | 1:8 | | | | | |
| | 18.5 | 1:6 | 13.5 | 1:15 | 7.5 | 1:6 | n/a |
| G1, G2, G3, H1 | 19 | 1:8 | | | | | |
| | 17.5 | 1:6 | 13 | 1:15 | 7.5 | 1:6 | n/a |
| F2, F1 | 17.5 | 1:8 | | | | | |
| | 17.5 | 1:6 | 12.5 | 1:15 | 7 | 1:6 | n/a |
| E2, E1 | 16.5 | 1:8 | | | | | |
| | 16.5 | 1:6 | 12 | 1:15 | 8.5 | 1:6 | n/a |
| B | 13 | 1:8 | | | | | |
| | 12.5 | 1:6 | 9.5 | 1:15 | 7.5 | 1:6 | n/a |
| B2 | 10 | 1:8 | | | | | |
| | 10 | 1:6 | 8 | 1:15 | 6.5 | 1:6 | n/a |
| A-North of GIWW | 8.5 | 1:8 | | | | | |
| | 8 | 1:6 | 6 | 1:15 | 4.5 | 1:6 | n/a |
| A-South of GIWW | 10 | 1:8 | | | | | |
| | 10 | 1:6 | 7 | 1:15 | 5 | 1:6 | n/a |

#### 2.6.1.1.1.1 Base and Future Conditions

As with existing conditions, 1%, 1.33%, and 2.0% designs were generated for base and future conditions. Future conditions designs made use of all with-project model simulations. SLR rates for base and future conditions ranged from 0.57 feet to 4.5 feet. Based on the timeline of design/ calculations, the future condition designs were done before the 5 feet SLR runs were considered. Therefore, the analysis made use of existing condition runs, 1.15 feet SLR runs, as well as the work done as part of the 3.2 feet SLR sensitivity analysis. None of the model runs were specifically done for any of the future condition SLR rates. Linear interpolation was considered the best method to compute approximate values for each specific SLR case. All base and future condition designs were to be based on the same surge and wave points. Thus, the limiting factor here was the lack of data available at the 3.2 ft. SLR runs. Surge was only available at points 36, 45, 80, 83, 90, 96, 174, and 208. Wave points included 31, 36, 41, 90, 96, 103, 140, and 208. Through mapping, pairs of surge and wave points were established for each reach (Table 39). Refer to ERDC's report on the 3.2ft SLR sensitivity analysis for more information.

**Table 39 - MTG Base (2035) and Future (2085) Design Points**

| Reach | Surge Pt. | Wave Pt. |
|---|---|---|
| K, L | 174 | 103 |
| H3, I1, I2, I3, J2, J1, J3 | 96 | 96 |
| H2 | 45 | 31 |
| G1, G2, G3, H1 | 36 | 36 |
| E2, E1, F2, F1 | 83 | 90 |
| B | 90 | 90 |
| B2 | 90 | 90 |
| A South of GIWW | 90 | 90 |
| A North of GIWW | 208 | 208 |

Table 40 through Table 43 provide the SWE, SWE Standard Deviation, Hs, and Tm, respectively, for all model runs and corresponding interpolated values for base and future condition SLR rates. Linear extrapolation of SLR data produced surge and wave characteristics at the 4.75 ft SLR rate. The same design procedure followed for existing condition designs was done for future conditions. A constant berm slope of 1 on 15 was used for all designs since this slope was most efficient in the existing condition design analysis. A larger number of designs had to be completed for base and future conditions due to all the SLR scenarios. Thus, a constant berm factor of 0.75 was approximated for all design cases. Design maps for base and future conditions are given in Figure 28 and Figure 29.

## Table 40 - Base and Future Condition 1%, 1.33%, and 2% SWE Values for Various SLR rates

| SURGE | Point | SWE 100 year | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 0.57 | 0.72 | 1.12 | 1.15 | 1.18 | 1.51 | 1.7 | 2.42 | 2.75 | 3.2 | 4.75 |
| Reach K, L | 174 | 14.9 | 15.9 | 16.1 | 16.8 | 16.8 | 16.8 | 17.1 | 17.2 | 17.7 | 18.0 | 18.3 | 19.4 |
| Reach H3, I1, I2, I3, I?, J1, J3 | 96 | 15.6 | 16.2 | 16.3 | 16.7 | 16.7 | 16.8 | 17.0 | 17.2 | 17.8 | 18.0 | 18.4 | 19.7 |
| Reach H2 | 45 | 14.6 | 15.2 | 15.3 | 15.7 | 15.8 | 15.8 | 16.1 | 16.3 | 17.0 | 17.4 | 17.8 | 19.3 |
| Reach G1, G2, G3, H1 | 36 | 14.3 | 14.7 | 14.8 | 15.1 | 15.2 | 15.2 | 15.5 | 15.6 | 16.2 | 16.5 | 16.9 | 18.2 |
| Reach E2, E1, F2, F1 | 83 | 14.6 | 15.1 | 15.2 | 15.5 | 15.5 | 15.6 | 15.8 | 16.0 | 16.6 | 16.8 | 17.2 | 18.5 |
| Reach B/B2/A south of GIWW | 90 | 11.4 | 12.2 | 12.4 | 12.9 | 13.0 | 13.0 | 13.3 | 13.5 | 14.2 | 14.6 | 15.0 | 16.6 |
| Reach A North of GIWW | 208 | 8.0 | 9.9 | 10.4 | 11.8 | 11.9 | 11.9 | 12.4 | 12.6 | 13.7 | 14.2 | 14.8 | 17.0 |

| SURGE | SWE 75 year | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 0.57 | 0.72 | 1.12 | 1.15 | 1.18 | 1.51 | 1.7 | 2.42 | 2.75 | 3.2 | 4.75 |
| Reach K, L | 13.8 | 14.7 | 15.0 | 15.6 | 15.7 | 15.7 | 15.9 | 16.0 | 16.4 | 16.6 | 16.8 | 17.7 |
| Reach H3, I1, I2, I3, I?, J1, J3 | 14.5 | 15.1 | 15.2 | 15.6 | 15.7 | 15.7 | 15.9 | 16.1 | 16.6 | 16.8 | 17.1 | 18.2 |
| Reach H2 | 13.6 | 14.2 | 14.3 | 14.7 | 14.8 | 14.8 | 15.1 | 15.2 | 15.8 | 16.1 | 16.5 | 17.8 |
| Reach G1, G2, G3, H1 | 13.3 | 13.8 | 13.9 | 14.2 | 14.2 | 14.2 | 14.4 | 14.5 | 15.0 | 15.1 | 15.4 | 16.3 |
| Reach E2, E1, F2, F1 | 13.6 | 14.0 | 14.2 | 14.5 | 14.5 | 14.6 | 14.7 | 14.8 | 15.2 | 15.4 | 15.6 | 16.4 |
| Reach B/B2/A south of GIWW | 10.5 | 11.3 | 11.5 | 12.0 | 12.0 | 12.1 | 12.3 | 12.5 | 13.1 | 13.4 | 13.8 | 15.1 |
| Reach A North of GIWW | 7.2 | 9.0 | 9.5 | 10.8 | 10.9 | 10.9 | 11.3 | 11.6 | 12.5 | 12.9 | 13.5 | 15.5 |

| SURGE | SWE 50 year | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 0.57 | 0.72 | 1.12 | 1.15 | 1.18 | 1.51 | 1.7 | 2.42 | 2.75 | 3.2 | 4.75 |
| Reach K, L | 12.1 | 13.0 | 13.3 | 14.0 | 14.0 | 14.0 | 14.2 | 14.3 | 14.8 | 15.0 | 15.3 | 16.3 |
| Reach H3, I1, I2, I3, I?, J1, J3 | 12.9 | 13.6 | 13.7 | 14.1 | 14.1 | 14.2 | 14.5 | 14.6 | 15.3 | 15.6 | 16.0 | 17.4 |
| Reach H2 | 12.2 | 12.7 | 12.9 | 13.3 | 13.3 | 13.3 | 13.7 | 13.8 | 14.5 | 14.9 | 15.3 | 16.8 |
| Reach G1, G2, G3, H1 | 11.8 | 12.3 | 12.4 | 12.8 | 12.8 | 12.8 | 13.0 | 13.2 | 13.7 | 13.9 | 14.2 | 15.3 |
| Reach E2, E1, F2, F1 | 11.9 | 12.5 | 12.6 | 13.0 | 13.0 | 13.0 | 13.2 | 13.3 | 13.7 | 13.9 | 14.2 | 15.1 |
| Reach B/B2/A south of GIWW | 9.1 | 9.8 | 10.0 | 10.5 | 10.6 | 10.6 | 10.9 | 11.1 | 11.8 | 12.1 | 12.5 | 14.0 |
| Reach A North of GIWW | 6.9 | 7.6 | 8.0 | 9.2 | 9.3 | 9.4 | 9.8 | 10.1 | 11.1 | 11.6 | 12.2 | 14.4 |

## Table 41 - Base and Future Condition 1%, 1.33%, and 2% SWE Standard Deviation Values for Various SLR rates.

| STANDARD DEVIATION | Point | SWE StDev 100 year | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 0.57 | 0.72 | 1.12 | 1.15 | 1.18 | 1.51 | 1.7 | 2.42 | 2.75 | 3.2 | 4.75 |
| Reach K, L | 174 | 1.52 | 1.52 | 1.52 | 1.51 | 1.51 | 1.51 | 1.54 | 1.55 | 1.60 | 1.62 | 1.65 | 1.75 |
| Reach H3, I1, I2, I3, I?, J1, J3 | 96 | 1.36 | 1.35 | 1.35 | 1.34 | 1.34 | 1.35 | 1.37 | 1.38 | 1.43 | 1.45 | 1.48 | 1.58 |
| Reach H2 | 45 | 1.17 | 1.18 | 1.18 | 1.19 | 1.19 | 1.19 | 1.22 | 1.23 | 1.28 | 1.31 | 1.34 | 1.46 |
| Reach G1, G2, G3, H1 | 36 | 1.13 | 1.11 | 1.10 | 1.09 | 1.09 | 1.09 | 1.11 | 1.12 | 1.17 | 1.19 | 1.21 | 1.31 |
| Reach E2, E1, F2, F1 | 83 | 1.29 | 1.24 | 1.23 | 1.19 | 1.19 | 1.19 | 1.21 | 1.22 | 1.26 | 1.28 | 1.31 | 1.41 |
| Reach B | 90 | 0.99 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 1.03 | 1.04 | 1.10 | 1.13 | 1.16 | 1.28 |
| Reach A north of GIWW | 208 | 1.04 | 1.16 | 1.19 | 1.28 | 1.28 | 1.29 | 1.34 | 1.37 | 1.48 | 1.53 | 1.60 | 1.84 |

| STANDARD DEVIATION | SWE StDev 75 year | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 0.57 | 0.72 | 1.12 | 1.15 | 1.18 | 1.51 | 1.7 | 2.42 | 2.75 | 3.2 | 4.75 |
| Reach K, L | 1.44 | 1.43 | 1.43 | 1.43 | 1.43 | 1.43 | 1.45 | 1.46 | 1.49 | 1.51 | 1.53 | 1.61 |
| Reach H3, I1, I2, I3, I?, J1, J3 | 1.28 | 1.28 | 1.27 | 1.27 | 1.27 | 1.27 | 1.29 | 1.30 | 1.34 | 1.36 | 1.38 | 1.47 |
| Reach H2 | 1.11 | 1.11 | 1.12 | 1.12 | 1.12 | 1.13 | 1.15 | 1.16 | 1.20 | 1.23 | 1.25 | 1.35 |
| Reach G1, G2, G3, H1 | 1.07 | 1.05 | 1.04 | 1.03 | 1.03 | 1.03 | 1.04 | 1.05 | 1.08 | 1.10 | 1.11 | 1.18 |
| Reach E2, E1, F2, F1 | 1.22 | 1.17 | 1.16 | 1.12 | 1.12 | 1.12 | 1.13 | 1.14 | 1.17 | 1.18 | 1.20 | 1.26 |
| Reach B | 0.93 | 0.94 | 0.94 | 0.95 | 0.95 | 0.95 | 0.97 | 0.98 | 1.03 | 1.06 | 1.09 | 1.19 |
| Reach A north of GIWW | 0.99 | 1.10 | 1.13 | 1.21 | 1.21 | 1.22 | 1.27 | 1.29 | 1.40 | 1.44 | 1.51 | 1.73 |

| STANDARD DEVIATION | SWE StDev 50 year | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 0.57 | 0.72 | 1.12 | 1.15 | 1.18 | 1.51 | 1.7 | 2.42 | 2.75 | 3.2 | 4.75 |
| Reach K, L | 1.32 | 1.32 | 1.32 | 1.31 | 1.31 | 1.31 | 1.33 | 1.34 | 1.39 | 1.41 | 1.43 | 1.52 |
| Reach H3, I1, I2, I3, I?, J1, J3 | 1.18 | 1.17 | 1.17 | 1.17 | 1.17 | 1.17 | 1.19 | 1.21 | 1.26 | 1.29 | 1.32 | 1.44 |
| Reach H2 | 1.02 | 1.02 | 1.02 | 1.03 | 1.03 | 1.03 | 1.05 | 1.07 | 1.13 | 1.15 | 1.18 | 1.30 |
| Reach G1, G2, G3, H1 | 0.98 | 0.96 | 0.96 | 0.96 | 0.94 | 0.95 | 0.96 | 0.97 | 1.01 | 1.03 | 1.05 | 1.13 |
| Reach E2, E1, F2, F1 | 1.12 | 1.07 | 1.06 | 1.03 | 1.03 | 1.03 | 1.04 | 1.05 | 1.09 | 1.10 | 1.12 | 1.19 |
| Reach B | 0.86 | 0.86 | 0.86 | 0.87 | 0.87 | 0.87 | 0.90 | 0.91 | 0.97 | 0.99 | 1.03 | 1.15 |
| Reach A north of GIWW | 0.90 | 1.01 | 1.03 | 1.11 | 1.11 | 1.12 | 1.17 | 1.20 | 1.33 | 1.38 | 1.46 | 1.71 |

## Table 42 - Base and Future Condition 1%, 1.33%, and 2% Wave Height Values for Various SLR rates

| WAVE HEIGHT | Point | Hs 100 year | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0.00 | 0.57 | 0.72 | 1.12 | 1.15 | 1.18 | 1.51 | 1.70 | 2.42 | 2.75 | 3.20 | 4.75 |
| Reach H2 | 31 | 6.2 | 6.5 | 6.6 | 6.9 | 6.9 | 6.9 | 7.1 | 7.2 | 7.6 | 7.8 | 8.0 | 8.8 |
| Reach H3, I1, I2, I3, J2, J1, J3 | 96 | 6.4 | 6.8 | 6.9 | 7.2 | 7.2 | 7.2 | 7.4 | 7.5 | 7.9 | 8.1 | 8.4 | 9.3 |
| Reach G1, G2, G3, H1 | 36 | 6.1 | 6.4 | 6.5 | 6.7 | 6.8 | 6.8 | 6.9 | 7.0 | 7.4 | 7.6 | 7.9 | 8.7 |
| Reach K, L | 103 | 4.5 | 4.8 | 4.9 | 5.1 | 5.1 | 5.1 | 5.4 | 5.5 | 6.0 | 6.3 | 6.6 | 7.7 |
| Reach B/ B2/ E2, E1, F2, F1/ A South of GIWW | 90 | 3.2 | 3.5 | 3.6 | 3.9 | 3.9 | 3.9 | 4.1 | 4.2 | 4.6 | 4.8 | 5.0 | 5.8 |
| Reach A North of GIWW | 208 | 2.0 | 2.8 | 3.0 | 3.6 | 3.6 | 3.6 | 3.8 | 4.0 | 4.5 | 4.7 | 5.0 | 6.1 |

| WAVE HEIGHT | Point | Hs 75 year | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0.00 | 0.57 | 0.72 | 1.12 | 1.15 | 1.18 | 1.51 | 1.70 | 2.42 | 2.75 | 3.20 | 4.75 |
| Reach H2 | 31 | 5.8 | 6.1 | 6.2 | 6.4 | 6.4 | 6.4 | 6.6 | 6.7 | 7.1 | 7.3 | 7.5 | 8.3 |
| Reach H3, I1, I2, I3, J2, J1, J3 | 96 | 5.8 | 6.2 | 6.4 | 6.7 | 6.7 | 6.7 | 6.9 | 7.0 | 7.4 | 7.5 | 7.8 | 8.5 |
| Reach G1, G2, G3, H1 | 36 | 5.6 | 5.9 | 6.0 | 6.3 | 6.3 | 6.3 | 6.4 | 6.5 | 6.8 | 6.9 | 7.1 | 7.6 |
| Reach K, L | 103 | 4.1 | 4.4 | 4.5 | 4.7 | 4.7 | 4.7 | 4.9 | 5.0 | 5.5 | 5.7 | 6.0 | 7.0 |
| Reach B/ B2/ E2, E1, F2, F1/ A South of GIWW | 90 | 2.7 | 3.0 | 3.1 | 3.4 | 3.4 | 3.4 | 3.5 | 3.6 | 3.9 | 4.0 | 4.2 | 4.7 |
| Reach A North of GIWW | 208 | 1.7 | 2.4 | 2.6 | 3.2 | 3.2 | 3.2 | 3.5 | 3.6 | 4.2 | 4.4 | 4.8 | 5.9 |

| WAVE HEIGHT | Point | Hs 50 year | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0.00 | 0.57 | 0.72 | 1.12 | 1.16 | 1.18 | 1.51 | 1.70 | 2.42 | 2.75 | 3.20 | 4.75 |
| Reach H2 | 31 | 5.0 | 5.3 | 5.4 | 5.7 | 5.7 | 5.7 | 5.9 | 6.0 | 6.5 | 6.7 | 7.0 | 8.0 |
| Reach H3, I1, I2, I3, J2, J1, J3 | 96 | 5.0 | 5.4 | 5.6 | 5.9 | 5.9 | 5.9 | 6.1 | 6.2 | 6.7 | 6.9 | 7.2 | 8.2 |
| Reach G1, G2, G3, H1 | 36 | 4.9 | 5.2 | 5.3 | 5.5 | 5.5 | 5.5 | 5.6 | 5.7 | 5.9 | 6.0 | 6.2 | 6.6 |
| Reach K, L | 103 | 3.5 | 3.8 | 3.9 | 4.2 | 4.2 | 4.2 | 4.4 | 4.5 | 4.9 | 5.1 | 5.4 | 6.3 |
| Reach B/ B2/ E2, E1, F2, F1/ A South of GIWW | 90 | 2.0 | 2.3 | 2.4 | 2.7 | 2.7 | 2.7 | 2.8 | 2.8 | 3.0 | 3.1 | 3.3 | 3.7 |
| Reach A North of GIWW | 208 | 1.2 | 1.9 | 2.1 | 2.6 | 2.6 | 2.6 | 2.9 | 3.1 | 3.8 | 4.1 | 4.5 | 5.9 |

## Table 43 - Base and Future Condition 1%, 1.33%, and 2% Mean Wave Period Values for Various SLR rates

| WAVE PERIOD | Point | Tm 100 year | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0.00 | 0.57 | 0.72 | 1.12 | 1.15 | 1.18 | 1.51 | 1.70 | 2.42 | 2.75 | 3.20 | 4.75 |
| Reach H2 | 31 | 7.9 | 7.9 | 8.0 | 8.0 | 8.0 | 8.0 | 8.1 | 8.2 | 8.4 | 8.5 | 8.6 | 9.1 |
| Reach H3, I1, I2, I3, J2, J1, J3 | 96 | 7.1 | 7.2 | 7.2 | 7.3 | 7.3 | 7.3 | 7.4 | 7.5 | 7.7 | 7.8 | 7.9 | 8.4 |
| Reach G1, G2, G3, H1 | 36 | 7.1 | 7.2 | 7.3 | 7.4 | 7.4 | 7.4 | 7.5 | 7.6 | 7.8 | 7.9 | 8.0 | 8.5 |
| Reach K, L | 103 | 6.7 | 6.8 | 6.9 | 7.0 | 7.0 | 7.0 | 7.2 | 7.3 | 7.6 | 7.8 | 8.0 | 8.8 |
| Reach B/ B2/ E2, E1, F2, F1/ Asouth of GIWW | 90 | 7.1 | 7.1 | 7.0 | 7.0 | 7.0 | 7.0 | 7.2 | 7.2 | 7.6 | 7.7 | 7.9 | 8.6 |
| Reach A north of GIWW | 208 | 4.6 | 5.0 | 5.2 | 5.5 | 5.5 | 5.5 | 5.7 | 5.8 | 6.1 | 6.3 | 6.5 | 7.3 |

| WAVE PERIOD | Point | Tm 75 year | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0.00 | 0.57 | 0.72 | 1.12 | 1.15 | 1.18 | 1.51 | 1.70 | 2.42 | 2.75 | 3.20 | 4.75 |
| Reach H2 | 31 | 7.8 | 7.9 | 7.9 | 8.0 | 8.0 | 8.0 | 8.1 | 8.2 | 8.4 | 8.5 | 8.7 | 9.2 |
| Reach H3, I1, I2, I3, J2, J1, J3 | 96 | 7.1 | 7.2 | 7.2 | 7.3 | 7.3 | 7.3 | 7.4 | 7.5 | 7.7 | 7.8 | 7.9 | 8.4 |
| Reach G1, G2, G3, H1 | 36 | 7.0 | 7.2 | 7.3 | 7.4 | 7.4 | 7.4 | 7.5 | 7.5 | 7.6 | 7.7 | 7.8 | 8.1 |
| Reach K, L | 103 | 6.5 | 6.7 | 6.8 | 6.9 | 6.9 | 6.9 | 7.1 | 7.1 | 7.5 | 7.6 | 7.8 | 8.5 |
| Reach B/ B2/ E2, E1, F2, F1/ Asouth of GIWW | 90 | 7.1 | 7.1 | 7.0 | 7.0 | 7.0 | 7.0 | 7.1 | 7.2 | 7.4 | 7.5 | 7.7 | 8.2 |
| Reach A north of GIWW | 208 | 4.4 | 4.8 | 5.0 | 5.3 | 5.3 | 5.3 | 5.5 | 5.7 | 6.2 | 6.4 | 6.7 | 7.8 |

| WAVE PERIOD | Point | Tm 50 year | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0.00 | 0.57 | 0.72 | 1.12 | 1.16 | 1.18 | 1.51 | 1.70 | 2.42 | 2.75 | 3.20 | 4.76 |
| Reach H2 | 31 | 7.8 | 7.9 | 7.9 | 8.0 | 8.0 | 8.0 | 8.2 | 8.2 | 8.6 | 8.7 | 8.9 | 9.6 |
| Reach H3, I1, I2, I3, J2, J1, J3 | 96 | 7.0 | 7.1 | 7.2 | 7.3 | 7.3 | 7.3 | 7.4 | 7.5 | 7.8 | 7.9 | 8.1 | 8.7 |
| Reach G1, G2, G3, H1 | 36 | 6.9 | 7.1 | 7.2 | 7.4 | 7.4 | 7.4 | 7.5 | 7.5 | 7.6 | 7.7 | 7.8 | 8.1 |
| Reach K, L | 103 | 6.3 | 6.5 | 6.6 | 6.8 | 6.8 | 6.8 | 7.0 | 7.0 | 7.4 | 7.5 | 7.7 | 8.4 |
| Reach B/ B2/ E2, E1, F2, F1/ Asouth of GIWW | 90 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 7.1 | 7.2 | 7.4 | 7.5 | 7.7 | 8.2 |
| Reach A north of GIWW | 208 | 4.1 | 4.6 | 4.7 | 5.1 | 5.1 | 5.1 | 5.4 | 5.5 | 6.1 | 6.3 | 6.7 | 7.9 |

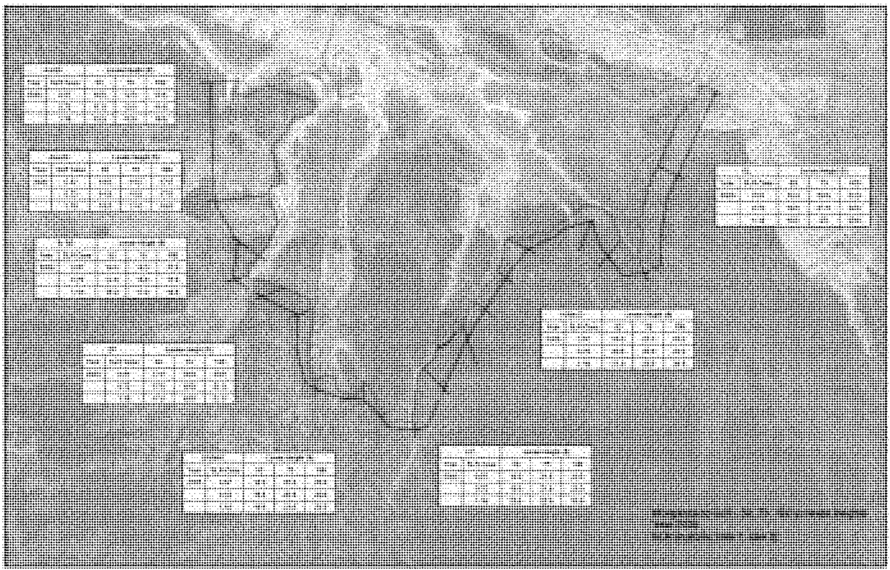


Figure 28 - Base Condition (2035) Levee Design Elevation Map

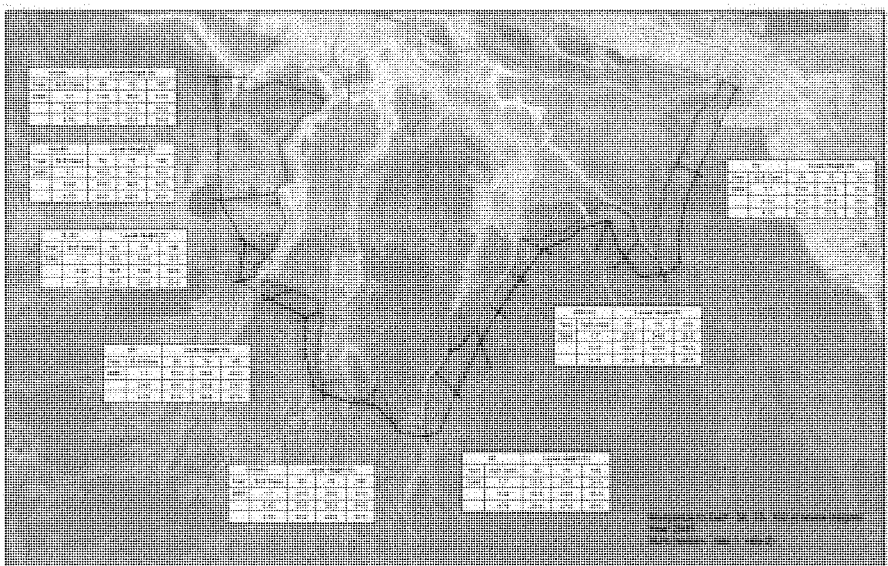


Figure 29 - Future Condition (2085) Levee Design Elevation Map

### 2.6.1.1.2 Barrier and Northern Alignment

In addition to designs done for the authorized alignment levee designs were completed for barrier and northern alignments. Approximate barrier and northern alignments are shown below in Figure 30. The barrier alignment was the western section of the authorized alignment stemming from the end of Reach A while the northern alignment stems from a high point in the ridge just above the end of Reach A. These alignments would also have to be broken into hydraulic reaches before doing levee design calculations. The barrier alignment was considered one continuous hydraulic reach while the northern alignment was separated into two hydraulic reaches. Only future condition designs were completed for the barrier and northern alignments.

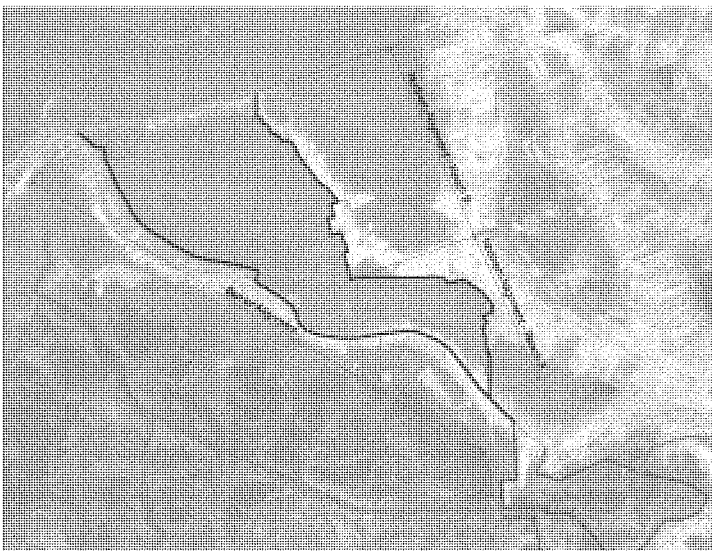


**Figure 30 - Barrier and Northern Alignments. Bottom –right corner of figure depicts Reach A-North connection to Barrier Alignment**

#### 2.6.1.1.2.1 Future Conditions

Future condition levee designs were completed for barrier and northern alignments. Barrier alignment design values were interpolated and just as the authorized alignment future condition design values. Design methodology was similar to the other designs. The northern alignment future condition values were calculated differently. This alignment was not modeled in the main mesh due to the barrier alignment always being included in with-project conditions. Computations were made to approximate with project conditions in front of the northern alignment reaches. With and without project conditions were examined in front of the barrier alignment and average differences were taken for all design parameters (i.e., SWE, Hs, and Tm). These average differences were applied to the without project northern alignment values to determine approximate with project conditions. The resulting values for with project conditions are given in Table 44. From this point, the designs were completed as normally done. The computed design elevations are provided in Table 45. Northern alignment surge and wave point bins contain acronym for not applicable, N/A, since multiple points in front of the northern alignment reaches were used to arrive at the final values. One of the resiliency criteria used in levee design is comparing the final levee design elevation to the 0.2% AEP value to make sure the design elevation is higher. Asterisks near the northern alignment design elevations indicate a need to raise the levee elevation above the 0.2% exceedance surge elevation.

**Table 44 - Design parameters for future condition (2085) 1% levee designs. Both barrier and northern alignment data are given in the table**

| Reach | Surge J-Point | Wave J-Point | Surge Elevation (ft) | | 90% Surge Elevation (ft) | Significant Wave Height (ft) | | Period (s) | |
|---|---|---|---|---|---|---|---|---|---|
| | | | mean | std | | mean | std | mean | std |
| Barrier Alignment | 225 | 225 | 14.08 | 1.4 | 15.9 | 4.9 | 0.49 | 6.2 | 1.24 |
| Northern Alignment - Reach A | N/A | N/A | 11.2 | 1.74 | 13.4 | 2.1 | 0.21 | 5.0 | 1.00 |
| Northern Alignment - Reach B | N/A | N/A | 11.31 | 1.52 | 13.3 | 1.9 | 0.19 | 6.3 | 1.26 |

**Table 45 - Design elevations for future condition (2085) 1% levee designs. Both barrier and northern alignment data are given in the table**

| Reach | Top of Levee (ft) | Levee Slope | Top of Berm (ft) | Berm Slope | Toe of Berm (ft) | Levee Slope | 0.2 % Exceedence Surge Elevation (ft) |
|---|---|---|---|---|---|---|---|
| Barrier Alignment | 20 | 1 on 6 | 14.1 | 1 on 15 | 9.2 | 1 on 6 | 19.3 |
| Northern Alignment - A | 18* (16) | 1 on 4 | 11.2 | 1 on 10 | 9.1 | 1 on 4 | 17.8 |
| Northern Alignment - B | 17* (16) | 1 on 4 | 11.3 | 1 on 15 | 9.4 | 1 on 4 | 16.7 |

### 2.6.1.1.3 Multiple Lines of Defense Alignment

The multiple lines of defense alignment, also known as MLODS, emerged as a possible alternative alignment early in the project. The alignment consists of 10 reaches including ring levees surrounding Theriot, LA and Dulac, LA (Figure 31).

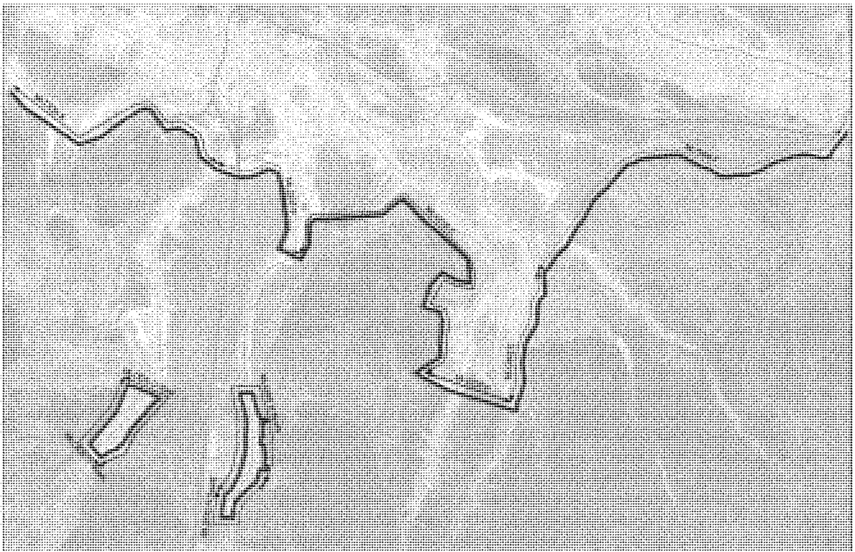


Figure 31 - MLODS alignment. Each of the 10 reaches is also given

### 2.6.1.1.3.1 Existing Conditions

Existing condition 1% designs were completed on the MLODS alignment. Table 46 gives all input values for each reach while Table 47 gives a summary of all design elevations.

**Table 46 - Summary of 1% MLODS input values**

| | Surge Point | Wave Point | Surge Elevation (ft) | | 90% Surge Elevation (ft) | Significant Wave Height (ft) | | Mean Period (s) | |
|---|---|---|---|---|---|---|---|---|---|
| **Reach** | | | mean | std | | mean | std | mean | std |
| MLODS-A | 189 | 208 | 9.8 | 1.18 | 11.3 | 2.2 | 0.22 | 4.8 | 0.96 |
| MLODS-B | 153 | 153 | 12.63 | 1.26 | 14.2 | 2.3 | 0.23 | 5.7 | 1.14 |
| MLODS-C | 148 | 145 | 14.16 | 1.38 | 15.9 | 3.6 | 0.36 | 5 | 1.00 |
| MLODS-D | 96 | 96 | 12.91 | 0.97 | 14.2 | 5.1 | 0.51 | 7 | 1.40 |
| MLODS-E | 117 | 106 | 13.26 | 1.09 | 14.7 | 4.8 | 0.48 | 6.8 | 1.36 |
| MLODS-F | 175 | 144 | 13.55 | 1.43 | 15.4 | 3.2 | 0.32 | 6.4 | 1.28 |
| MLODS G-West | 90 | 90 | 11.07 | 0.94 | 12.3 | 2.7 | 0.27 | 6.8 | 1.36 |
| MLODS G-East | 98 | 83 | 12.95 | 1.12 | 14.4 | 4.3 | 0.43 | 6.2 | 1.24 |
| MLODS H-North | 123 | 95 | 13.11 | 1.22 | 14.7 | 4 | 0.40 | 6.1 | 1.22 |
| MLODS H-South | 81 | 72 | 12.54 | 1.08 | 13.9 | 3.4 | 0.34 | 6 | 1.20 |

**Table 47 - Summary of 1% design elevations established for MLODS alignment**

| Reach | Top of Levee (ft) | Levee Slope | Top of Berm (ft) | Berm Slope | Toe of Berm (ft) | Levee Slope | 0.2 % Exceedence Surge Elevation (ft) |
|---|---|---|---|---|---|---|---|
| MLODS-A | 13* (14.5) | 1:6 | 10 | 1:15 | 8 | 1:6 | 14.21 |
| MLODS-B | 16* (17.5) | 1:6 | 13 | 1:15 | 10.5 | 1:6 | 17.35 |
| MLODS-C | 19* (19.5) | 1:6 | 14.5 | 1:15 | 11 | 1:6 | 19.33 |
| MLODS-D | 19.5 | 1:6 | 13 | 1:15 | 8 | 1:6 | 16.56 |
| MLODS-E | 19.5 | 1:6 | 13.5 | 1:15 | 8.5 | 1:6 | 17.35 |
| MLODS-F | 18* (19) | 1:6 | 14 | 1:15 | 10.5 | 1:6 | 18.91 |
| MLODS G-West | 15 | 1:6 | 11.5 | 1:15 | 8.5 | 1:6 | 14.58 |
| MLODS G-East | 18.5 | 1:6 | 13 | 1:15 | 9 | 1:6 | 17.12 |
| MLODS H-North | 18.5 | 1:6 | 13.5 | 1:15 | 9.5 | 1:6 | 17.69 |
| MLODS H-South | 17 | 1:6 | 13 | 1:15 | 9.5 | 1:6 | 16.56 |

After comparing existing condition designs to that of the authorized alignment, the project management team decided to continue with the authorized alignment and forego MLODS.

#### 2.6.1.2 Structure Designs

Structure designs were completed for a total of 27 structures throughout the authorized alignment. The structure types include locks, sector gates, flood gates, and sluice gates. A list of structures along with invert is provided below in Table 48. The acronyms GIWW and HNC refer to Gulf Intracoastal Waterway and Houma Navigation Canal, respectively. Structures are only looked at from a surge reduction perspective and not from a hydrological perspective.

**Table 48 - List of structures for the authorized alignment including invert elevations**

| Structure | Invert (ft.) |
|---|---|
| Minors Canal Gate | -9 |
| GIWW Sector Gate West | -12 |
| Falgout Canal Sector Gate | -9 |
| ECS- 6-6'x6' Box Culverts With Sluice Gates - Reach B | -4.5 |
| Bayou Dularge Sector Gate | -7 |
| Bayou Grand Caillou Sector Gate | -12 |
| HNC Lock | -20 |
| HNC Floodgate | -20 |
| ECS- 6-6'x6' Box Culverts With Sluice Gates - Reach G2 | -4.5 |
| ECS- 9-6'x6' Box Culverts With Sluice Gates - Reach E1 | -4.5 |
| ECS- 9-6'x6' Box Culverts With Sluice Gates - Reach E2 | -4.5 |
| ECS- 1-6'x6' Box Culvert With Sluice Gate - Reach H1 | -4.5 |
| ECS- 6-6'x6' Box Culvert With Sluice Gate - Reach H1 | -4.5 |
| Lapeyrouse Sector Gate | -9 |
| Placid Canal Sector Gate | -8 |
| Bayou Petite Caillou Sector Gate | -8 |
| Bush Canal Sector Gate | -12 |
| Bayou Terrebonne Floodgate | -9 |
| Humble Canal Sector Gate | -9 |
| ECS- 5-5'x10' Box Culverts With Sluice Gates - Reach J2 | -3.5 |
| ECS- 4-5'x10' Box Culverts With Sluice Gates - Reach J2 | -3.5 |
| Point Au Chiene Sector Gate | -6 |
| ECS- 2-6'x6' Box Culverts With Sluice Gates - Reach K | -4.5 |
| Grand Bayou Sector Gate | -9 |
| ECS- 6-5'x10' Box Culverts With Sluice Gates - Reach L | -4.5 |
| Four Point Bayou Sector Gate | -6 |
| GIWW Sector Gate East | -12 |

Additionally, some of the structure inverts were modified based on decisions made by the project management team. HNC structures were changed from -23 to -20 feet (-18 feet sill depth with two feet of overdredge) and GIWW structures were changed from -15 to -12 feet. For a given structure the SWE, Hs, Tm, and all other design information was needed similar to levee design. The same matlab script used for levee design was used here. The Franco and Franco overtopping formulations are used instead of the Van der Meer overtopping equation as in levee design (TAW, 2002). Choosing the option for floodwall design in the script the slope and berm factor input lines become inactive. All structures will have no slope since it is vertical and will not use a berm factor since it will be in the channel. From this point, the same type of 10,000 iteration Monte Carlo simulation is done to compute structural elevations. The q90 criterion is the same as in levee design while the q50 criterion is modified to 0.03 cfs/ft per linear foot instead of the original levee threshold of 0.01 cfs/ft per linear foot as outlined in *Hurricane and Storm Damage Reduction System Design Guidelines (Interim), New Orleans District, Engineering Division, October 2007.*

#### 2.6.1.2.1 Authorized Alignment Future Conditions

Authorized alignment 1% structure designs are given in Table 49. Two feet of structural superiority was added to the design elevation on all structures on the basis that it would be very difficult to rebuild, if damaged, because of disruption in services.

**Table 49 - Results for 1% future condition (2085) Structure Designs**

| Structure | Lat | Lon | SWE (ft.) | StDev (ft.) | 90% SWE (ft.) | Structure Elevation (ft.) | Structure Elevation (ft.) (2 ft. Structural Superiority) |
|---|---|---|---|---|---|---|---|
| Minors Canal Gate | 29.55273 | -90.79693 | 13.7 | 1.5 | 15.6 | 21.0 | 23.0 |
| GIWW Sector Gate West | 29.53519 | -90.79261 | 13.7 | 1.5 | 15.6 | 21.0 | 23.0 |
| Falgout Canal Sector Gate | 29.41448 | -90.78560 | 14.2 | 1.1 | 15.6 | 21.0 | 23.0 |
| ECS- 6-6'x6' Box Culverts With Sluice Gates - Reach B | 29.46103 | -90.76387 | 14.2 | 1.1 | 15.6 | 21.0 | 23.0 |
| Bayou Dularge Sector Gate | 29.40828 | -90.78688 | 16.6 | 1.3 | 18.2 | 23.5 | 25.5 |
| Bayou Grand Caillou Sector Gate | 29.34256 | -90.73667 | 16.6 | 1.3 | 18.2 | 23.5 | 25.5 |
| HNC Lock | 29.33112 | -90.73086 | 16.2 | 1.2 | 17.7 | 28.5 | 30.5 |
| HNC Floodgate | 29.33112 | -90.73086 | 16.2 | 1.2 | 17.7 | 28.5 | 30.5 |
| ECS- 6-6'x6' Box Culverts With Sluice Gates - Reach G2 | 29.31783 | -90.69562 | 16.2 | 1.2 | 17.7 | 28.0 | 30.5 |
| ECS- 9-6'x6' Box Culverts With Sluice Gates - Reach E1 | 29.40731 | -90.76983 | 16.6 | 1.3 | 18.2 | 23.5 | 25.5 |
| ECS- 9-6'x6' Box Culverts With Sluice Gates - Reach E2 | 29.39878 | -90.74622 | 16.6 | 1.3 | 18.2 | 23.5 | 25.5 |
| ECS- 1-6'x6' Box Culvert With Sluice Gate - Reach H1 | 29.30226 | -90.67001 | 16.2 | 1.2 | 17.7 | 28.0 | 30.5 |
| ECS- 6-6'x6' Box Culvert With Sluice Gate - Reach H1 | 29.29727 | -90.65869 | 16.2 | 1.2 | 17.7 | 28.0 | 30.5 |
| Lapeyrouse Sector Gate | 29.30892 | -90.64590 | 17.0 | 1.3 | 18.6 | 29.5 | 31.5 |
| Placid Canal Sector Gate | 29.33804 | -90.63685 | 17.0 | 1.3 | 18.6 | 29.5 | 31.5 |
| Bayou Petite Caillou Sector Gate | 29.29672 | -90.64844 | 16.2 | 1.2 | 17.7 | 28.5 | 30.5 |
| Bush Canal Sector Gate | 29.36816 | -90.60206 | 17.8 | 1.4 | 19.6 | 31.0 | 33.0 |
| Bayou Terrebonne Floodgate | 29.38804 | -90.58806 | 17.8 | 1.4 | 19.6 | 31.0 | 33.0 |
| Humble Canal Sector Gate | 29.43804 | -90.56649 | 17.8 | 1.4 | 19.6 | 31.0 | 33.0 |
| ECS- 5-5'x10' Box Culverts With Sluice Gates - Reach J2 | 29.43639 | -90.53922 | 17.8 | 1.4 | 19.6 | 31.0 | 33.0 |
| ECS- 4-5'x10' Box Culverts With Sluice Gates - Reach J2 | 29.44678 | -90.51375 | 17.8 | 1.4 | 19.6 | 31.0 | 33.0 |
| Point Au Chiene Sector Gate | 29.41569 | -90.44689 | 17.8 | 1.4 | 19.6 | 31.0 | 33.0 |
| ECS- 2-6'x6' Box Culverts With Sluice Gates - Reach K | 29.44617 | -90.44638 | 17.7 | 1.6 | 19.8 | 27.5 | 29.5 |
| ECS- 2-6'x6' Box Culverts With Sluice Gates - Reach K | 29.46964 | -90.43881 | 17.7 | 1.6 | 19.8 | 27.5 | 29.5 |
| Grand Bayou Sector Gate | 29.51833 | -90.41173 | 17.7 | 1.6 | 19.8 | 27.5 | 29.5 |
| ECS- 6-5'x10' Box Culverts With Sluice Gates - Reach L | 29.50408 | -90.41902 | 17.7 | 1.6 | 19.8 | 27.5 | 29.5 |
| Four Point Bayou Sector Gate | -- | -- | 16.2 | 1.2 | 17.7 | 28.0 | 30.0 |
| Bayou Lafourche Gate (GIWW East) | 29.58809 | -90.37252 | 12.0 | 0.8 | 12.9 | 19.5 | 21.5 |

#### 2.6.1.3 Wave Load Designs

Flood side wave loads were computed on each structure. Wave load calculations mainly determine pressure, hydrostatic force, and dynamic force on a floodwall. Similar to structure designs, wave loadings were only done for future conditions. Structural superiority was included in the total structure elevation for wave load computation. Loads were computed using a Matlab script similar to that used in the levee design effort. See Figure 32 for an example of the script user interface. A typical wave load computation uses many of the same inputs as in levee design along with some additional values. Inputs to the script will be given in the bullet list below.

- Top of Wall – Elevation of structure including structural superiority.
- Water level backside – Assumed zero unless otherwise known.
- Top of rock – Assumed equal to invert elevation of channel if no berm is present
- Top of fill – Equal to invert elevation of channel if no berm is present.
- Base Level – Invert elevation. Same as channel invert if sill is on channel bottom.
- Berm width – Width of berm if included. Zero if no berm is present.
- Cotangent of slope – Slope in front of structure. A large number indicates insignificant slope (e.g., 100).
- Structure code/description – Computation run time
- Still water level/ Wave height/ Wave period – Input corresponding to your frequency.
- Number of simulations – 10,000.
- Non-exceedance % - Compute only 90% confidence values.

The script uses all the input data to run a large number of Monte Carlo simulations (10,000) to determine 90% exceedance limit values. Wave load computations are based on the Goda formulations, published in EM 1110-2-1100, Part VI, Chapter 5, 1 June 2006). Figure 33 gives an example of a wave load computation.

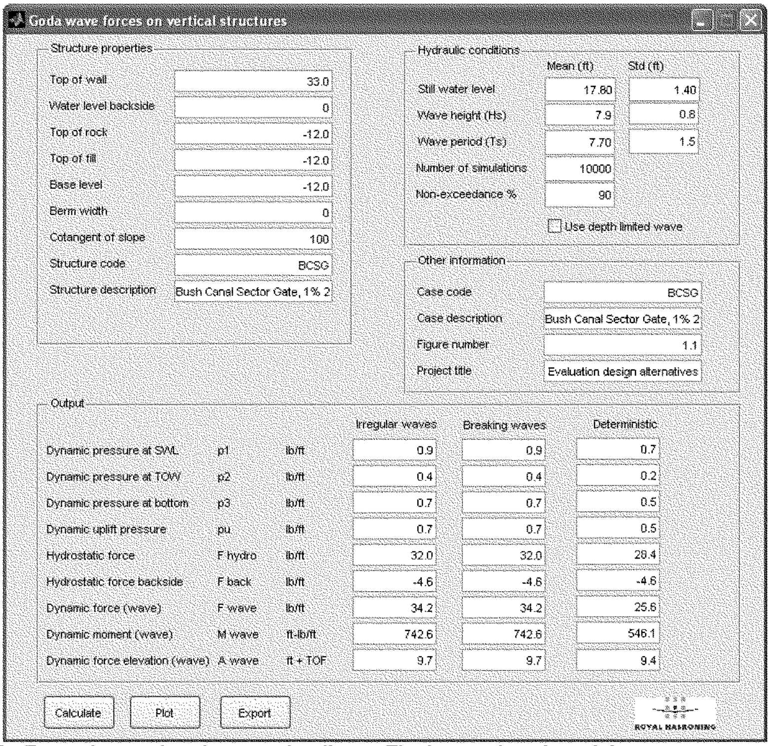
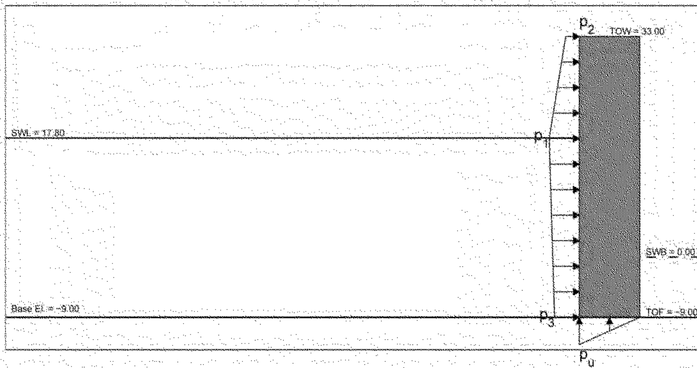



**Figure 32 - Example template for wave loadings. The invert elevation of the structure was used as the top of rock, fill, and base level elevations**

04-Nov-2010 14:48:46 Status: final draft

## BAYOU TERREBONE FLOODGATE 1% 2085




```
Structure dimensions :                  Hydraulic conditions :

Top of wall          =    33.00 ft      Hs (mu, sigma)           =   7.90,  0.80 ft
Top of rock          =    -9.00 ft      Ts (mu, sigma)           =   7.70,  1.50  s
Top of fill          =    -9.00 ft      Water level (mu, sigma)  =  17.80,  1.40 ft
Base elevation       =    -9.00 ft      Confidence band (%)      =     90
Berm width           =     0.00 ft      No of simulations        =  10000
Slope (1:value)      =   100.00  -
Water level backside =     0.00 ft + datum

Hydrostatic and wave forces on wall (90 % non-exceedance values) :
Wave type  =    irregular   breaking

p1         =        0.92       0.92   lb/sqft
p2         =        0.41       0.41   lb/sqft
p3         =        0.75       0.75   lb/sqft
pu         =        0.75       0.75   lb/sqft
F hydro    =       26.27      26.27     lb/ft
F back     =       -2.59      -2.59     lb/ft

F wave     =       32.85      32.85     lb/ft
M wave     =      661.10     661.10  ft-lb/ft
A wave     =       11.13      11.13        ft

*All levels are referenced to datum, forces and pressures are in thousands
```

| | | |
|---|---|---|
| Wave forces on sea wall according Goda formula for breaking and non breaking waves | BTFG-100 | |
| | BTFG-100 | |
| Bayou Terrebone Floodgate 1% 2085 | Fig. 1.1 | ROYAL HASKONING |
| Evaluation of sea wall designs | 9S2231.01 | |

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**Figure 33 - Example of a wave load result sheet**

#### 2.6.1.3.1 Authorized Alignment Future Conditions

A total of 27 wave loading cases were completed for future conditions. Section 5.2 provides a list of all structures with corresponding coordinates. All future condition design figures for 1% frequency can be furnished upon request.

## 2.6.2 3% AEP Storm Surge Risk Reduction System Designs

### 2.6.2.1 Determine Post-Katrina Level of Risk Reduction

The old 1% chance exceedance designs outlined in the 2002 Feasibility Report are shown in Table 50. These designs were done before the latest design criteria were established. In light of the new design criteria, the old 1% level of risk reduction was re-evaluated to determine the actual frequency. The 2002 designs were termed the 1% authorized designs. The process used to re-evaluate the authorized 1% authorized designs to determine the 3% AEP will now be given.

**Table 50 - 1% Design characteristics and associated levee elevations from the 2002 MTG Feasibility Report**

| Reach | Stillwater Elevation (SWL) | Fetch | | Significant Wave | | Runup | Design Levee | |
|---|---|---|---|---|---|---|---|---|
| | | Length | Depth | Height($H_s$) | Period(T) | | Elevation | Slope |
| | feet NGVD | feet | feet | feet | seconds | feet | feet NGVD | 1:00 |
| A | 8 | 0.5 | 7 | 2.2 | 2.1 | 2 | 10 | 3.0 |
| B | 8 | 10 | 8 | 4.2 | 4.6 | 3 | 11 | 7.0 |
| C | 9 | 0.5 | 8 | 2.2 | 2.1 | 2 | 11 | 3.0 |
| | 9 | 10 | 9 | 4.6 | 4.7 | 3 | 12 | 7.5 |
| | 10 | 10 | 10 | 5.0 | 4.8 | 3 | 13 | 8.0 |
| D | 10 | 10 | 10 | 5.0 | 4.8 | 3 | 13 | 8.0 |
| E | 10 | 10 | 10 | 5.0 | 4.8 | 3 | 13 | 8.0 |
| BRG | 10 | 10 | 10 | 5.0 | 4.8 | 3 | 13 | 8.0 |
| F | 10 | 10 | 10 | 5.0 | 4.8 | 3 | 13 | 8.0 |
| G | 11 | 10 | 11 | 5.3 | 4.9 | 3 | 14 | 8.3 |
| H | 11 | 10 | 11 | 5.3 | 4.9 | 3 | 14 | 8.3 |
| | 12 | 10 | 12 | 5.6 | 4.9 | 3 | 15 | 8.5 |
| I | 11 | 10 | 11 | 5.3 | 4.9 | 3 | 14 | 8.3 |
| | 10 | 10 | 10 | 5.0 | 4.8 | 3 | 13 | 8.0 |
| J | 10 | 10 | 10 | 5.0 | 4.8 | 3 | 13 | 8.0 |
| JSC(1) | 10 | 10 | 10 | 5.0 | 4.8 | 3 | 13 | 8.0 |
| JSC(2) | 11 | 10 | 11 | 5.3 | 4.9 | 3 | 14 | 8.3 |
| K | 10 | 10 | 10 | 5.0 | 4.8 | 3 | 13 | 8.0 |
| | 9 | 10 | 9 | 4.6 | 4.7 | 3 | 12 | 7.5 |
| | 8 | 10 | 8 | 4.2 | 4.6 | 3 | 11 | 7.0 |
| L | 8 | 0.5 | 7 | 2.2 | 2.1 | 2 | 10 | 3.0 |
| | 7 | 0.5 | 6 | 2.1 | 2.1 | 2 | 9 | 3.0 |

Surge and wave characteristics associated with pre-Katrina 1% frequency designs given in the feasibility report needed to be updated to be comparable to work done post-Katrina. First, surge and wave characteristics from the report were associated with a new post-Katrina frequency. Analyses related to this conversion process can be furnished upon request. From the multiple methods utilized, a new 2.86% chance exceedance frequency event was established as the 3% AEP corresponding to the old 1% frequency values in the 2002 feasibility report.

### 2.6.2.2 Levee Designs

#### 2.6.2.2.1 Authorized Alignment

##### 2.6.2.2.1.1 Base and Future Conditions

This section discusses base and future condition designs for the 2.86% frequency. The designs were based only on the intermediate SLR rate. The decision to only use the intermediate rate was made after learning from USACE MVN Economics Branch that only intermediate SLR results would go through the full economic cost-benefit analysis. Until now, only surge and wave characteristics for existing condition 2.86% frequency had been calculated. Base and future conditions also have to be established. Interpolation could not simply be performed to determine base and future condition 2.86% frequency surge and wave characteristics. A stair step method was used to develop base and future condition surge and wave characteristics. Existing condition 2.86% frequency data was used to develop base condition values then base condition 2.86% frequency data were used to develop future condition values. Since existing condition 10% data were already adjusted no further vertical or with-project adjustments would have to be made to base and future condition 10% values once they are known. All available data from Table 40 through Table 43 was used in this analysis. The methodology will now be examined in bullet format.

- Collect existing, base and future condition data available for 1%, 1.33% and 2% frequencies.
- Since the existing condition data had frequency curves developed to 10% the existing condition 2.86% SWE and SWE standard deviations were interpolated from the curve.
- The lower frequency statistics (i.e., 1%, 1.3%, and 2% values) were provided by ERDC and the higher frequency data was developed using a gage analysis as discussed in Section 2.5.3.2.
- Using the stair step method ratios of base to existing conditions at the 2% frequency were computed and assumed to be approximately equal to the ratio at the 2.86% frequency.
- With SWE and SWE standard deviation ratios calculated, the ratios were multiplied by the existing condition 2.86% frequency data to arrive at base condition 2.86% SWE and SWE standard deviation values over all reaches (Table 51).

- The same method was applied using the newly created base condition 2.86% SWE and SWE standard deviation values to compute 2.86% future condition SWE and SWE standard deviation values (Table 52).
- To calculate 2.86% Hs values, Hs to depth relationships were calculated across each reach. This is the same method used to calculate 2.86% values for existing conditions.
- The ratios were calculated at the 2% frequency and assumed to be the same at the 2.86% frequency. Depth of water was calculated using existing condition 2% Hs and SWE. Average bottom elevations were selected in front of each reach and depths were calculated by subtracting the existing condition 2% SWE.
- For reach E2, E1, F2, F1 wave characteristics were taken from point 90 which was also the same point used for reach B. However, the bottom elevation for reach E2, E1, F2, F1 was taken within the reach area instead of just using the elevation assumed for reach B.
- With known ratios a depth was now calculated using the existing condition 2.86% SWE for each reach.
- Each ratio was then multiplied by its corresponding depth to arrive at a 2.86% Hs value. In this manner all base condition 2.86% Hs values were computed.
- The same method was used to solve for future condition 2.86% frequency Hs values with base condition 2% frequency Hs values as a starting point for ratio calculation (Table 53).

The following equation was used to develop base, and future 2.86% Tm values.

$$Tm_2 = \sqrt{Hs_2 / Hs_1} \times Tm_1 \qquad (2)$$

where Hs is the significant wave height and Tm is the mean wave period. The subscript 1 corresponds to existing condition values when solving for base condition Tm and base condition when solving for future condition Tm.

Table **53** provides 2.86% surge and wave characteristics for existing, base, and future conditions.

### Table 51 - Developed Future Condition (2085) 2.86% SWE and SWE Standard Deviation for each reach

| SWE | Pt | SWE Base 35 yr | 50 yr | | | | SWE Future 35yr |
|---|---|---|---|---|---|---|---|
| | | | Base SWE | Future (2085) SWE | Ratio ($fut_{2085}/base_{2035}$) | | |
| Reach K, L | 174 | 11.75 | 13.3 | 14.8 | 1.11 | | 13.09 |
| Reach H3, I1, I2, I3, J2, J1, J3 | 96 | 12.48 | 13.7 | 15.3 | 1.12 | | 13.94 |
| Reach H2 | 45 | 11.84 | 12.9 | 14.5 | 1.13 | | 13.37 |
| Reach G1, G2, G3, H1 | 36 | 11.35 | 12.4 | 13.7 | 1.10 | | 12.48 |
| Reach E2, E1, F2, F1 | 83 | 11.41 | 12.6 | 13.7 | 1.09 | | 12.45 |
| Reach B | 90 | 9.06 | 10.0 | 11.8 | 1.18 | | 10.66 |
| Reach A north of GIWW | 208 | 7.09 | 8.0 | 11.1 | 1.38 | | 9.79 |

| SWE Standard Deviation | Pt | SWE StDEV Base 35yr | 50 yr | | | | SWE StDev Future 35yr |
|---|---|---|---|---|---|---|---|
| | | | Base StDev 2008 | Future (2085) StDev | Ratio ($fut_{2085}/base_{2035}$) | | |
| Reach K, L | 174 | 1.18 | 1.32 | 1.39 | 1.05 | | 1.25 |
| Reach H3, I1, I2, I3, J2, J1, J3 | 96 | 1.11 | 1.17 | 1.26 | 1.08 | | 1.20 |
| Reach H2 | 45 | 0.97 | 1.02 | 1.13 | 1.10 | | 1.07 |
| Reach G1, G2, G3, H1 | 36 | 0.91 | 0.96 | 1.01 | 1.05 | | 0.96 |
| Reach E2, E1, F2, F1 | 83 | 1.00 | 1.06 | 1.09 | 1.02 | | 1.03 |
| Reach B | 90 | 0.83 | 0.86 | 0.97 | 1.12 | | 0.93 |
| Reach A north of GIWW | 208 | 0.93 | 1.03 | 1.33 | 1.28 | | 1.19 |

### Table 52 - Developed Existing, Base (2035), and Future Condition (2085) 2.86% Hs for each reach

| Hs Existing | Pt | 50 yr | | | | | | 35 yr | 35 yr |
|---|---|---|---|---|---|---|---|---|---|
| | | ERDC 2008 - Hs | ERDC 2008 - SWE | Bottom Elev. (ft.) | Depth (ft) | Ratio (Hs/Depth) | | Hs - Existing | Hs - Base (2035) |
| Reach K, L | 103 | 3.50 | 12.1 | 1.30 | 10.80 | 0.32 | | 3.05 | 3.39 |
| Reach H3, I1, I2, I3, J2, J1, J3 | 96 | 5.00 | 12.9 | 2.89 | 10.01 | 0.50 | | 4.45 | 4.79 |
| Reach H2 | 31 | 5.00 | 12.2 | 1.03 | 11.17 | 0.45 | | 4.55 | 4.84 |
| Reach G1, G2, G3, H1 | 36 | 4.90 | 11.8 | 1.94 | 9.86 | 0.50 | | 4.40 | 4.68 |
| Reach E2, E1, F2, F1 | 90 | 2.00 | 11.9 | -0.98 | 12.88 | 0.16 | | 1.83 | 1.92 |
| Reach B | 90 | 2.00 | 9.1 | 1.20 | 7.90 | 0.25 | | 1.77 | 1.99 |
| Reach A north of GIWW | 208 | 1.20 | 5.9 | 1.05 | 4.85 | 0.25 | | 1.03 | 1.50 |

| Hs Existing | Pt | 50 yr | | | | | | 35 yr |
|---|---|---|---|---|---|---|---|---|
| | | 2035 - Hs | 2035 - SWE | Bottom Elev. (ft.) | Depth (ft) | Ratio (Hs/Depth) | | Hs - 2085 |
| Reach K, L | 103 | 3.9 | 13.3 | 1.30 | 11.99 | 0.33 | | 3.88 |
| Reach H3, I1, I2, I3, J2, J1, J3 | 96 | 5.6 | 13.7 | 2.89 | 10.80 | 0.52 | | 5.69 |
| Reach H2 | 31 | 5.4 | 12.9 | 1.03 | 11.85 | 0.46 | | 5.66 |
| Reach G1, G2, G3, H1 | 36 | 5.3 | 12.4 | 1.94 | 10.48 | 0.50 | | 5.31 |
| Reach E2, E1, F2, F1 | 90 | 2.4 | 12.6 | -0.98 | 13.59 | 0.18 | | 2.41 |
| Reach B | 90 | 2.4 | 10.0 | 1.20 | 8.80 | 0.28 | | 2.62 |
| Reach A north of GIWW | 208 | 2.1 | 8.0 | 1.05 | 7.00 | 0.30 | | 2.60 |

**Table 53 – Surge and Wave characteristics for 2.86% existing, base, and future condition designs**

| Reach | SWE Pt. | Wave Pt. | 2008 | | | | 2035 | | | | 2085 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SWE | SWE StDev | Hs | Tm | SWE | SWE StDev | Hs | Tm | SWE | SWE StDev | Hs | Tm |
| K, L | 174 | 103 | 10.7 | 1.19 | 3.05 | 3.85 | 11.75 | 1.18 | 3.39 | 4.06 | 13.09 | 1.25 | 3.88 | 4.35 |
| H3, I1, I2, I3, J2, J1, J3 | 96 | 96 | 11.9 | 1.12 | 4.45 | 4.68 | 12.48 | 1.11 | 4.79 | 4.83 | 13.94 | 1.20 | 5.69 | 5.27 |
| H2 | 45 | 91 | 11.2 | 0.96 | 4.55 | 4.71 | 11.84 | 0.97 | 4.84 | 4.86 | 13.37 | 1.07 | 5.66 | 5.26 |
| G1, G2, G3, H1 | 36 | 36 | 10.9 | 0.93 | 4.40 | 4.63 | 11.35 | 0.91 | 4.68 | 4.78 | 12.48 | 0.96 | 5.31 | 5.09 |
| E2, E1, F2, F1 | 83 | 90 | 10.8 | 1.06 | 1.83 | 2.99 | 11.41 | 1.00 | 1.92 | 3.06 | 12.45 | 1.03 | 2.41 | 3.43 |
| B | 90 | 90 | 8.2 | 0.82 | 1.77 | 2.94 | 9.06 | 0.83 | 1.99 | 3.12 | 10.66 | 0.93 | 2.62 | 3.58 |
| B2 | 90 | 90 | 8.2 | 0.82 | 1.77 | 2.94 | 9.06 | 0.83 | 1.99 | 3.12 | 10.66 | 0.93 | 2.62 | 3.58 |
| A South | 90 | 90 | 8.2 | 0.82 | 1.77 | 2.94 | 9.06 | 0.83 | 1.99 | 3.12 | 10.66 | 0.93 | 2.62 | 3.58 |
| A North | 208 | 208 | 5.2 | 0.81 | 1.03 | 2.24 | 7.09 | 0.93 | 1.50 | 2.70 | 9.79 | 1.19 | 2.60 | 3.56 |

### 2.6.2.2.2 Barrier Alignment

At this point in the design comparison process, the project management team decided it would be more beneficial to continue designing for only the barrier alignment. The northern alignment was considered less feasible as the project continued going forward. Hydraulic reaches for the barrier alignment were kept constant for both 1% AEP and 3% AEP designs. Designs were completed for a 2.86% frequency event.

#### 2.6.2.2.2.1 Existing Conditions

Existing condition designs were not completed for the Barrier Alignment. This was a decision made by the project management team.

#### 2.6.2.2.2.2 Future Conditions

There was one hydraulic reach representing the barrier alignment. The same MTG design point used in the 1% AEP alternative barrier design, point 225, was used here. Also, the same methodology used to compute 2.86% future condition values for authorized alignment was followed here to compute future conditions. Existing condition data were used to develop base condition values then base condition data were used to ultimately develop future condition design values. With lack of data, ratios were greatly used in the computations. Several with-project frequencies were used in this analysis. Of those frequencies, 10% data were needed. The 10% data values in front of the Barrier alignment needed adjusting for with project conditions as well as vertical datum. Before continuing any further the 10% frequency data were adjusted. A with-project correction was applied first by calculating differences between with and without project SWE values at various points around 225 for a 1%, 1.33%, and 2% events. The resulting differences were averaged at each frequency and plotted. A 10% frequency with project correction was extrapolated from the plot. An adjustment was applied next as the ground truthing correction. The ground truthing work peformed by Roy Dokka is discussed in detail within ERDC's final modeling report (Cialone et al., 2010). It was assumed the Dokka adjustment was approximately constant in the project area regardless of frequency. This was validated through a check of multiple frequencies. The 10% values are now consistent with other “with project” frequency values (Table 54). All SWE, Hs, and Tm input data used to compute future condition design values are given in Table 55.

Final design values are provided towards the end of the step-wise process. In some cases comments are given in a figure cell to explain how a value was computed. Logarithmic interpolation was performed to compute an existing condition 2.86% SWE and standard deviation values for point 225. From this point the step wise procedure follows that developed for authorized alignment base and future condition computations. In the case of developing a future conditions Tm a constant wave steepness of 4% was used. This is also consistent with the value used to for authorized alignment base and future conditions. A levee design was then computed for the single barrier alignment reach Table 56.

**Table 54 - Computations needed to develop 10% AEP with project frequency value**

| | Without Proj Value |
|---|---|
| Pt 225 | 10yr |
| Raw FEMA | 3.1 |

B2EDHLB3:
With Project Adjustment: The raw 10yr FEMA data was for without project conditions. This adjustment determines the differences between WP and WOP to calculate an avg adjustment to the 10yr data.

| | Returns | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 100yr | | | 75yr | | | 50yr | | |
| | Pt 233 | Pt 225 | Pt 221 | Pt 233 | Pt 225 | Pt 221 | Pt 233 | Pt 225 | Pt 221 |
| With Proj | 7.35 | 7.9 | 7.88 | 6.59 | 7.11 | 7.04 | 5.47 | 5.92 | 5.8 |
| Without Proj | 7.37 | 7.69 | 7.73 | 6.66 | 7 | 6.97 | 5.59 | 5.96 | 5.86 |
| Difference | -0.02 | 0.21 | 0.15 | -0.07 | 0.11 | 0.07 | -0.12 | -0.04 | -0.06 |
| Average | | 0.11 | | | 0.04 | | | -0.07 | |

| | 10yr | (WP-WOP) Adj Value |
|---|---|---|
| | 3.1 | -0.5 |
| Final After WP Adjustment | 3.6 | |

B2EDHLB3:
Approximate 10yr value taken from extrapolation.

B2EDHLB3:
This adjustment is to incorporate the ground truthing correction. It's done by taking the average difference (ERDC-FEMA) for 100yr without project values.

| Return | | | |
|---|---|---|---|
| | 100 | | |
| | Pt 233 | Pt 225 | Pt 221 |
| Without Proj (FEMA) | 7.4 | 8.2 | 7.8 |
| Without Proj (ERDC) | 7.37 | 7.69 | 7.73 |
| Difference | -0.03 | -0.51 | -0.07 |
| Average | | -0.20 | |

| | 10yr | WOP (ERDC-FEMA) Adj Value |
|---|---|---|
| Final After WP Adjustment | 3.1 | -0.20 |
| | 2.9 | |

*All values are in feet.

## Table 55 - Computations for developing 3% AEP future condition design parameters

| | | ERDC Values - SWE - Existing Conditions (0 ft SLR) | | | | | SWE Existing | | SWE StDEV Existing Conditions |
|---|---|---|---|---|---|---|---|---|---|
| SWE Existing - 2008 | Pt | 10 | 50 | 75 | 100 | | 35 yr | | 35 yr |
| Barrier Alignment | 225 | 2.90 | 5.92 | 7.11 | 7.9 | >>>>>> | 5.2 | | 0.6 |

| | | 50 yr | | | | 35 yr - 2035 |
|---|---|---|---|---|---|---|
| Calculate SWE Futures - 2035 | Pt | ERDC 2008 (no slr) | Base 2035 (0.72 slr) | Ratio (base$_{2035}$/exis$_{2010}$) | | SWE - Base (0.72 ft slr) |
| Barrier Alignment | 225 | 5.9 | 8.1 | 1.368 | >>>>>> | 7.11 |

| | | 50 yr | | | | 35 yr - 2035 |
|---|---|---|---|---|---|---|
| Calculate SWE StDev Futures - 2035 | Pt | StDev 2008 (no slr) | StDev 2035 (0.72 slr) | Ratio (base$_{2035}$/exis$_{2010}$) | | SWE StDev - Base (0.72 ft slr) |
| Barrier Alignment | 225 | 0.91 | 1.10 | 1.209 | >>>>>> | 0.73 |

| | | 50 yr | | | | | | 35 yr | 35 yr |
|---|---|---|---|---|---|---|---|---|---|
| Hs Existing | Pt | ERDC 2008 - Hs | ERDC 2008 - SWE | Bottom Elev. (ft.) | Depth (ft) | Ratio (Hs/Depth) | | Hs - Existing | Hs - Base (2035) |
| Barrier Alignment | 225 | 1.40 | 5.9 | 1.05 | 4.85 | 0.29 | >>>>>> | 1.20 | 1.75 |

| | | 35 yr | | |
|---|---|---|---|---|
| Tm Existing/Futures - 2008/2035 | Pt | Constant Wave Steepness | 2008 - Tm | Base 2035 - Tm |
| Barrier Alignment | 225 | 0.04 | 2.4 | 2.9 |

| | | 50 yr | | | | 35 yr - 2085 |
|---|---|---|---|---|---|---|
| Calcuate SWE Futures - 2085 | Pt | 2035 (0.72 slr) | 2085 (2.42 slr) | Ratio (fut$_{2085}$/fut$_{2035}$) | | SWE - Future (2.42 ft slr) |
| Barrier Alignment | 225 | 8.1 | 11.6 | 1.43 | >>>>>> | 10.19 |

| | | 50 yr | | | | 35 yr - 2085 |
|---|---|---|---|---|---|---|
| SWE StDev Futures - 2085 | Pt | StDev 2035 (0.72 slr) | StDev 2085 (2.42 slr) | Ratio (fut$_{2085}$/fut$_{2035}$) | | SWE StDev - Future (2.42 ft slr) |
| Barrier Alignment | 225 | 1.10 | 1.21 | 1.10 | >>>>>> | 0.80 |

| | | 50 yr | | | | | | 35 yr |
|---|---|---|---|---|---|---|---|---|
| Hs Existing | Pt | 2035 - Hs | 2035 - SWE | Bottom Elev. (ft.) | Depth (ft) | Ratio (Hs/Depth) | | Hs - 2085 |
| Barrier Alignment | 225 | 2.3 | 8.1 | 1.05 | 7.05 | 0.33 | >>>>>> | 2.98 |

| | | 35 yr |
|---|---|---|
| Tm Existing/Futures - 2085 | Pt | 2085 - Tm |
| Barrier Alignment | 225 | 3.8 |

## Table 56 - Final future condition (2085) 2.86% Levee Design for Barrier Alignment

2.86% Exceedence - Future (2085) With Project Hydraulic Conditions

| 1% Exceedance | Surge J-Point | Wave J-Point | Surge Elevation (ft) | | 90% Surge Elevation (ft) | Significant Wave Height (ft) | | Period (s) | |
|---|---|---|---|---|---|---|---|---|---|
| Reach | | | mean | std | | mean | std | mean | std |
| Barrier Alignment | 225 | 225 | 10.19 | 0.8 | 11.2 | 2.98 | 0.45 | 3.8 | 0.30 |

| Reach | Top of Levee (ft) | Levee Slope | Top of Berm (ft) | Berm Slope | Toe of Berm (ft) | Levee Slope | Minimum Hydraulic Requirement for Structure Elevations | 0.2% Exceedence Surge Elevation |
|---|---|---|---|---|---|---|---|---|
| Barrier Alignment | 13.0 | 1 on 6 | 10.2 | 1 on 12 | 7.2 | 1 on 6 | | N/A |

- all elevations are in NAVD88 (2004.65)

#### 2.6.2.3 Structure Designs

Approximately 27 structures were designed in addition to all levee designs. Structure types included mainly flood, sector, and sluice gates. All structures were located along the MTG authorized alignment. Structures are only looked at from a surge reduction perspective and not from a hydrological perspective. Table 48 provides the invert elevation of each structure. Structure inverts were provided by the project management team with input from the Terrebonne Parish Levee Board. Modifications were made to some of the original structure inverts. Structures were only designed based on the intermediate SLR rate for future conditions. The overall design procedure for a structure is very similar to that of a levee except for specific exceptions. The Franco and Franco overtopping formulations are used in structure design instead of the Van der Meer overtopping equation as in levee design (TAW, 2002). The 50% confidence overtopping limit is raised from 0.01 to 0.03 cfs per linear foot as outlined in *Hurricane and Storm Damage Reduction System Design Guidelines (Interim), New Orleans District, Engineering Division, October 2007*. Also, in most cases a structure is not built on a berm. Therefore, structure slopes are normally set to zero. With no berm the PC-Overslag step is removed from the process.

Structure designs use the same type of surge and wave information as needed for levee design. Surge and wave points were assumed to be the same for each reach as those used in levee design. All structures were first grouped according to the reach that it was located within. Every structure within a particular reach was given the same surge and wave value associated with that reach. Consequently, structures within a given reach will most likely have the same structure elevation. Two structures with the same surge and wave design inputs could possibly develop two different design elevations if channel depth for a structure limits wave height. If this becomes the case the resulting structural elevations should still be fairly similar.

##### 2.6.2.3.1 Authorized Alignment Future Conditions

Authorized alignment 2.86% structure designs are given in Table 57. Two feet of structural superiority was added to the design elevation on all structures on the basis that it would be very difficult to rebuild, if damaged, because of disruption in services.

**Table 57 - Future condition (2085) authorized alignment 2.86% structure designs**

| Structure | Lat | Lon | SWE (ft.) | StDev (ft.) | 90% SWE (ft.) | Structure Elevation (ft.) | Structure Elevation (ft.) (2 ft. Structural Superiority) |
|---|---|---|---|---|---|---|---|
| Minors Canal Gate | 29.55273 | -90.79693 | 9.8 | 1.2 | 11.3 | 14.0 | 16.0 |
| GIWW Sector Gate West | 29.53519 | -90.79261 | 9.8 | 1.2 | 11.3 | 14.0 | 16.0 |
| Falgout Canal Sector Gate | 29.41448 | -90.78560 | 10.7 | 0.9 | 11.9 | 14.5 | 16.5 |
| ECS- 6-6'x6' Box Culverts With Sluice Gates - Reach B | 29.46103 | -90.76387 | 10.7 | 0.9 | 11.9 | 14.0 | 16.5 |
| Bayou Dularge Sector Gate | 29.40828 | -90.78688 | 12.5 | 1.0 | 13.8 | 16.0 | 18.0 |
| Bayou Grand Caillou Sector Gate | 29.34256 | -90.73667 | 12.5 | 1.0 | 13.8 | 16.0 | 18.0 |
| HNC Lock | 29.33112 | -90.73086 | 12.5 | 1.0 | 13.7 | 20.5 | 22.5 |
| HNC Floodgate | 29.33112 | -90.73086 | 12.5 | 1.0 | 13.7 | 20.5 | 22.5 |
| ECS- 6-6'x6' Box Culverts With Sluice Gates - Reach G2 | 29.31783 | -90.69562 | 12.5 | 1.0 | 13.7 | 20.5 | 22.5 |
| ECS- 9-6'x6' Box Culverts With Sluice Gates - Reach E1 | 29.40731 | -90.76983 | 12.5 | 1.0 | 13.8 | 16.0 | 18.0 |
| ECS- 9-6'x6' Box Culverts With Sluice Gates - Reach E2 | 29.39878 | -90.74622 | 12.5 | 1.0 | 13.8 | 16.0 | 18.0 |
| ECS- 1-6'x6' Box Culvert With Sluice Gate - Reach H1 | 29.30226 | -90.67001 | 12.5 | 1.0 | 13.7 | 20.5 | 22.5 |
| ECS- 6-6'x6' Box Culvert With Sluice Gate - Reach H1 | 29.29727 | -90.65869 | 12.5 | 1.0 | 13.7 | 20.5 | 22.5 |
| Lapeyrouse Sector Gate | 29.30892 | -90.64590 | 13.4 | 1.1 | 14.7 | 22.0 | 24.0 |
| Placid Canal Sector Gate | 29.33804 | -90.63685 | 13.4 | 1.1 | 14.7 | 22.0 | 24.0 |
| Bayou Petite Caillou Sector Gate | 29.29672 | -90.64844 | 12.5 | 1.0 | 13.7 | 20.5 | 22.5 |
| Bush Canal Sector Gate | 29.36816 | -90.60206 | 13.9 | 1.2 | 15.5 | 23.0 | 25.0 |
| Bayou Terrebonne Floodgate | 29.38804 | -90.58806 | 13.9 | 1.2 | 15.5 | 23.0 | 25.0 |
| Humble Canal Sector Gate | 29.43804 | -90.56649 | 13.9 | 1.2 | 15.5 | 23.0 | 25.0 |
| ECS- 5-5'x10' Box Culverts With Sluice Gates - Reach J2 | 29.43639 | -90.53922 | 13.9 | 1.2 | 15.5 | 23.0 | 25.0 |
| ECS- 4-5'x10' Box Culverts With Sluice Gates - Reach J2 | 29.44678 | -90.51375 | 13.9 | 1.2 | 15.5 | 23.0 | 25.0 |
| Point Au Chiene Sector Gate | 29.41569 | -90.44689 | 13.9 | 1.2 | 15.5 | 23.0 | 25.0 |
| ECS- 2-6'x6' Box Culverts With Sluice Gates - Reach K | 29.44617 | -90.44638 | 13.1 | 1.3 | 14.7 | 19.0 | 21.0 |
| ECS- 2-6'x6' Box Culverts With Sluice Gates - Reach K | 29.46964 | -90.43881 | 13.1 | 1.3 | 14.7 | 19.0 | 21.0 |
| Grand Bayou Sector Gate | 29.51833 | -90.41173 | 13.1 | 1.3 | 14.7 | 19.0 | 21.0 |
| ECS- 6-5'x10' Box Culverts With Sluice Gates - Reach L | 29.50408 | -90.41902 | 13.1 | 1.3 | 14.7 | 19.0 | 21.0 |
| Four Point Bayou Sector Gate | -- | -- | 12.5 | 1.0 | 13.7 | 20.5 | 22.5 |
| Bayou Lafourche Gate (GIWW East) | 29.58809 | -90.37252 | 9.7 | 0.6 | 10.4 | 15.0 | 17.0 |

### 2.6.2.3.2 Barrier Alignment

#### 2.6.2.3.2.1 Future Conditions

A total of 6 structure designs were done for the barrier alignment. No structures were designed for the northern alignment. The same methodology used in Table 49 was used here to develop the future condition design parameters for selected points. Since only 3 unique surge and wave point combinations existed, the future condition computations were done only with the three combinations. The full future condition computation table is broken into two sections (Table 58 and Table 59). Based on the resulting design parameters the future condition designs are provided in Table 60.

**Table 58 - Part 1 - Barrier alignment future condition (2085) 2.86% design parameter computations**

| | | [illegible] | | | | | [illegible] | | [illegible] |
|---|---|---|---|---|---|---|---|---|---|
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | | [illegible] | | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | | [illegible] | | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | | [illegible] | | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | | [illegible] | | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | | [illegible] | | | |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | | [illegible] | | | |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | | [illegible] | | | |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | | [illegible] | | | |
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| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | | [illegible] | | | |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | | [illegible] | | | |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | | [illegible] | [illegible] |

**Table 59 - Part 2 - Barrier alignment future condition (2085) 2.86% design parameter computations**

| | | 35 yr | | |
|---|---|---|---|---|
| Tm Existing/Futures - 2008/2035 | Pt | Constant Wave Steepness | 2008 - Tm | Base 2035 - Tm |
| Barrier Structure Type 1 | 233 | 0.04 | 2.3 | 2.8 |
| Barrier Structure Type 2 | 221 | 0.04 | 2.3 | 2.8 |
| Barrier Structure Type 3 | 261 | 0.04 | 1.9 | 2.5 |

| | | 50 yr | | | | 35 yr - 2085 |
|---|---|---|---|---|---|---|
| Calcuate SWE Futures - 2085 | Pt | 2035 (0.72 slr) | 2085 (2.42 slr) | Ratio (fut$_{2085}$/fut$_{2035}$) | | SWE - Future (2.42 ft slr) |
| Barrier Structure Type 1 | 233 | 7.7 | 11.2 | 1.45 | | 9.57 |
| Barrier Structure Type 2 | 215 | 8.2 | 11.4 | 1.39 | | 9.91 |
| Barrier Structure Type 3 | 261 | 7.4 | 10.9 | 1.47 | | 9.29 |

| | | 50 yr | | | | 35 yr - 2085 |
|---|---|---|---|---|---|---|
| SWE StDev Futures - 2085 | Pt | StDev 2035 (0.72 slr) | StDev 2085 (2.42 slr) | Ratio (fut$_{2085}$/fut$_{2035}$) | | SWE StDev - Future (2.42 ft slr) |
| Barrier Structure Type 1 | 233 | 1.01 | 1.15 | 1.14 | | 1.06 |
| Barrier Structure Type 2 | 215 | 1.07 | 1.19 | 1.11 | | 1.09 |
| Barrier Structure Type 3 | 261 | 1.01 | 1.11 | 1.10 | | 1.02 |

| | | 50 yr | | | | | | 35 yr |
|---|---|---|---|---|---|---|---|---|
| Hs Existing | Pt | 2035 - Hs | 2035 - SWE | Bottom Elev. (ft.) | Depth (ft) | Ratio (Hs/Depth) | | Hs - 2085 |
| Barrier Structure Type 1 | 233 | 2.3 | 7.7 | 1.35 | 6.35 | 0.36 | | 2.98 |
| Barrier Structure Type 2 | 221 | 2.2 | 8.2 | 1.12 | 7.08 | 0.32 | | 2.78 |
| Barrier Structure Type 3 | 261 | 1.9 | 7.4 | 1.18 | 6.22 | 0.31 | | 2.48 |

| | | 35 yr |
|---|---|---|
| Tm Existing/Futures - 2085 | Pt | 2085 - Tm |
| Barrier Structure Type 1 | 233 | 3.8 |
| Barrier Structure Type 2 | 221 | 3.7 |
| Barrier Structure Type 3 | 261 | 3.5 |

**Table 60 - Future condition (2085) barrier alignment structure designs corresponding to a 2.86% frequency.**

| 35 YEAR BARRIER ALIGNMENT DESIGNS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| STRUCTURE | SWE Pt | Wave Pt | SWE (ft.) | StDev (ft.) | 90% Surge (ft.) | Hs (ft.) | Hs StDev (ft.) | Tm (s) | Tm StDev (s) | Struc Invert (ft.) | Design Elev. (ft.) |
| Shell Canal E | 233 | 233 | 9.57 | 1.06 | 10.93 | 3.0 | 0.5 | 3.8 | 0.3 | -12.0 | 16.0 |
| Shell Canal W | 233 | 233 | 9.57 | 1.06 | 10.93 | 3.0 | 0.5 | 3.8 | 0.3 | -10.0 | 16.0 |
| Elliot Jones Canal | 233 | 233 | 9.57 | 1.06 | 10.93 | 3.0 | 0.5 | 3.8 | 0.3 | -8.0 | 16.0 |
| NAFTA | 215 | 221 | 9.91 | 1.09 | 11.31 | 2.8 | 0.5 | 3.7 | 0.3 | -12.0 | 16.0 |
| Humphries Canal | 215 | 221 | 9.91 | 1.09 | 11.31 | 2.8 | 0.5 | 3.7 | 0.3 | -8.0 | 16.0 |
| Bayou Black | 261 | 261 | 9.29 | 1.02 | 10.60 | 2.5 | 0.5 | 3.5 | 0.3 | -12.0 | 15.0 |

The design elevation contains 2 feet of structural superiority.

### 2.6.2.4 Wave Load Designs

Wave loads corresponding to a 2.86% frequency were computed based on the structure designs given in Table 60. The matlab script was used here to produce the load results. Wave loads were not computed for the northern alignment because no structures were designed.

### 2.6.2.4.1 Authorized and Barrier Alignments

#### 2.6.2.4.1.1 Future Conditions

Wave load output corresponding to a 2.86% frequency event for both authorized and barrier alignment can be furnished upon request. All structures included in the 1% wave load computations for authorized alignment were included here for 2.86% computations. As mentioned previously a total of 6 structures were used for wave loading computations for the barrier alignment.

## 2.6.3 Environmental Control Structures

### 2.6.3.1 Introduction

The Environmental gate sizing analysis was completed by ERDC. A summary of the analysis is provided here, while the complete report can be furnished upon request. The hydrologic and hydraulic analysis of the proposed Environmental Flow Control Structures (EFCS) for the isolated system areas in Reaches 4, 3, 2, B, G, H, J2, K and L of the MTG project. An isolated system area is a near-shore area of marsh or open water that will be separated from the open tidal zone by the MTG levee alignment. An EFCS allows drainage of interior stormwater and provides limited tide exchange for areas isolated by the new levee. Isolated system areas in the MTG project vary in size from several thousand acres to many square miles. The EFCS are intended to be closed during storm surge events and are not designed for navigation passage. Storm gates sizing is discussed in Section 2.6.3.6. The analysis and findings assume that the existing drainage system will function the same after the proposed levee construction. Therefore; only isolated system areas are considered in locating and sizing EFCS.

### 2.6.3.2 Isolated System Area by Reach

The **Reach B** system is comprised of one isolated system area (ISA). Reach B culvert group 1 will drain 2.25 square miles from a portion of sub-basins BD-1. The new MTG levee will be constructed along the alignment of the existing levee on the west side of FDA 8-2C and 8-2D and extend north along the western boundary of BD-1 until it crosses the GIWW. Topography along the culvert location has elevations +2.5 ft NAVD88 2004.65 or higher will not be subject to tidal influence. All sub-basins north of the GIWW, GW-17 and portions of GW-16 and BD-1 drain to the GIWW and will be transported out of the basin by the GIWW.

The **Reach 4** system is comprised of one isolated system area (ISA), two forced drainage areas (FDA), and two pump stations. Reach 4 culvert group 1 will drain 0.5 square miles including portions of sub-basins E1 and FDA D-42. Reach 4 culvert group 2 will drain 1.57 square miles including the north end of E-1 and FDA D-44. Topography along the culvert locations have elevations +2.5 ft NAVD88 2004.65 or higher will not be subject to tidal influence. All sub-basins north of the Black Bayou will drain to and be transported out of the basin by Black Bayou.

The **Reach 3** system is comprised of one ISA. Reach 3 culvert group 1 will drain 0.75 square miles including portions of sub-basins E2 and E2-LF. Reach 3 culvert group 2 will drain 1.45 square miles including portions of E2 and E2-LF. Topography along the Reach 3 culvert locations have elevations +2.5 ft NAVD88 2004.65 or higher will not be subject to tidal influence. All sub-basins north of the Black Bayou will drain to and be transported out of the basin by Black Bayou.

The **Reach 2** system is comprised of one ISA including sub-basins E-2, E2-LF and GW-18. Reach 2 culvert groups 1 and 2 will drain 3.13 square miles. Topography along the Reach 2 culvert locations have elevations +2.5 ft NAVD88 2004.65 or higher will not be subject to tidal influence. All sub-basins north of the Black Bayou will drain to and be transported out of the basin by Black Bayou.

The **Reach E** will not have an ISA due to the high ground along the southern end of the reach. Rainfall events will be passed through the Houma Navigation Canal.

The **Reach G** system is comprised of one ISA HNC9 and one FDA D-10. Reach G culvert group 23 will drain 6.32 square miles. Assume all pumps will not be operational during storm events. Reach G will be subject to tidal activity.

The **Reach H** system is comprised of one ISA including LB1, LB2, LB3, LB4, LB5, and HNC10 and six FDA's 1-5, D60, D-36, 3-1B, 5-1A, and 5-1B. Reach H culvert group 24 and 25 will drain 91.83 square miles. Reach H will be subject to tidal activity.

The **Reach J2** system is comprised of two ISA's including ISA W, ISA E and seven FDA's 1-4, D-03, 4-1, D-25, D-02, 1-4, and D-69. Reach J2 culvert group 26, 27, and 28 will drain the storage area. Reach J2 will be subject to tidal activity.

The **Reach K and L** system is comprised of one ISA including SL1, SL2, SL3, PAC1. Reach K and L culvert group 29, 30 and 31 will drain 43.34 square miles. Reach K and L will be subject to tidal activity.

#### 2.6.3.3 Environmental Flow Control Structure Design Criteria

The Project Delivery Team (PDT) and Habitat Evaluation Team (HET) established the following criteria for determining the size of the MTG Environmental Flow Control Structures (EFCS):

1. The 10% AEP 24-hour precipitation event is the design condition for the EFCS,

2. Performance of the EFCS should be checked for the 1% AEP 24-hour precipitation event,

3. The increased water level in the isolated system areas due to the 10% AEP 24-hour precipitation runoff should recede to the external tide zone water surface level within four to seven days when the storm surge gates are open,
4. The initial water surface level in the isolated system area should be the medium 2% AEP sea level rise,
5. The EFCS should be box culverts,
6. The length of culverts should be as short as possible,
7. The invert of culverts should be as close to the existing bed as possible,
8. The slope of culverts should be zero (no slope),

The average flow velocities during peak flood or ebb tides through the EFCS should not exceed 2.6 ft/s.

#### 2.6.3.4 Hydrology

Design stormwater inflow for each reach was determined by hydrologic modeling of the 10 percent AEP and 1 percent AEP exceedance precipitation events. Stormwater runoff modeling was performed with the Hydrologic Engineer Center Hydrologic Modeling System (HEC-HMS 3.5). Further detail on the hydrologic analysis can be found in the full report MTG – Environmental Flow Control Structures Study and can be furnished upon request.

#### 2.6.3.5 Hydraulic Analysis of the Environmental Flow Control Structures

The MTG Project creates a system of forced drainage areas connected by pumps and open channels that are unique for each reach along the proposed levee. The HET criteria requires the EFCS drain the increased water level in the isolated system areas due to the 10% AEP 24-hour precipitation runoff to the external tide zone water surface level within four to seven days when the storm surge gates are open. Performance of the EFCS was also checked for the 1% AEP 24-hour precipitation event. The average flow velocities during peak flood and ebb tides through the EFCS should not exceed 2.6 ft/s. The results of the HEC-RAS simulations provide the basis for the EFCS size recommendations.

#### 2.6.3.6 Preliminary Environmental Flow Control Structure Sizes

Preliminary sizes for environmental flow control structures (EFCS) for the MTG Proposed Levee Reaches were suggested in the 2000 feasibility report. In the feasibility study documentation was a system map that suggested locations and sizes of

EFCS for the MTG project. The EFCS sizes suggested in the feasibility report and system map are summarized in Table 61.

**Table 61 - Preliminary sizes and locations of EFCS for all Levee Reaches**

| Table 3- Environmental Structures*,** | | | | | |
|---|---|---|---|---|---|
| Levee Reach | Structure Geometry | Invert | Height | Coordinates | |
| | | | | X | Y |
| B | | | | | |
| 20 | 6-6x6 box culverts | -4.5 | 23 | 29°27'39.72"N | 90°45'49.93"W |
| E | | | | | |
| 21 | 9-6x6 box culverts | -4.5 | 25.5 | 29°24'26.31"N | 90°46'11.40"W |
| 22 | 9-6x6 box culverts | -4.5 | 25.5 | 29°23'55.60"N | 90°44'46.40"W |
| G-2 | | | | | |
| 23 | 6-6x6 box culverts | -4.5 | 30.5 | 29°19'4.20"N | 90°41'44.24"W |
| H-1 | | | | | |
| 24 | 1-6x6 box culverts | -4.5 | 30.5 | 29°18'8.15"N | 90°40'12.05"W |
| 25 | 6-6x6 box culverts | -4.5 | 30.5 | 29°17'50.16"N | 90°39'31.28"W |
| J-2 | | | | | |
| 26 | 5-5x10 box culverts | -3.5 | 33 | 29°26'11.02"N | 90°32'21.19"W |
| 27 | 4-5x10 box culverts | -3.5 | 33 | 29°26'48.39"N | 90°30'49.51"W |
| 28 | 5-5x10 box culverts | -3.5 | 33 | 29°27'16.38"N | 90°30'0.34"W |
| K | | | | | |
| 29 | 2-6x6 box culverts | -4.5 | 29.5 | 29°26'46.20"N | 90°26'46.96"W |
| 30 | 2-6x6 box culverts | -4.5 | 29.5 | 29°28'10.71"N | 90°26'19.71"W |
| L | | | | | |
| 31 | 6-6x6 box culverts | -4.5 | 29.5 | 29°30'11.73"N | 90°25'9.78"W |
| *Barrier Plan-Reach 4* | 1-6x6 box culvert | -4.5 | 23 | 29°40'10.935"N | 91°0'20.012"W |
| | 1-6x6 box culvert | -4.5 | 23 | 29°39'40.218"N | 90°59'0.639"W |
| | 1-6x6 box culvert | -4.5 | 23 | 29°38'48.282"N | 90°58'17.71"W |
| *Barrier Plan-Reach 3* | 1-6x6 box culvert | -4.5 | 23 | 29°36'45.149"N | 90°54'17.183"W |
| | 1-6x6 box culvert | -4.5 | 23 | 29°36'7.937"N | 90°50'58.563"W |
| *Barrier Plan-Reach 2* | 1-6x6 box culvert | -4.5 | 23 | 29°36'4.44"N | 90°50'48.434"W |
| | 1-6x6 box culvert | -4.5 | 23 | 29°35'36.08"N | 90°50'5.268"W |

#### 2.6.3.7 Conclusions and Final Environmental Flow Control Structures

Details on the hydrologic and hydraulic analysis of the proposed EFCSs for the reaches of the MTG Project can be furnished upon request. Design criteria were discussed and the precipitation depth-duration-frequency of all reaches was determined using published data. USGS gages, referenced previously in this report were used to determine tide stages. The sea level rise used was provided by USACE, MVN and was 2.42 feet. A HEC-HMS precipitation model was developed to derive the inflow hydrographs for a HEC-RAS simulation of the EFCS. All Reaches were modeled in HEC-RAS. Trial box culvert sizes were evaluated with the HEC-RAS model. Based on the hydraulic modeling, modifications of the original EFCS geometry were necessary to meet the HET tidal criteria (Section 2.6.3.3). Existing site conditions should be defined by site visits to determine the conditions and elevations at the site to check that culvert elevations are close to the ground elevations. Table 62 lists the levee reaches, culvert group number, recommended geometry, recommended invert elevation, and recommended latitude and longitude for the EFCS in the MTG project.

**Table 62 - Recommended culvert sizes and location based on HEC-RAS simulation**

| Levee Reach | EFCS Geometry | Invert Elevation | Latitude | Longitude |
|---|---|---|---|---|
| Culvert number | | | | |
| B | | | | |
| 20 | 3-6x6 box culverts | -1.5 | 9°30'55.99"N | 90°46'0.83"W |
| E | | | | |
| | Culverts not needed | | | |
| | | | | |
| G | | | | |
| 23 | 6-8x6 box culverts | -4.5 | 29°19'4.20"N | 90°41'44.24"W |
| 23A | 6-8x6 box culverts | -4.5 | 29°18'49.21"N | 90°40'5.29"W |
| H | | | | |
| 24 | 1-6x6 box culverts | -4.5 | 29°18'8.15"N | 90°40'12.05"W |
| **25** | 6-6x6 box culverts | -4.5 | 29°17'50.16"N | 90°39'31.28"W |
| | | | | |
| J2 | | | | |
| 26 | 14-6x6 box culverts | -4.5 | 29°26'12.21"N | 90°32'22.13"W |
| 27 | 14-6x6 box culverts | -4.5 | 29°26'33.45"N | 90°31'15.87"W |
| 28 | 10-10x6 box culverts | -4.5 | 29°27'20.46"N | 90°29'59.10"W |
| K & L | | | | |
| 30 | 8-8x8 box culverts | -2.5 | 29°28'10.71"N | 90°26'19.71"W |
| 31 | 8-8x8 box culverts | -2.5 | 29°30'11.73"N | 90°25'9.78"W |
| **Barrier Plan** | | | | |
| **Reach 4** | | | | |
| | 1-6x6 box culverts | -1.5 | 29°37'37.76"N | 90°56'50.86"W |
| | 1-6x6 box culverts | -1.5 | 29°38'48.28"N | 90°58'17.71"W |
| **Barrier Plan** | | | | |
| **Reach 3** | | | | |
| | 1-6x6 box culverts | -1.5 | 29°37'16.87"N | 90°55'18.70"W |
| | 1-6x6 box culverts | -1.5 | 29°36'46.87"N | 90°54'21.89"W |
| **Barrier Plan** | | | | |
| **Reach 2** | | | | |
| | 1-6x6 box culverts | -1.5 | 29°36'1.93"N | 90°50'48.67"W |
| | 1-6x6 box culverts | -1.5 | 9°35'36.05"N | 90°50'5.27"W |

### 2.6.4 Gate Structures

#### 2.6.4.1 ADH Modeling

##### 2.6.4.1.1 Introduction

The U.S. Army Engineer Research and Development Center (ERDC) performed a number of engineering studies in support of efforts to determine the proper sizes of six proposed structures (Bush Canal, Bayou Terrebonne, Lapeyrouse Canal, Placid Canal, Bayou Petit Caillou, and Humble Canal). These structure sizes were determined through numerical modeling using the Adaptive Hydraulics Code (ADH). AdH is a state-of-the-art code developed by the U.S. Army ERDC to simulate both saturated and unsaturated groundwater, overland flow, three-dimensional Navier-Stokes flow, and two- or three-dimensional shallow water problems (Berger, et al., 2010). The study area along with the proposed levee alignment and structure locations are shown in Figure 34. The primary objective was to determine the smallest structures that resulted in reasonable velocity fields for the six proposed locations.

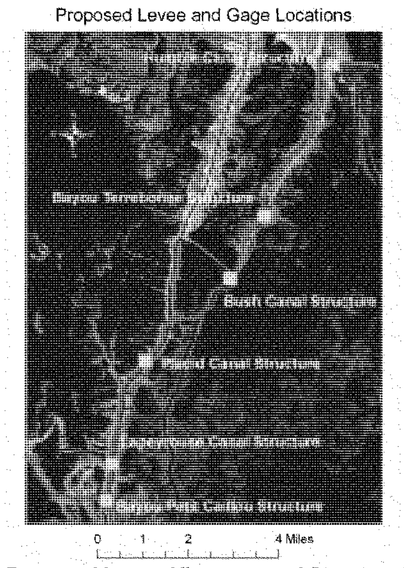


**Figure 34 - Proposed Levee Alignment and Structure Locations**

Once all navigational and environmental structure sizes were determined using ADH, the final configuration was modeled using a previously validated TABS-MDS model. This model determined the effects of the levee system on the salinity conditions throughout the system. Discussion of the TABS-MDS systemwide model can be found in Section 2.7.1.

### 2.6.4.1.2 Model Development

An existing RMA2 mesh of the south central Louisiana coast was provided by the New Orleans District. This initial mesh was created by Dr. Joseph V. Letter, Jr., for an Atchafalaya Bay study using RMA2 (Donnell et al.,1991). It was later modified by Mr. David Elmore and again by Ms. Amena Henville (both of MVN) for the MTG project, also using RMA2. This initial mesh, shown in Figure 35, extends from the Atchafalaya Bay on the west to Port Fourchon on the east. It contains a large area to the west of the study area that was not necessary for the current numerical model study.

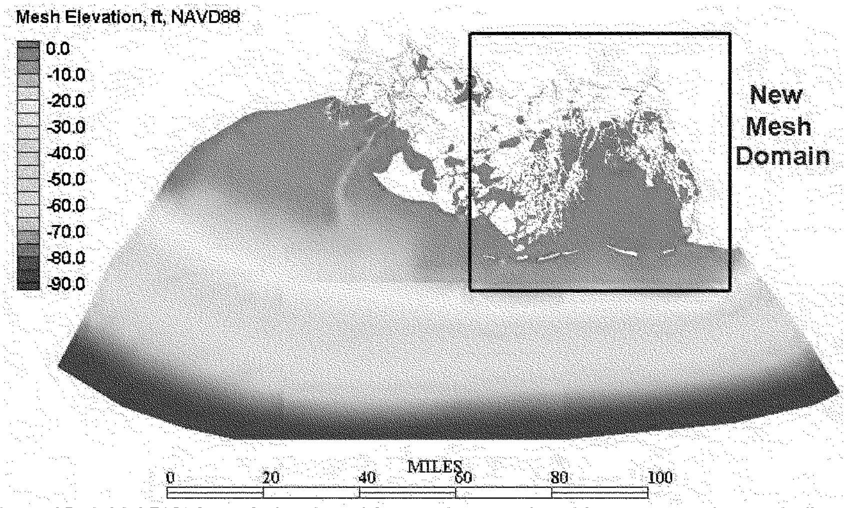


**Figure 35 - Initial RMA2 mesh developed for previous study, with current study area indicated**

The western area outside the greater study location was removed and the remaining mesh converted to an ADH compatible format for the Bush Canal study (McAlpin et al. 2009). For the current MTG gate sizing study, the resolution in the study area near proposed gate locations was significantly increased. Bathymetry data were also taken near the proposed structure locations by the CHL field crew and incorporated into the model.

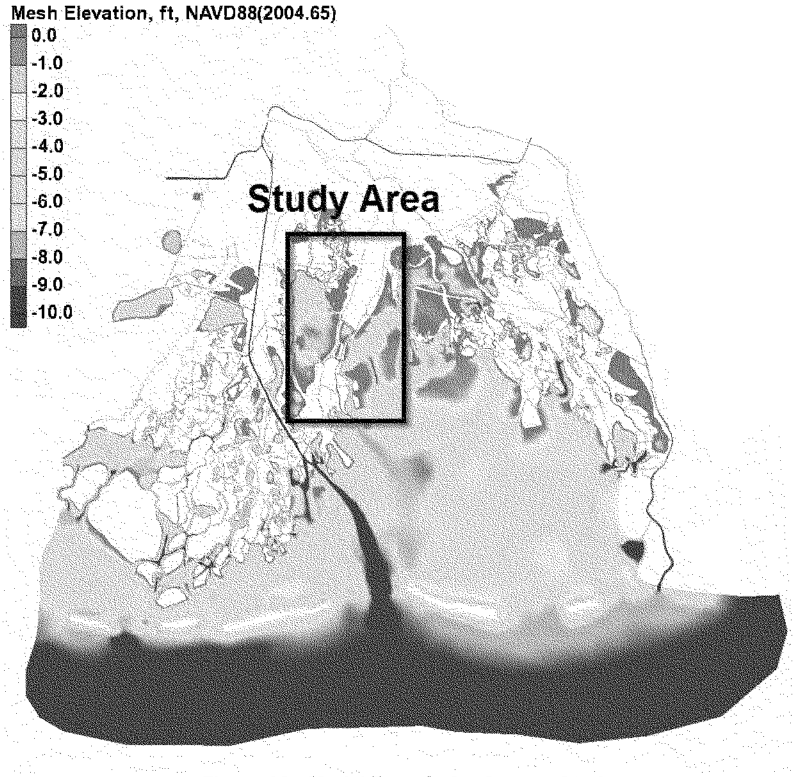


**Figure 36 - Model Domain for Current Study**

These mesh modifications were performed in the Surface Water Modeling System (SMS), a graphical user interface developed for use in setting up and running numerical models (Aquaveo 2009). The final model domain and bathymetry used in this study are shown in Figure 36. The horizontal and vertical coordinate systems were State Plan 83, Louisiana South, ft and NAVD88(2004.65), ft respectively. Further model information including boundary condition development and model validation can be furnished upon request.

### 2.6.4.1.3 Design Alternatives

The aim of the design alternatives was to determine appropriate structure sizes that would also result in reasonable velocity fields. The initial design included navigational structures and environmental structures. This began with an initial configuration, Plan 1 (Figure 37), that was arranged based on preliminary model results. The evolution of the plan configurations (Plan 1 –Plan 6) consisted solely of modifications to the Placid Canal and Bayou Petit Caillou structures. All remaining navigational and environmental structures were left unchanged from the initial plan configuration. The modifications of these structures from Plan 1 to Plan 6 are provided in Table 63 at the end of this section along with a bar plot comparison(Figure 53) of the maximum velocities for those two structures for all modeled configurations. The final configurations, Plan 6 and Plan 7 (Plan 6 with environmental structures closed), are also discussed in this section. It should be noted that the structure configurations are conceptual in nature as finalized designs have not been created.

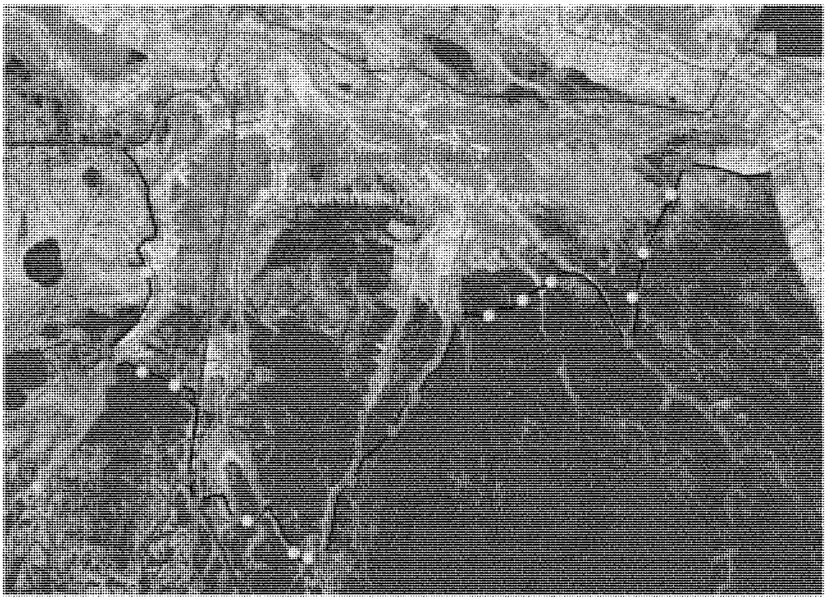

Figure 37 - Structure locations

The GIWW west of Houma structure, shown in Figure 38, consisted of two 125 ft wide structures with bottom elevation of -20 ft, NAVD88(2004.65).

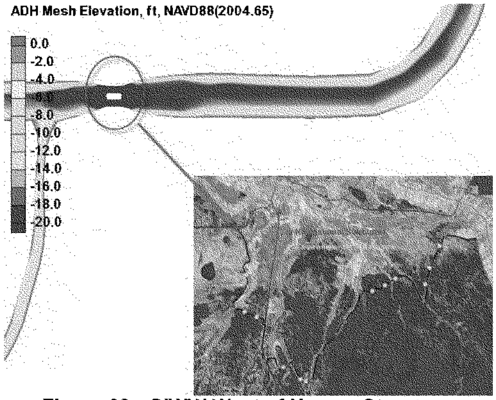


**Figure 38 - GIWW West of Houma Structure**

The formerly free-flowing Marmande Canal is joined by a set of six 6'x6' culverts. For this modeling effort the widths for these culverts were combined into one culvert with a width of 36 ft and a bottom elevation of -4.5 ft NAVD88(2004.65)). The model representation of this configuration is shown in Figure 39.

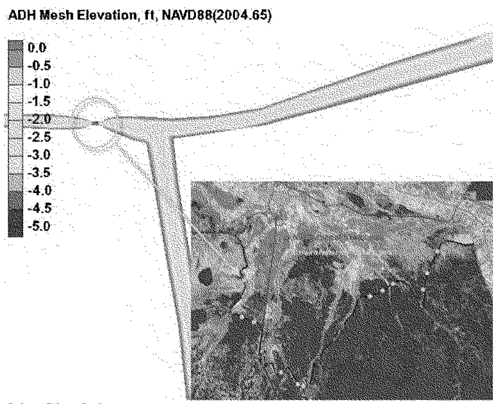


**Figure 39 - Model representation of the Marmande Canal culverts**

The Falgout Canal (upper left circle) and the Bayou Dularge (lower circle) structures are shown in Figure 40. The Falgout Canal structure consists of one 56 ft sector gate and three 46 ft sluice gates with -9 ft NAVD88(2004.65) bottom elevations. The Bayou Dularge structure consists of one 56 ft sector gate with a bottom elevation of -7 ft NAVD88(2004.65).

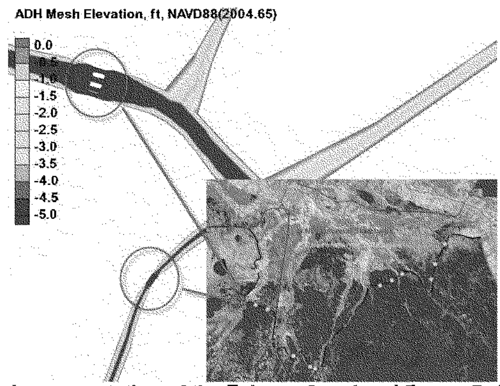


**Figure 40 - Model representation of the Falgout Canal and Bayou Dularge structures**

Two sets of nine 6'x6' culverts are located along Falgout Canal. In the model, the two sets of culverts are represented as single culverts with widths of 54 ft and bottom elevations of -4.5 ft NAVD88(2004.65). This configuration is shown in Figure 41.

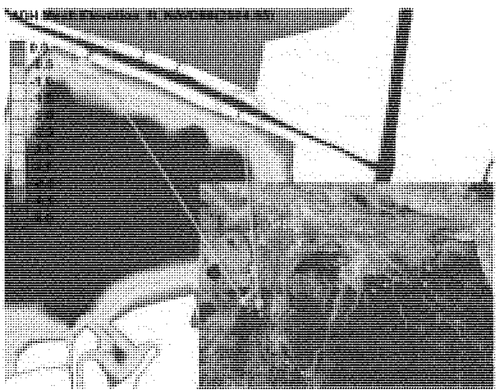

**Figure 41 - Model representation of the two sets of culverts located along Falgout Canal.**

The Bayou Grand Caillou structure, shown in Figure 42 in the top circle, consists of three 46' sluice gates and one 56' sector gate possessing bottom elevations of -12 ft, NAVD88(2004.65). The Houma Navigation Canal structure consists of a 250 ft wide structure and a 110 ft wide lock, both with bottom elevations of -23 ft, NAVD88(2004.65). The -23 ft bottom elevation for this structure is based on the 50% Plans and Specifications (P&S) for the Houma Navigational Canal. The Houma Navigational Canal structure will also consist of ten 10 ft wide sluice gates, each with a 5 ft vertical opening (from -2 ft to -7 ft NAVD88(2004.65). Four of these sluice gates will be located on the eastern side of the structure and four on the western side of the structure. Two will be located between the lock and the sector gate structures. This configuration can be observed in Figure 42.

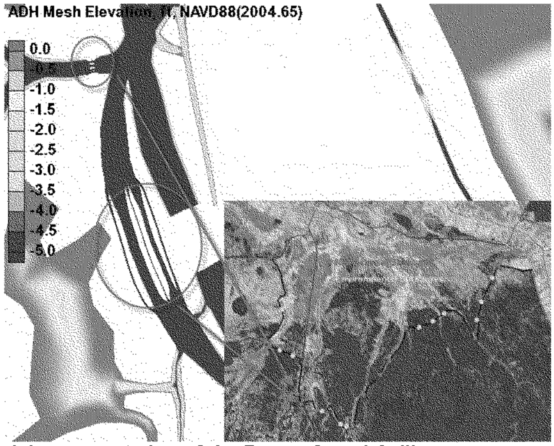


**Figure 42 - Model representation of the Bayou Grand Caillou structure and the Houma Navigational Canal structure and lock**

The structure located on Bayou Fourpoints (red circle on left in Figure 43) had a 30 ft sector gate with a -8 ft NAVD88(2004.65) bottom elevation. It should also be noted that two existing earthen plugs were removed and another plug was installed farther to the North as described in Permit MVN-2008-518-CT (U.S. Army Corp of Engineers, 2008). A set of six 6'x6' culverts are located just east of Bayou Fourpoints (green circle in Figure 43). This structure was represented as a single culvert with a 36 ft width and a bottom elevation of -4.5 ft, NAVD88(2004.65).

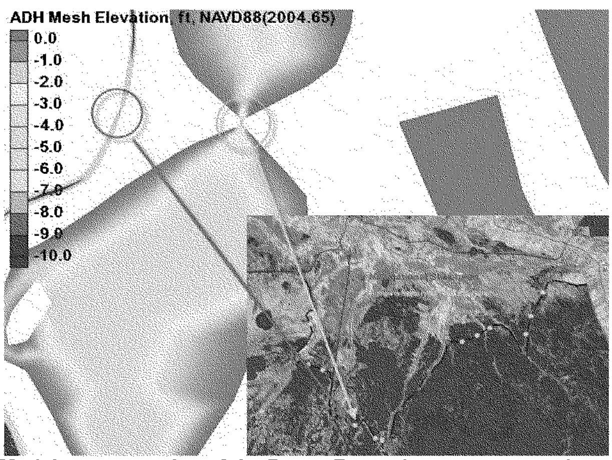


**Figure 43 - Model representation of the Bayou Fourpoints structure and one culvert set**

The left circle in Figure 44 is a single culvert with a width of 6 ft and a bottom elevation of -4.5 ft, NAVD88(2004.65). Another set of six 6 ft wide culverts are shown in Figure

44 (right circle). This culvert set also has a bottom elevation of -4.5 ft, NAVD88(2004.65).

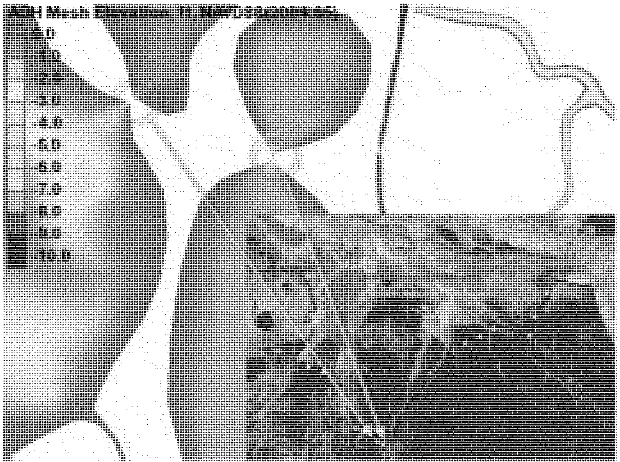

Figure 44 - Two culvert sets west of Bayou Petit Caillou

The Bayou Petit Caillou structure shown in Figure 45, is a 56 ft wide sector gate with two 46 ft wide sluice gates with bottom elevations of -8 ft, NAVD88(2004.65).

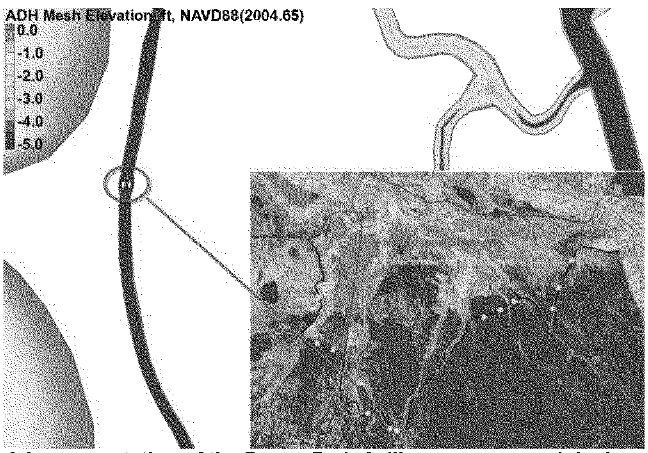


**Figure 45 - Model representation of the Bayou Petit Caillou structure and the Lapeyrouse Canal closure**

The Placid Canal structure, shown in Figure 46, consists of one 56 ft sector gate and two 46 ft wide sluice gates with a bottom elevation of -8 ft, NAVD88(2004.65).

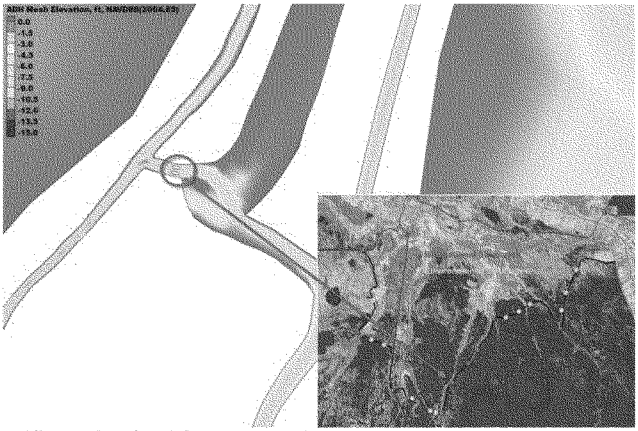

**Figure 46 - Model representation of the Placid Canal structure**

The Bush Canal structure, the lower circle shown in Figure 47, consists of three 46 ft sluice gates and one 56 ft sector gate. This structure had a bottom elevation of -12 ft, NAVD88(2004.65). The Bayou Terrebonne structure (upper circle) is a 56 ft sector gate with a bottom elevation of -9 ft, NAVD88(2004.65).

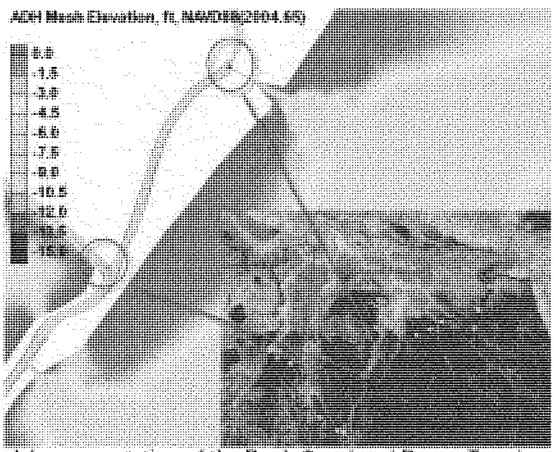

**Figure 47 - Model representation of the Bush Canal and Bayou Terrebonne structures**

The Humble Canal structure, shown in Figure 48, is a 56 ft sector gate with a bottom elevation of -9 ft, NAVD88(2004.65).

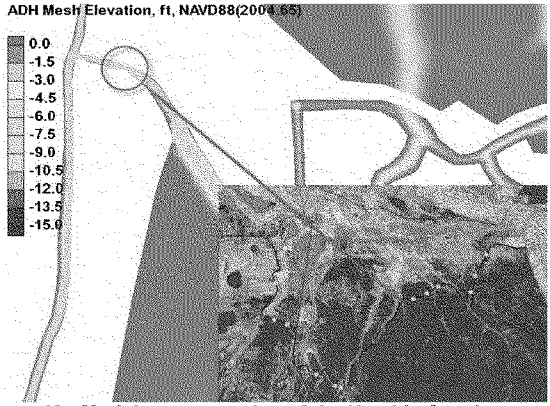


**Figure 48 - Model representation of the Humble Canal structure**

Shown in Figure 49 are three sets of culverts located in the Wonder Lake area (also known as the Montegut Wildlife Management Area). The left set of culverts consists of five 5' x 10' culverts which were represented in the model as having a width of 50 ft with a bottom elevation of -4.5 ft, NAVD88(2004.65). The center set of culverts consists of four 5' x 10' culverts which are represented in the model as having a width of 40 ft and a bottom elevation of -4.5 ft, NAVD88(2004.65). The right most set of culverts is a set of five 5' x 10' culverts located on the eastern part of Wonder Lake. This set had a width of 50 ft and a bottom elevation of -4.5 ft, NAVD88(2004.65).

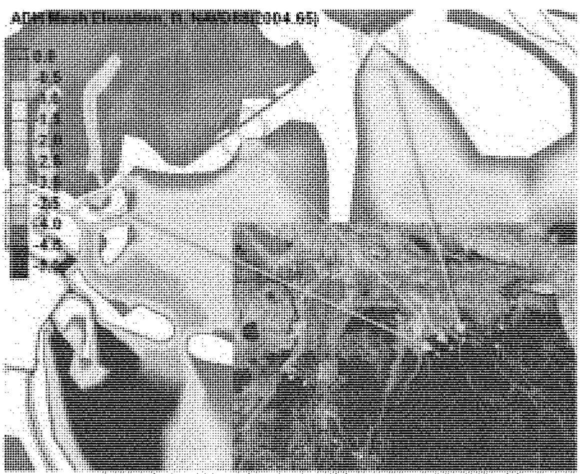

**Figure 49 - Model representation of the Wonder Lake (Montegut Wildlife Management Area) culvert configuration**

The Pointe-aux-Chenes structure, lower circle shown in Figure 50, has a 56 ft width with a bottom elevation of -6 ft, NAVD88(2004.65). Two 6' x 6' culverts, located along Grand Bayou Canal(upper circle shown in Figure 50) were represented as a single culvert with a width of 12 ft and a bottom elevation of -4.5 ft, NAVD88(2004.65).

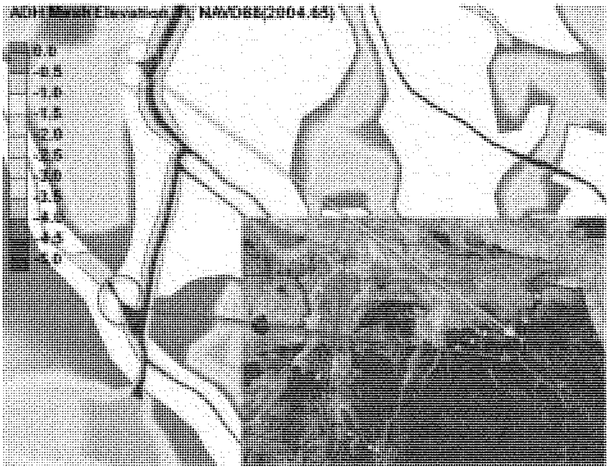

Figure 50 - Model representation of the Pointe-aux-Chenes structure and a culvert set

Two sets of two 6' x 6' culverts connected to Grand Bayou are shown in Figure 51. These two culvert sets were represented in the model as single culverts with widths of 12 ft with bottom elevations of -4.5 ft, NAVD88(2004.65).

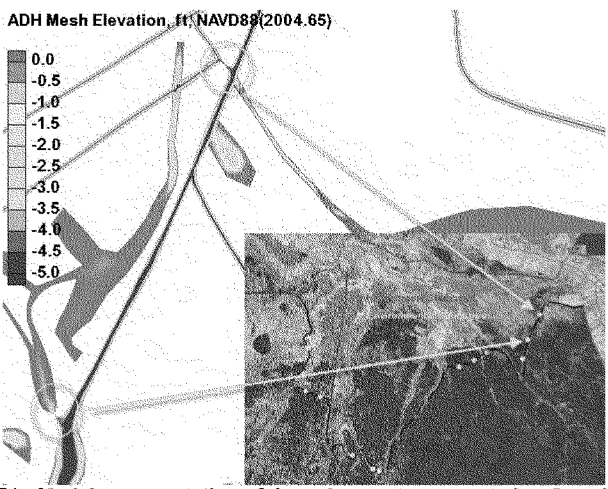


Figure 51 - Model representation of the culvert sets connected to Grand Bayou

Figure 52 is the structure located on Grand Bayou. This structure has a 56 ft wide sector gate with two 46 ft wide sluice gates with a bottom elevation of -9 ft, NAVD88(2004.65). The initial plan called for three sluice gates for this location. However, only two sluice gates are recommended by the final plan. This is due to the width of the channel and the small measured discharges for this area.

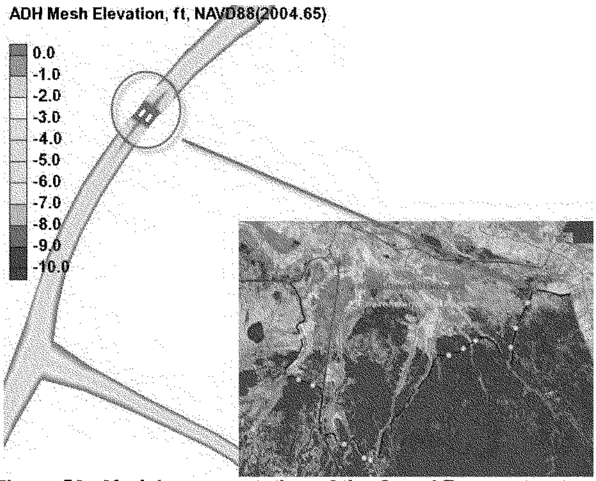


**Figure 52 - Model representation of the Grand Bayou structure**

**Table 63 - Evolution of the Plan Configuration for Placid Canal and Bayou Petit Caillou**

| Alternative Number | Placid Canal Sector Gate Width (ft) | Sluice Gates for Placid Canal | Bayou Petit Caillou Sector Gate Width (ft) | Sluice Gates for Bayou Petit Caillou |
|---|---|---|---|---|
| Plan 1 | 56 | 0 | 56 | 0 |
| Plan 2 | 30 (Barge Gate) | 0 | 56 | 0 |
| Plan 3* | 56 | 0 | 56 | 0 |
| Plan 4 | 80 | 0 | 80 | 0 |
| Plan 5 | 100 | 0 | 100 | 0 |
| Plan 6** | 56 | 2 – 46 ft Sluice Gates | 56 | 2 – 46 ft Sluice Gates |
| Plan 7** | 56 | 2 – 46 ft Sluice Gates | 56 | 2 – 46 ft Sluice Gates |

***Plan 3 has an added structure on Lapeyrouse Canal (56 ft wide sector gate with a bottom elevation of -10 ft, NAVD88(204.65). The Lapeyrouse Canal structure was eliminated for all other plan configurations.**

****Plan 7 is the Plan 6 configuration with all Environmental Structures closed.**

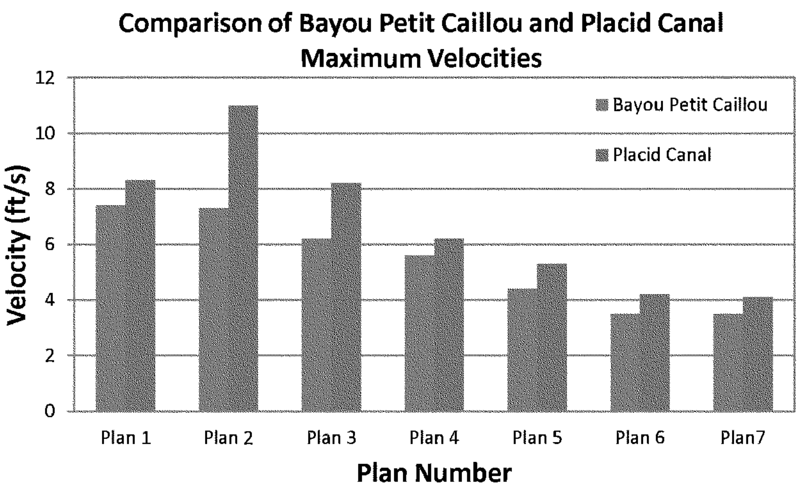


**Figure 53 - Comparison of Petit Caillou and Placid Canal Maximum Velocities**

#### 2.6.4.1.4 Results

The plan simulations were performed using the same tidal, wind, and inflow forcing as those used during the base validation time period. This should be a reasonably accurate representation of a normal fall time period with the occurrence of several frontal passage events. These frontal passages occur approximately 2 times per month based on data observations, and can produce significant increases and decreases in water level over a short period of time thereby creating higher velocities throughout the system. From observations of measured data, these types of meteorological events are much less likely to occur during the summer months and therefore make the fall conditions more appropriate for these types of plan evaluations.

The inflow conditions for the western GIWW location are slightly higher than normal as this flow is directly related to the Atchafalaya River flow. The Atchafalaya River flow for the base validation time period was approximately 450 kcfs (Wax Lake Outlet flow plus the Atchafalaya River at Morgan City flow), which is slightly less than the 10% AEP flow of 570 kcfs (FEMA 2010). The flow for the base validation time period was approximately a 50% AEP flow event; therefore this flow event was a slightly higher than normal flow but not significantly so, again making it a good time period for this type of analysis.

A percentile analysis was performed on the Base Plan, Plan 6, and Plan 7 model simulations. Plots of the velocity exceedance values are presented in Figure 54 to Figure 56. Additional data including velocity exceedance plots and figures showing water surface differences can be furnished upon request. Percentile analysis prevents a biasing of the results by a single large event that investigation of the maximums alone would create. It should be noted that the model output velocity in these figures are for the sector gates only.

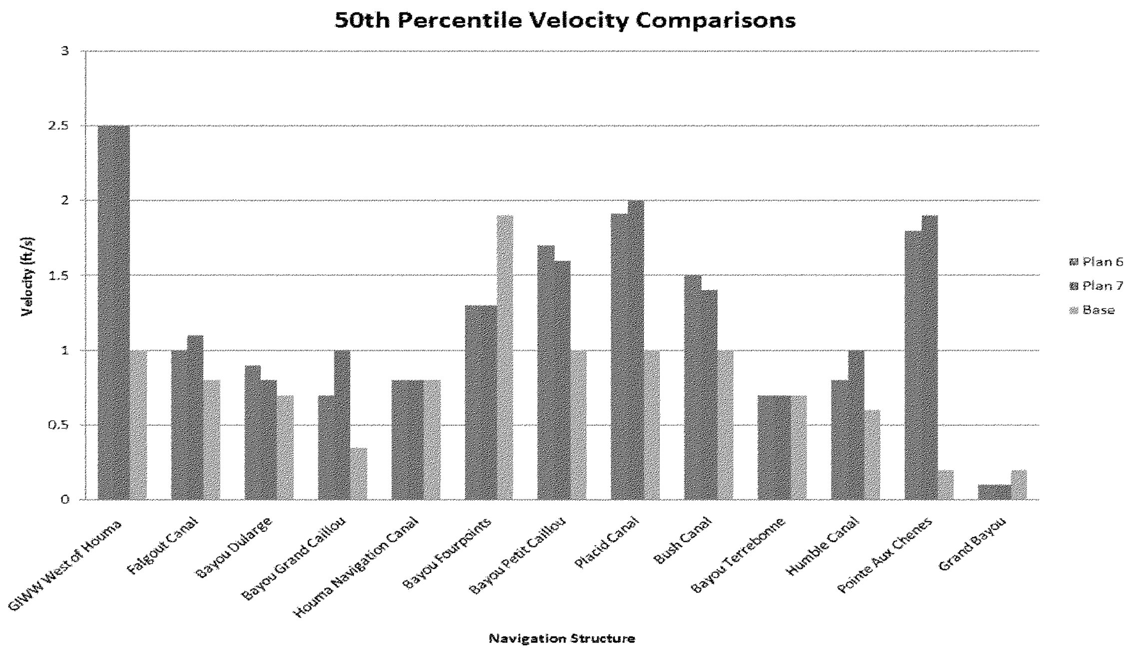


**Figure 54 - 50 Percent Exceedance Velocities for Plan 6, Plan 7 and Base Model Simulations**

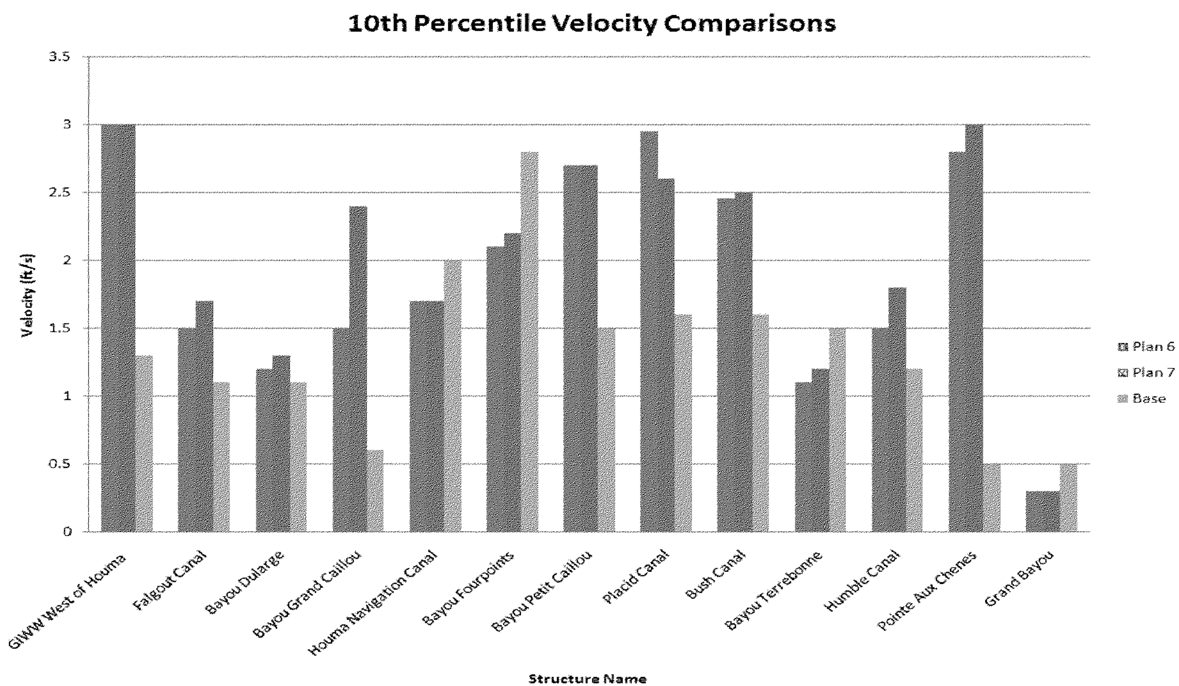


**Figure 55 - 10 Percent Exceedance Velocities for Plan 6, Plan 7 and Base Model Simulations**

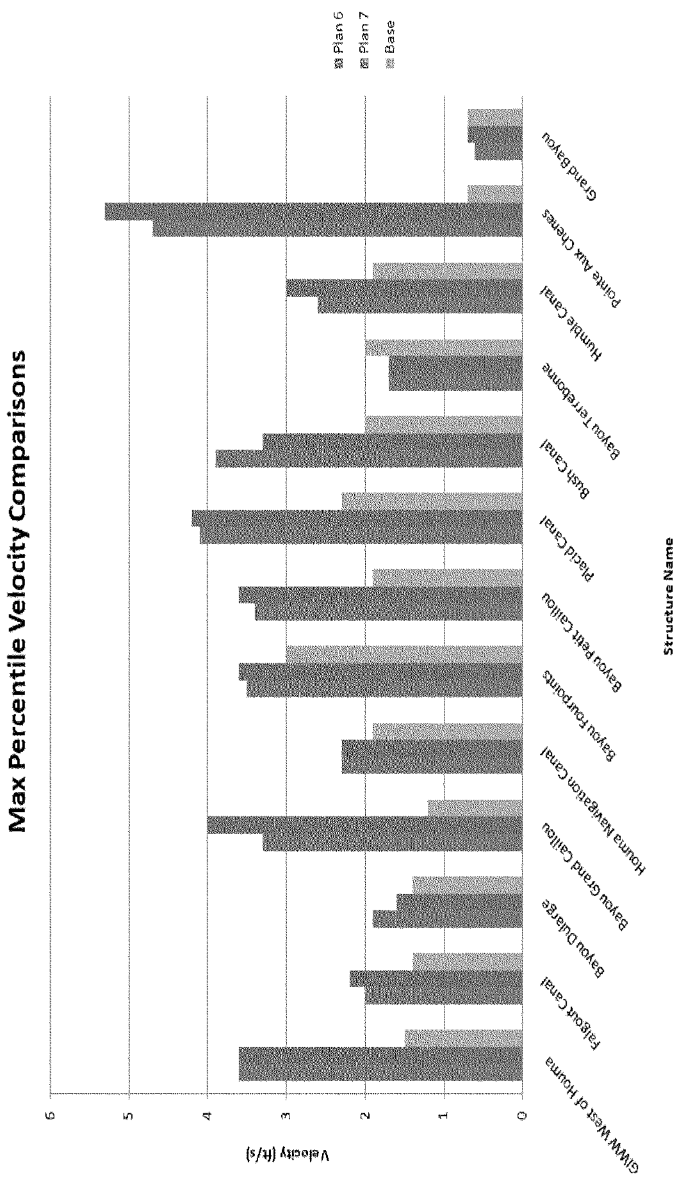


Figure 56 - Maximum Velocities for Plan 6, Plan 7 and Base Model Simulations

#### 2.6.4.1.5 Conclusions

Some of the maximum velocities did reach as high as 3.5 ft/s or more but those were maximum velocities over an approximately three month time frame consisting of multiple frontal passages. The exceedance curves allow MVN the option of performing a cost to benefit analysis on select structures where the cost of increasing a particular structure size may not warrant the relatively minor decrease in the prevalent velocities. The results show that the changes associated with the Plan 6 and Plan 7 configurations produce minimal effects on the velocity fields, less than 1 ft/s change from the base, for the majority of the structures (Falgout Canal, Bayou Dularge, Houma Navigational Canal, Bayou Fourpoints, Bush Canal, Bayou Terrebonne, and Grand Bayou). The remaining structures (GIWW West of Houma, Bayou Grand Caillou, Bayou Petit Caillou, Placid Canal, and Pointe-aux-Chenes) have higher velocity increases but the 10$^{th}$ percentile exceedance velocities are below 3 ft/s for all navigational structures. This indicates that velocities above 3 ft/s would not be regular occurrences.

The 50$^{th}$ percentile exceedance velocities are below 2 ft/s for all navigational structures except the GIWW West of Houma structure (2.5 ft/s). These 50$^{th}$ percentile exceedance velocities indicate that on average the velocities for all the structures (except GIWW West of Houma at 2.5 ft/s) are below 2 ft/s. These values should be taken as an indication of the expected velocities for each structure location.

Previous salinity modeling considered configurations with all navigational structures open and all environmental structures closed. To ensure no significant changes occurred in the velocity fields due to the closure of these environmental structures, Plan 7 (Plan 6 with all environmental structures closed) was modeled. As expected, the Plan 7 model results produced minimal changes in velocity (less than ~0.3 ft/s). This indicates that the closure of the environmental structures for ecological/biological reasons should not have a significant impact on the velocities in the navigational structures.

### 2.6.4.2 TABS Modeling

#### 2.6.4.2.1 Introduction

Subsequent to the ADH modeling, the U.S. Army Corps of Engineers Vicksburg District completed further analysis for the MTG floodgates using TABS - MDS with updated geometry. TABS-MDS (TABS – Multi-Dimensional Sediment) is the ERDC version of RMA-10 with sediment transport. TABS-MDS performs one-, two-, and three-dimensional shallow water hydrodynamic calculations with salinity transport coupled to the hydrodynamics (King 1988). Where structures were analyzed in both studies, the TABS -MDS modeling was used to determine the final gate sizing.

The TABS-MDS modeling incorporates two-dimensional system flow reproductions for open floodgate widths (for the above listed sites). These planned structures are part of the overall flood and storm surge risk reduction work in Terrebonne and Lafourche Parishes. These proposed structures will allow navigation passage through the current levee alignment, but are designed for closure during storm surges to protect Houma, La, and vicinity. Model results show resulting velocity flow fields across the proposed gate widths and head differential across the structure as well as combined system impacts from all structures in place. Further information is provided showing the effective flow field at the GIWW floodgates that develop with passing vessel/barge tow combinations. The loaded vessels (barge tows) passing through the proposed floodgates occupy a significant cross sectional area, thus causing a local velocity increase. Strategic boundary condition development and vessel presence simulations offer an accurate estimate of navigation conditions.

#### 2.6.4.2.2 Model Development and Verification

Existing USACE model studies were reviewed, and a combination strategy of using the recently-completed simulations and bathymetry from other studies was compiled to build the subject floodgate simulation model in both a cost-effective and quality fashion. Major components originated with an ERDC TABS MD study (Figure 57), an MVN modeling effort for the Barataria Basin (Figure 58), and parts of a coastal Louisiana ADCIRC model. Bathymetry, boundary conditions, and proposed gate location site flows were gleaned from these existing studies, and also from new field data sets at the proposed gate locations. The existing model verification efforts from other studies offered an unusually high level of quality assurance since the floodgate sites were along the GIWW and Houma Navigation Canal vicinities, where verification efforts, technical review, and USACE approval were either complete or nearly complete for other modeling projects, namely the ERDC TABS MD study and the Barataria Basin study. Model development began with merging two versions of ERDC models that cover the GIWW, Houma Navigation Canal (HNC), and Atchafalaya Bay. The resulting mesh/domain also includes added bathymetry in the areas north of Larose, LA, to improve the simulations at the GIWW Larose floodgate site.

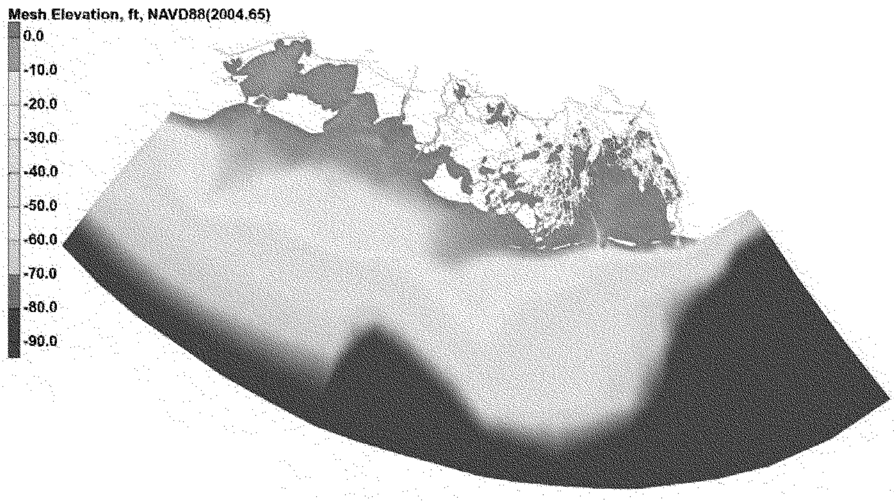


**Figure 57 - ERDC TABS MD study model domain (McAlpin, 2010)**

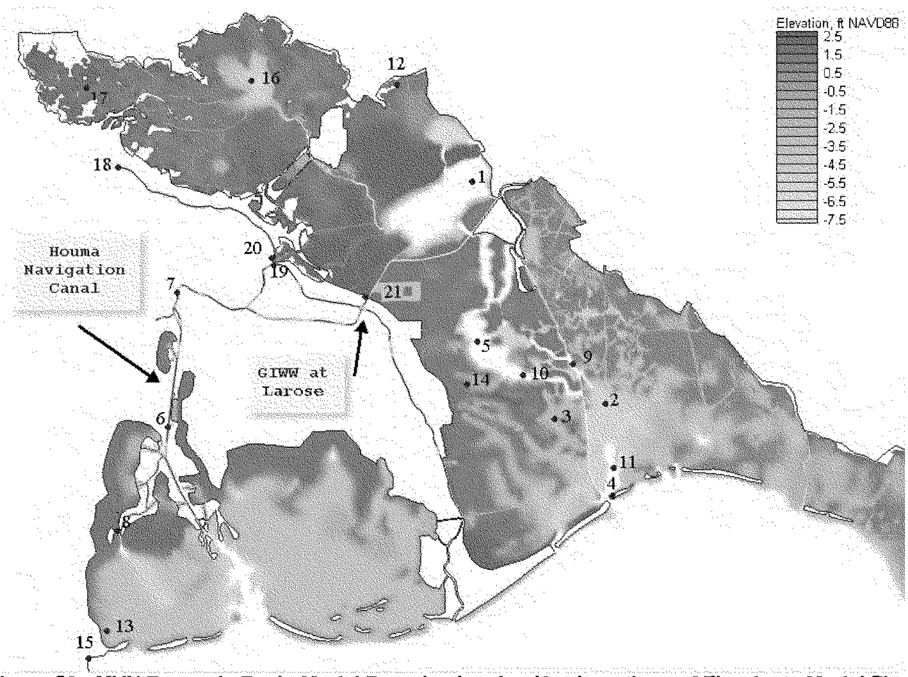


**Figure 58 - MVN Barataria Basin Model Domain showing Key Locations of Floodgate Model Flow Compatibility**

Model development and verification included 3 phases. Phase 1 began with studying the time-series simulations from the ERDC TABS MD. Phase 2 evolved a steady state approach using design flows, and Phase 3 consisted of a stage-discharge verification effort using field data. Ideally and often necessarily, field data is available at the beginning of a model study, but sufficient existing model development and simulations were already completed, and previous work was considered minimally adequate for the floodgate evaluations. Thus the Phase 2 steady-state development served as the actual model verification. Phase 3 field data arrived after gate-width simulations were completed, but was included as a comparative and qualitative verification effort.

Phase 1 - The time-series simulations for the ERDC model were reviewed for a 6-month period that ran from January to June in 2004. Details on the time-series simulations can be furnished upon request. The proposed gate locations are identified, and model data were extracted along the channel centerline. Table 64 highlights the highest velocity magnitude at each floodgate location for the 6 month period.

**Table 64 - Highest Flow Velocities at the Proposed Floodgate Locations**

| Proposed Site | Velocity, fps |
|---|---|
| GIWW at Larose | 0.75 |
| Grand Bayou | 0.75 |
| Minors Canal | * |
| GIWW at Houma | 1.7 |
| Falgout Canal | 2 |
| Bayou DuLarge | 2.2 |
| Bayou Grand Caillou | 0.75 |

***The Minors Canal site was added after Phase 1 evaluations and is addressed in the following phases of verification.**

Velocity magnitudes were used to determine acceptable gate widths for navigation in this study, and water surface elevations across the simulated gate constrictions are also reported. The New Orleans Westbank (WBV) project delivery team established navigable velocity criteria of up to 3 mph (4.4 fps) with much input from the navigation industry. This same criteria was applied to the navigable MTG GIWW project sites. The gate designs were based on meeting two conditions: 1) providing enough width for vessel passage and, 2) providing enough flow cross sectional area at the gate sites so that the constricted flow velocities would neither exceed the navigation criteria nor result in channel scouring problems. The Phase 1 data review (Table 64) indicated that existing condition velocities were generally low, and that controlling width may be a function of vessel width requirements at most of the sites. MVN strategy for storm surge and flood risk reduction improvements where gates were required was to design adequate vessel passage and augment flow passage with adjoining sluice gates as needed. This cost-effective approach was applied to the proposed MTG floodgates.

Phase 2 - A tow navigating through one of the planned floodgates would take only a few minutes, and no significant changes in channel stage or flow would be encountered during the short passage time. The short time interval associated with a passing vessel was the basis for a steady-state flow condition that represented maximum navigation difficulty. (*The passing vessel would generate additional navigation issues because its presence would further reduce cross-sectional area at the floodgate constriction,* and this important effect is evaluated in Part III of this report.) In addition to the ERDC TABS-MD study, two additional sources of information were available to define stage-discharge relationships at MTG floodgate sites, the 2-dimensional MVN Barataria Basin model (Teeter, 2010), and USGS stage and flow data (USGS Professional Paper 1672). Like the subject floodgate model, the Barataria Basin model was also developed using the RMA2 finite element code, and it offered a comprehensive evaluation of flow in the GIWW at Larose, LA. Flows through the Houma Navigation Canal were based on the USGS data set.

Model development for the 7 proposed gate sites included grouping the gate sites by region. The northern (roughly east-west) gate sites (Figure 59) along the GIWW and vicinity include Minors Canal, GIWW at Houma, GIWW at Larose, and Grand Bayou. Three additional floodgate sites (Figure 60) were evaluated along channels that connect to the mid- to lower-Houma Navigation Canal (HNC), and these are presented as the Mid-HNC sites. Since the proposed sites were up to 25 miles apart, initial strategy included verifying that a given steady state event simulation could define the most difficult navigation conditions at all 7 proposed sites. The study goal was to reproduce high flow and velocity combinations that provide the highest level of difficulty to navigation for the open gate conditions.

Table 65 lists the probability-based discharges on the GIWW at Larose, LA, in the eastward flow direction using USGS data and existing model boundary condition development for the MVN Barataria Basin Model Study.

**Table 65 - GIWW flows at Larose, LA (eastward)**

| Flow, cfs | Probability, % |
|---|---|
| 5335 | 99.9 |
| 4327 | 99 |
| 3430 | 95 |
| 2920 | 90 |

The GIWW flow at Larose, at times, reverses direction, but stage and discharge data show that when flows move westward at this site, magnitudes are much lower than the more common easterly flows. USGS records (1997-1999) show the maximum recorded westward flow here at 1860 cfs (Prof. Paper 1672). This same reference lists median eastward flow at 2670 cfs with a maximum measurement of 4,930 cfs.

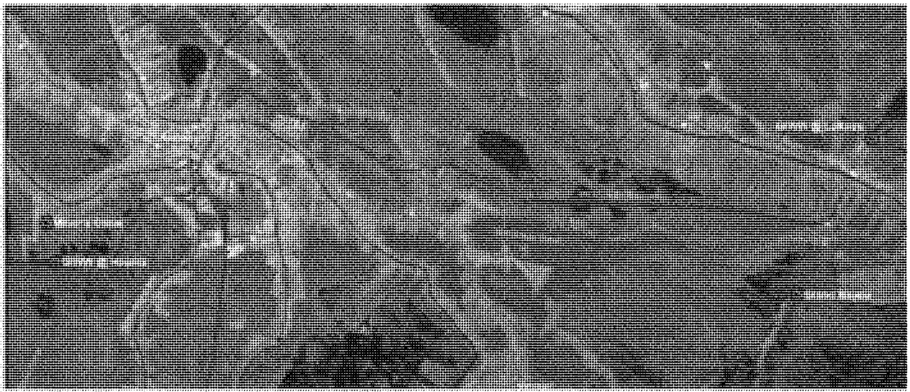

Figure 59 - Floodgate sites along the GIWW

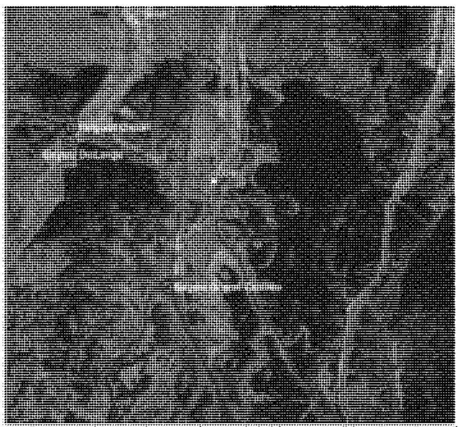

**Figure 60 - Floodgate sites along the mid-Houma Navigation Canal vicinity**

The USGS data maximum for the 1997-1999 records falls between the 99 % and 99.9% values in Table 65. Model boundary condition adjustments for the maximum eastward flow at Larose resulted in a model simulation flow of 4800 cfs. This value was very close to the 99.9% probability of not exceeding, and was selected as the Larose site design flow. The Barataria Model flow comparison to the USGS data added consistency and confidence that the flow maximums in the USGS data set generally represent the highest level of difficulty for navigation.

The USGS recorded flows at the proposed gate site in the GIWW West of Houma range from 4980 to 11800 cfs. Adjusting the Amelia LA inflow (within its recorded range) to achieve the design flow at Larose resulted in a flow of 12,100 cfs at the GIWW Larose Site. This was slightly higher than the recorded maximum, but was considered roughly equivalent and completed the design flows for the Northern Gate Sites. No USGS data were available at the proposed Grand Bayou and Minors' Canal sites, and the design flow selections at these sites are addressed in the Phase 3 effort below.

The USGS discharge information on the HNC near Dulac, LA, ranged from 4200 to 13,700 cfs over the 1997-1999 record. This data was near the remaining 3 mid-HNC floodgate sites, but model simulations indicate the major driving forces for these sites are from the West, more influenced by Atchafalaya River flows and conveyance from the Atchafalaya to the southeast and east directions along the interconnected canals and bayous including Bayou Penchant. The mid-HNC gate sites are also addressed in the following Phase 3 section.

Simulation strategy began using stage and discharge conditions from the ERDC TABS MD model and adjusting the GIWW inflow from the model inflow boundary condition at Amelia, LA, until the design discharge was achieved at the Larose, LA, outflow boundary. USGS data indicated that the flow at Amelia can move north or south, but that the higher GIWW discharges eastward approaching Houma and eventually at Larose occur when the Amelia flow is south into the GIWW. USGS average flow eastward approaching Houma is listed at 5700 cfs. The resulting HNC discharge at Dulac was 8400 cfs. This event was used as the base and plan condition for the proposed gate configurations. A low Gulf tidal boundary (-0.5 ft) was applied with the design flows to account for increases in velocities due to tide. Figure 61 shows the initial Floodgate model, and Figure 62 shows the revised (reduced) domain where the Gulf of Mexico boundary was moved inland to improve steady state water level agreement at the lower HNC.

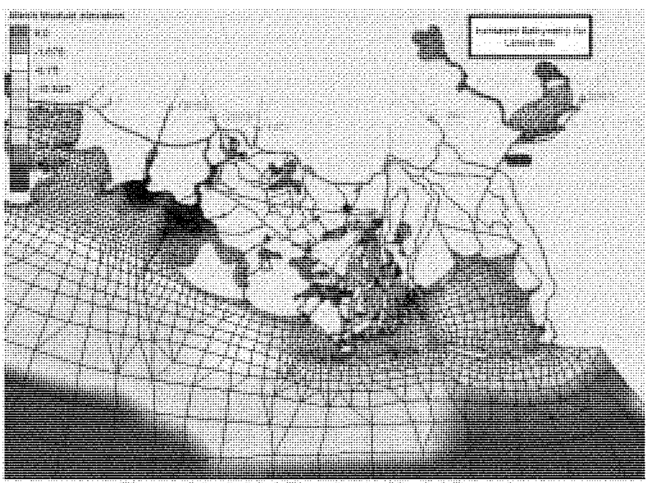

Figure 61 - Initial Floodgate Model Domain

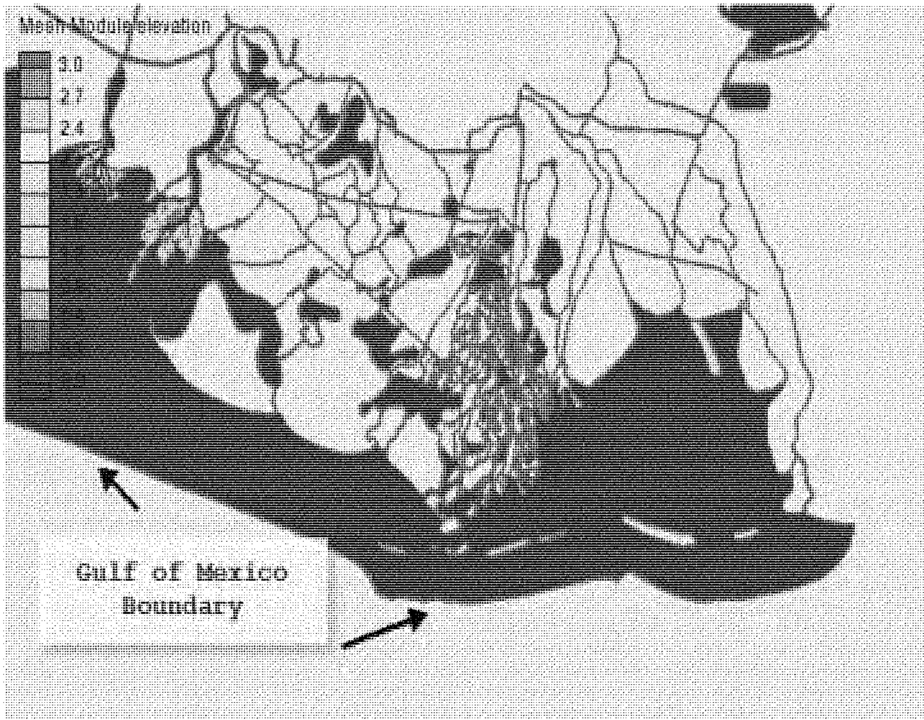


Figure 62 - Model Domain showing Gulf Boundary

<u>Phase 3</u> - The field data set arrived after scheduled draft report submission, but offered a comparison for the selected design flows. Like the Minors Canal and Grand Bayou sites, the mid-HNC sites were compared to the Phase 1 ERDC model peak values and to the June 2010 ERDC field data. Table 66 summarizes the design flow and velocity at each proposed floodgate site with the comparable peak flow and velocities from the Phase 1 ERDC model study and the recent June 2010 Field Data set peak flow and velocities. Table 66 shows both reasonable agreement between some of the peak stage and velocity design values and differences at others. Noteworthy is the complex network of large river, canal, and bayous with tidal exchanges in the project area.

**Table 66 - Floodgate Model Design Flows compared to Existing Model and Field data Peak Flow and Velocity data**

| Location | Floodgate Model Design Flow | | ERDC Phase 1 | | ERDC Phase 3 Field Data | |
|---|---|---|---|---|---|---|
| **North Gate Sites** | Discharge (CFS) | Velocity (ft/s) | Peak Discharge (CFS) | Peak Velocity (ft/s) | Peak Discharge (CFS) | Peak Velocity (ft/s) |
| GIWW @ Houma | 12132 | 1.09 | 15400 | 1.70 | 8632 | 1.84 |
| GIWW @ Larose | 4797 | 0.78 | 6410 | 0.75 | 7706 | 1.48 |
| Minors Canal | 150 | 0.30 | * | * | * | * |
| Grand Bayou | 379 | 0.58 | 678 | 0.75 | 677 | 0.62 |
| **Mid - HNC Gate Sites** | | | | | | |
| Falgout Canal | 2632 | 0.91 | 3534 | 2.00 | 6021 | 1.71 |
| Bayou Dularge | 819 | 1.30 | 603 | 2.20 | 603 | 0.47 |
| Bayou Grand Caillou | 2052 | 0.51 | * | 0.75 | * | * |

*** No data at the proposed gate site.**

## Part II- Floodgate Simulations

General- The hydraulic effects of the proposed floodgates to navigation were evaluated using the flow magnitude created by the physical constriction at the floodgates and the head differential across the structure as defined by water surface elevations. The 2 dimensional modeling completed offers an accurate assessment of flow impacts through the gates using the design flows. The 7 floodgate sites are presented in Figure 63 - Figure 76, showing the design flow field with the gate or gate/sluice gate configurations as defined at MVN. Table 67 defines the gate dimensions and configurations simulated, and Table 68 shows the existing Condition and With Gate or Gate + Sluice Gates velocities. Gate simulations were completed with sluice gates open and with sluice gates closed.

**Table 67 - 4 Floodgate and Sluice Gate Configurations**

| Location | Gate Width (ft) | Sluice Width (ft) | Depth (ft) |
|---|---|---|---|
| GIWW @ Houma | 2 X 125 = 250<br>Single 175 | None<br>4 @ 25 ft each | -16<br>-16 |
| Minor's Canal | Single 56 | None | -9 |
| Falgout Canal | Single 56 | 3 @ 46 ft each | -9 |
| Bayou DuLarge | Single 56 | None | -7 |
| Bayou Grand Caillou | Single 56 | 3 @ 46 ft each | -12 |
| Grand Bayou Canal | Single 56 | 3 @ 46 ft each | -9 |
| GIWW @ Larose | Single 125<br>Single 175 | None<br>2 @ 25 ft each | -16<br>-16 |

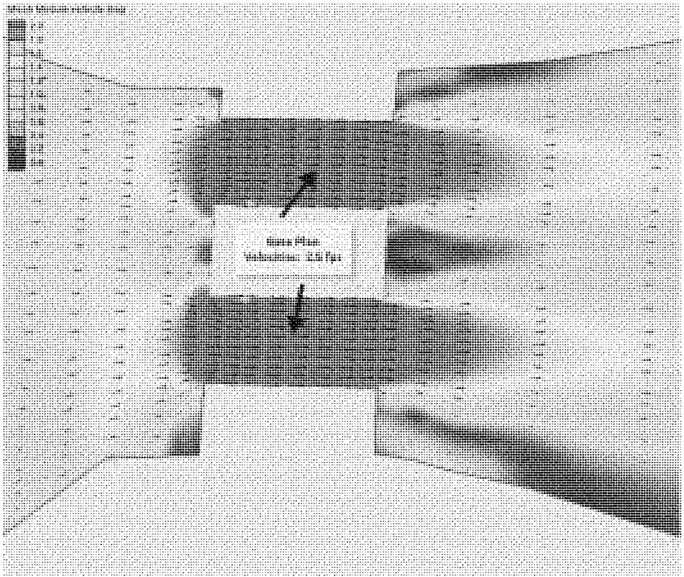

**Figure 63 - GIWW at Houma with two 125 ft wide sector gates, no sluice gates**

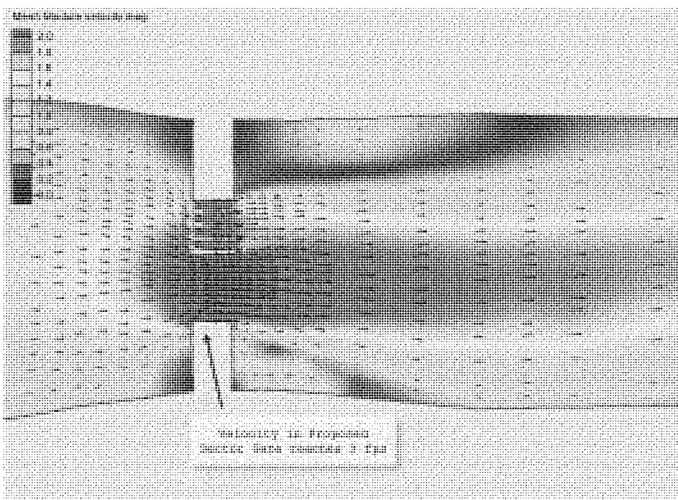

**Figure 64 – GIWW at Houma for single 175 ft sector gate with four, 25 ft wide sluice gates**

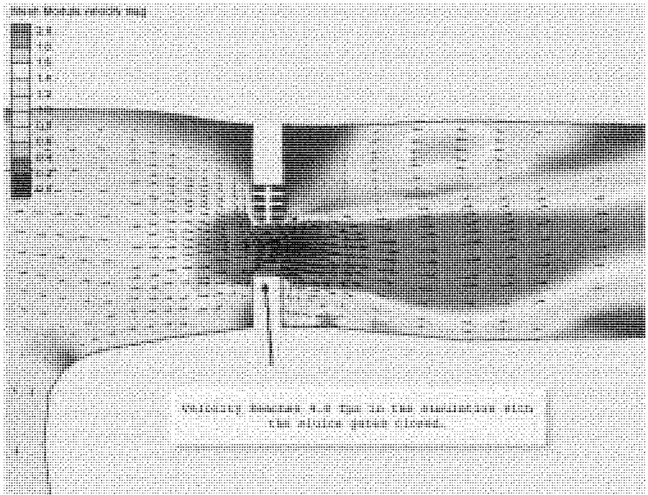

Figure 65 - GIWW at Houma for single 175 ft sector gate with four, 25 ft wide sluice gates closed

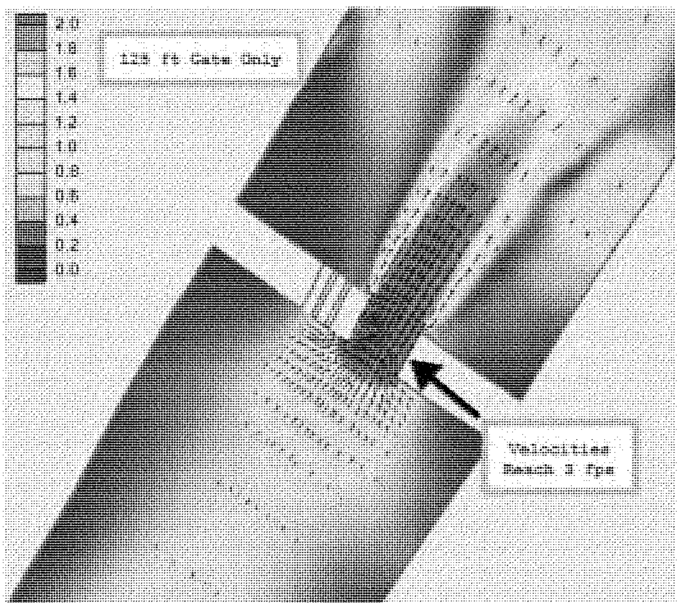


Figure 66 - GIWW at Larose for single 125 ft wide sector gate

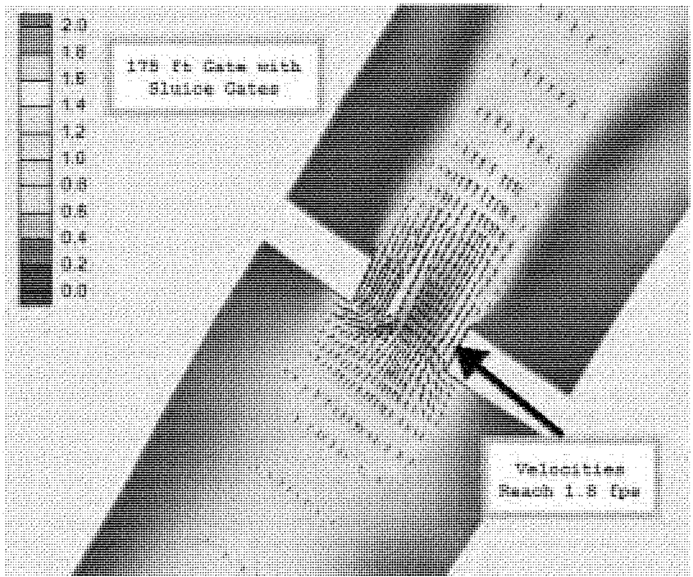


Figure 67 – GIWW at Larose for single 175 ft wide sector gate with two, 25ft sluice gates

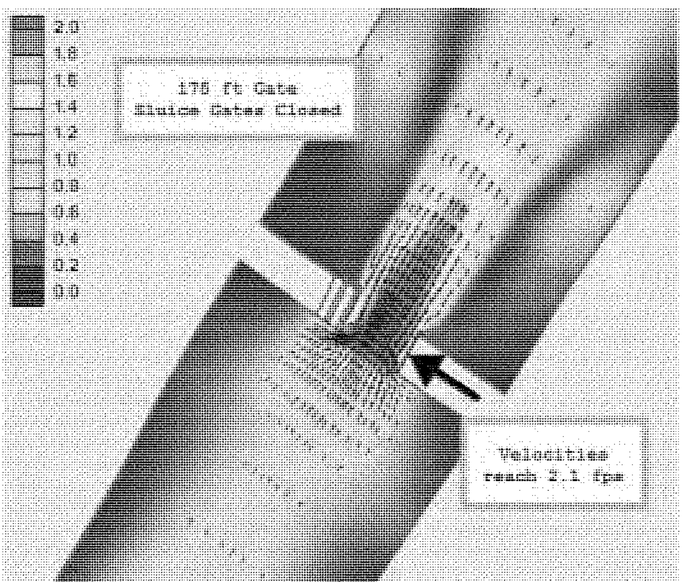


Figure 68 - GIWW at Larose for single 175 ft wide sector gate with two, 25ft sluice gates closed

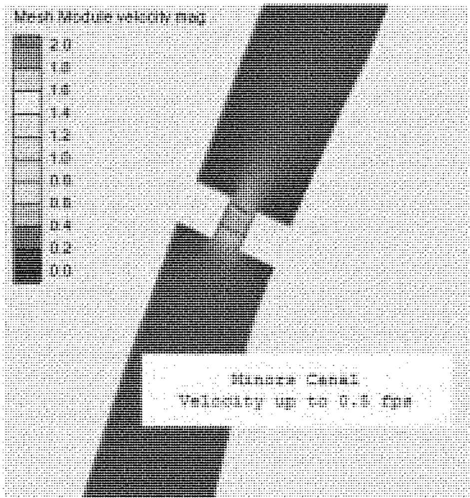


Figure 69 - Minors Canal with single 56 ft wide sector gate, no sluice gates

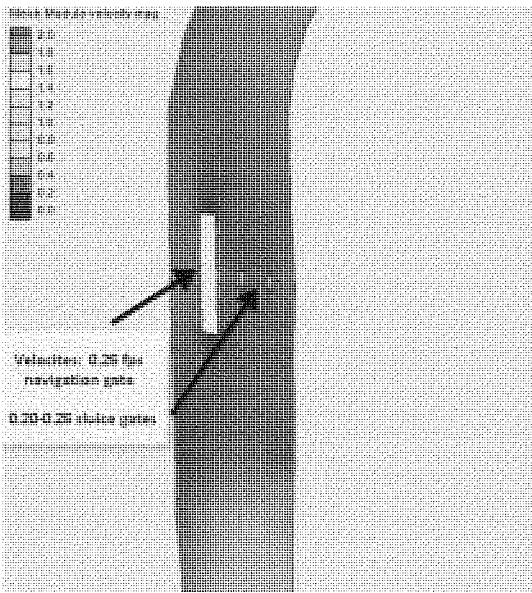


Figure 70 - Grand Bayou with single 56 ft wide sector gate, three 45 ft wide sluice gates

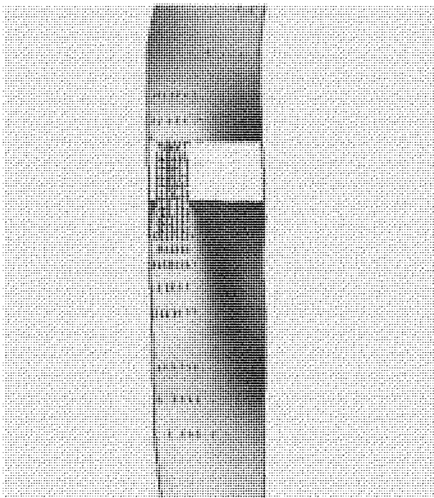

Figure 71 - Grand Bayou with single 56 ft wide sector gate, three, 46 ft wide sluice gates closed

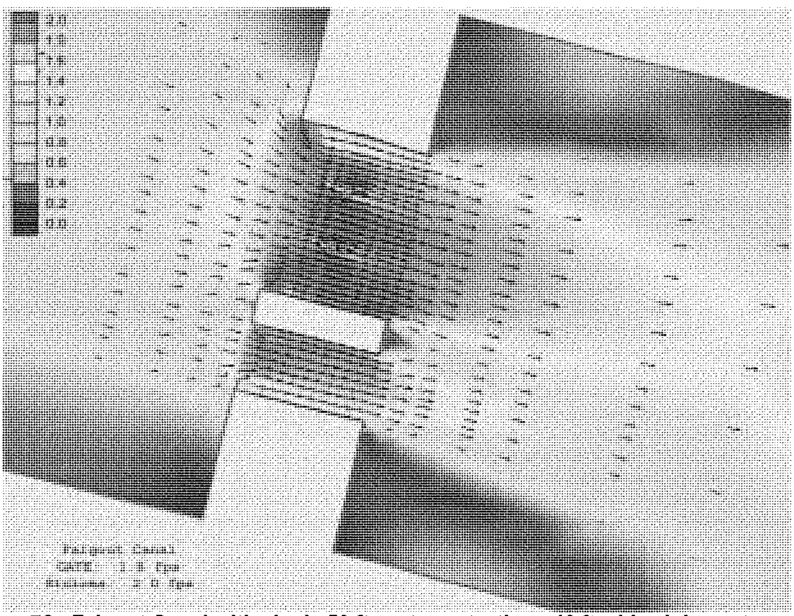


Figure 72 - Falgout Canal with single 56 ft sector gate, three 46 ft wide sluice gates open

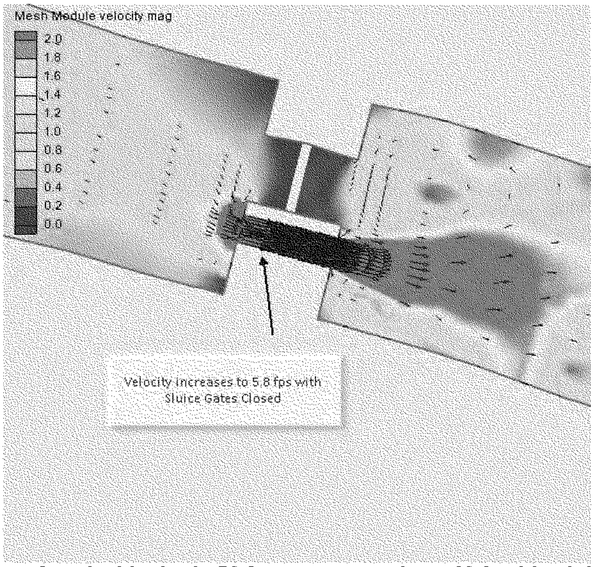


**Figure 73 - Falgout Canal with single 56 ft sector gate, three 46 ft wide sluice gates closed**

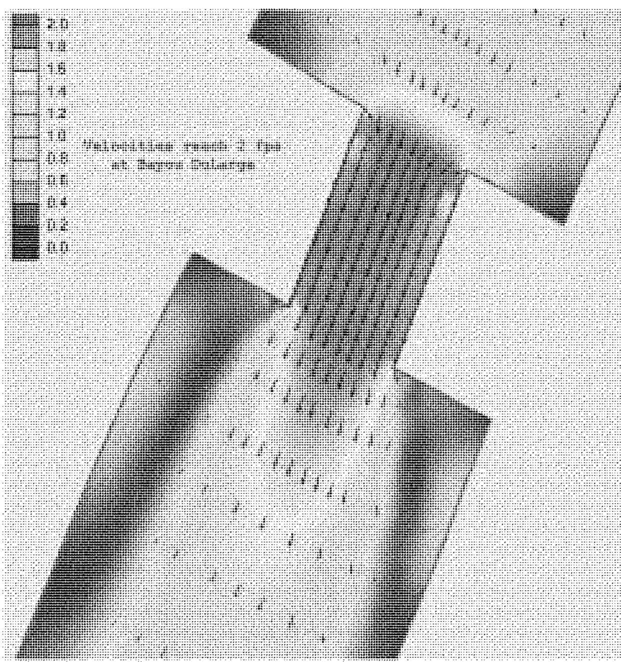


**Figure 74 - Bayou Dularge with single 56 ft sector gate, no sluice gates**

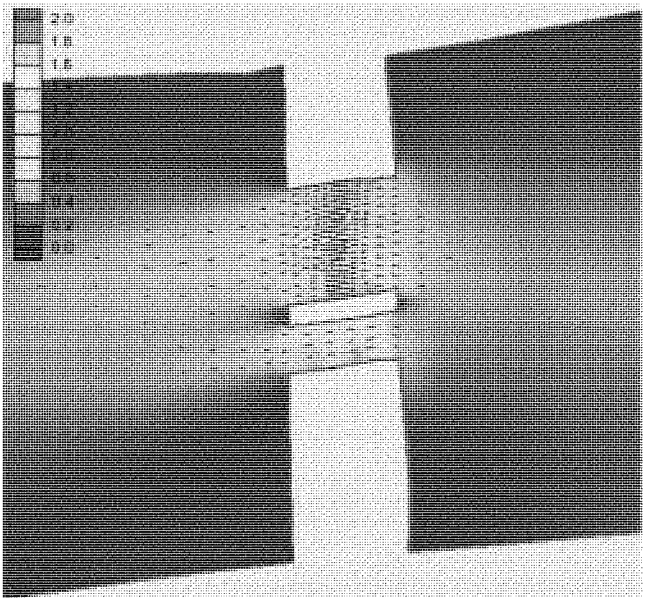

Figure 75 – Bayou Grand Caillou with single 56 ft wide sector gate, three 46 ft wide sluice gates

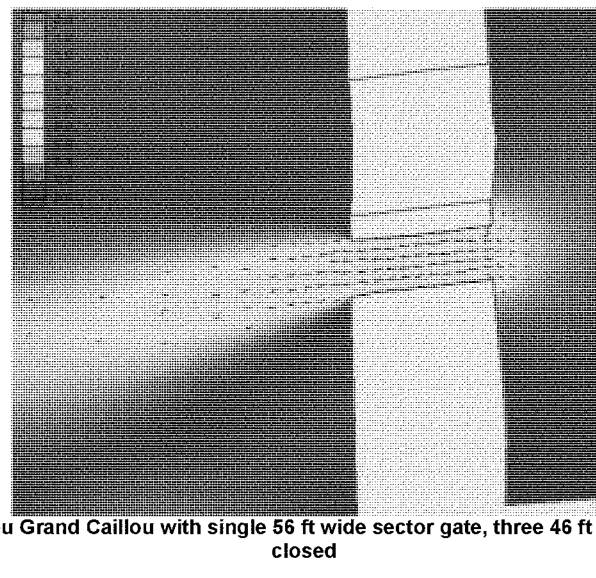

Figure 76 - Bayou Grand Caillou with single 56 ft wide sector gate, three 46 ft wide sluice gates closed

**Table 68 - Existing Condition and With Gate or Gate + Sluice Gates**

| Location | Model Velocities, FPS | |
|---|---|---|
| **North Gate Sites** | Existing Condition Velocity, fps | Open Gate/Open Sluice gate velocities |
| GIWW @ Houma-<br><br>Two 125 ft Sector Gates only<br>Single 175 ft Sector with 4-25 ft sector gates Open<br>Single 175 ft Sector with 4-25 ft sector gates Closed | 1.09 | <br>2.5<br>3.0<br><br>4.8 |
| GIWW @ Larose-<br><br>125 ft Navigation gate only<br>175 ft Navigation gate<br>175 ft Navigation gate + 2 sluice gates | 0.78 | <br><br>3.0<br>2.1<br>1.8 |
| Minors Canal | 0.29 | 0.5 |
| Grand Bayou-<br><br>56 ft Navigation Gate only<br>56 ft Navigation Gate + 3 sluice gates | 0.58 | 1.1<br>0.5 |
| **Mid - HNC Gate Sites** | | |
| Falgout Canal-<br>56 ft Navigation Gate only<br>56 ft Navigation + 3 sluice gates | 0.91 | 5.8<br>1.8 |
| Bayou Dularge | 1.30 | 2.0 |
| Bayou Grand Caillou<br>56 ft Navigation Gate only<br>56 ft Navigation Gate + 3 sluice gates | 0.56 | 1.1<br>0.8 |

Details on the plan view floodgate existing condition versus floodgate and floodgate/sluice combinations be furnished upon request. Proposed floodgate simulations logically cause an increase in velocity over existing condition velocities. However, Bayou Grand Caillou and Grand Bayou show lower gate plan constriction velocities than their existing condition. This occurred because the gate sill elevation for the gate/sluice plans at these sites is deeper than the surrounding channel bottom elevations, increasing channel area and slowing velocities.

**Part III Vessel Presence Velocity Accelerations.**

Velocity Acceleration Problem - When a vessel passes a waterway constriction such as one of the proposed floodgates, additional impacts may be significant. The moving vessel occupies a cross-sectional area as it passes the gate constriction, and the additional loss of cross section further increases velocities. In wide, deep waterways, the impact of vessel presence is often negligible. But in the GIWW, a loaded barge tow can occupy an additional 30 percent or more of the channel cross section at the GIWW floodgate sites.

Evaluation Methodology - In the adjacent eastern sections of the GIWW where storm surge and flood improvements are ongoing along the New Orleans Westbank Western Closure Complex (WCC), similar vessel presence velocity accelerations posed a problem for planned ship simulator evaluations. The method for defining vessel presence accelerations was developed in the 2 dimensional model work for the WCC. The largest of 3 design vessel configurations used at the WCC was used to define the velocity fields at the 2 GIWW gate sites, Larose and Houma. Figure 77 schematizes the flow block concept. Cross sectional area was calculated and applied as a full-depth input. The flow block cross sectional area was equivalent to the design vessel, but was narrower than the actual vessel. This adaptation was necessary because RMA2 cannot evaluate pressure flows under a vessel, thus the area adjustments were made as a full channel depth block.

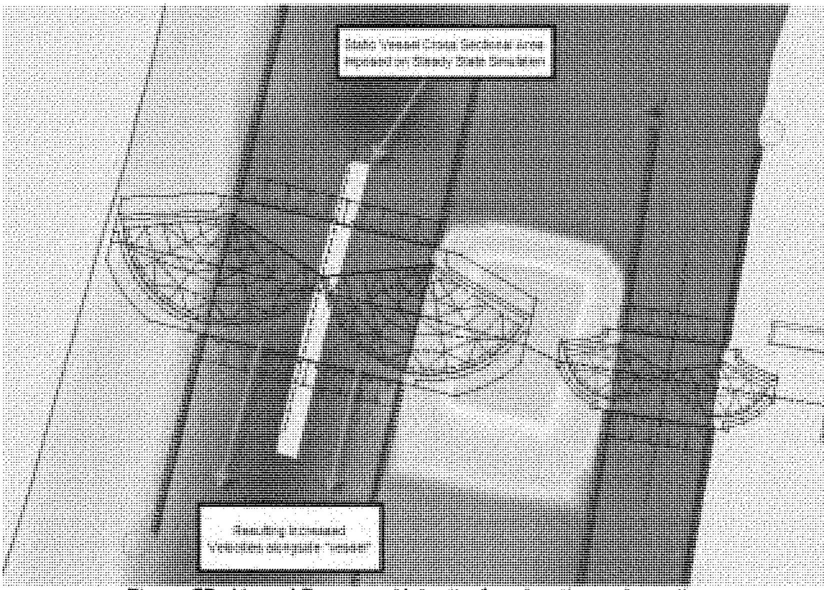

Figure 77 - Vessel Presence Velocity Acceleration schematic

Accuracy of Vessel Presence Velocity Accelerations - The WCC benefitted from a navigation physical model that re-produced certain numerical model simulations. The 2 dimensional flow block velocity strategy defined vessel presence increases, removed the flow block and ramped up discharge to match the flow block velocities. Flow velocities recorded along-side the model tow vessel in the physical model matched the 2 dimensional "flow block" velocities within 0.1 fps. Though no MTG physical model values are available for comparison, this strategy shows a reasonable estimate of the velocity increase in the GIWW as a vessel passes. Figure 78 and Figure 79 show the accelerations expected for 70 ft wide tow drafting 10 ft at the GIWW Houma and Larose gate sites. No significant water surface elevations were noted due to the proposed floodgate configurations. Figure 80 shows a typical minor local water surface elevation change at the GIWW Larose location. Table 69 displays a few selected water surface elevation changes at a few locations, with the greatest differentials reaching only a tenth of one foot.

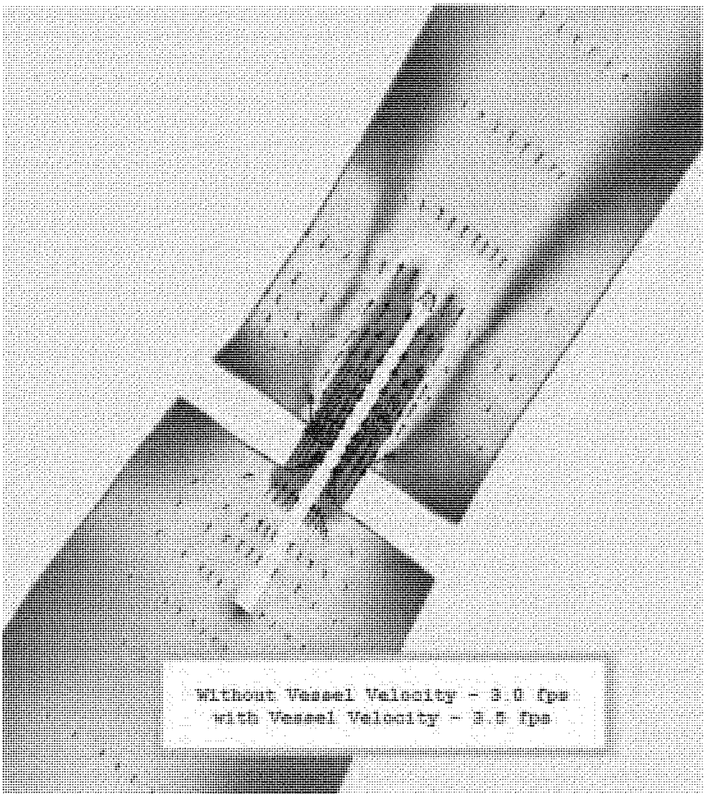


**Figure 78 - GIWW at Larose Vessel Presence Velocity field**

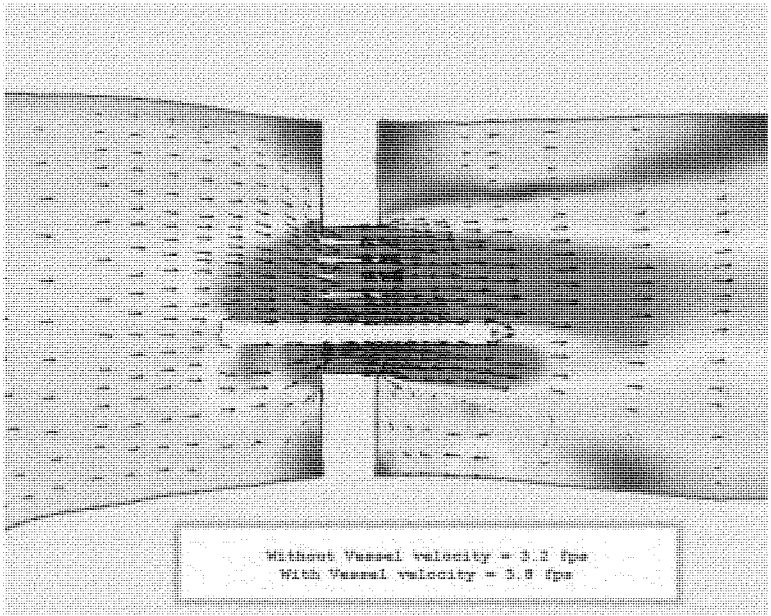

Figure 79 - Vessel Presence Velocity Field at GIWW Houma

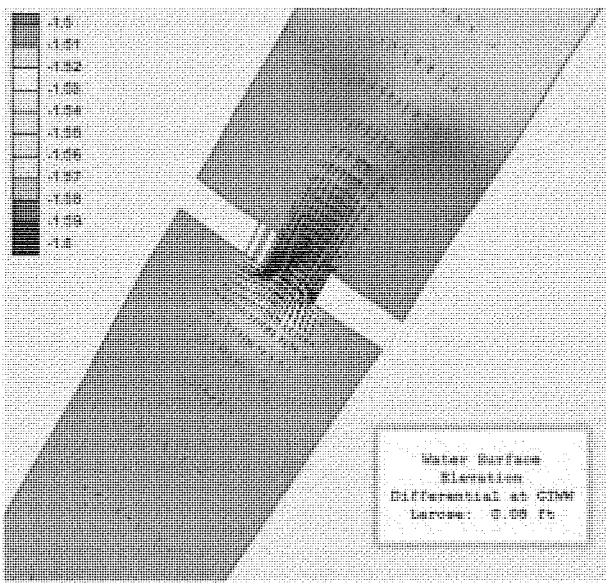


Figure 80 - Head Differential showing 0.08 ft at the GIWW Houma gate site

**Table 69 - Water Surface Elevation Comparisons**

| Location | Existing | With Gates |
|---|---|---|
| Amelia | 4.36 | 4.35 |
| Larose | -0.16 | -0.14 |
| Dulac | 1.14 | 1.02 |
| Houma | 1.79 | 1.64 |

**Part IV - Conclusions and Recommendations.**

This report contains an initial gate design for each of the 7 proposed floodgate sites. Some revisions to the design flows were completed during technical review and field data review that became available during the technical review schedule. Also, 175 ft wide configurations were evaluated for the GIWW floodgate sites at Houma and Larose. A range of magnitudes is evident between the design flows and velocities associated with the 7 floodgate sites in this study and comparisons to ERDC study simulations and field data. Some of the design values offer close agreement, some are farther apart. To explain, the Gulf, canal, and river system in the project areas is very complex, with certain floodgate sites being controlled more by high discharges, and others that are more sensitive to water surface elevation (tide, storm, and wind combinations). The model domains and boundary conditions used in this study and as reviewed from the ERDC studies are all considered accurate, and the range of magnitudes is a function of system complexity. The resulting range is presented as more accurate than a single study. The more significant design flow range occurs with the Mid-HNC gates, where the values range from <1.0 to < 2.0 fps. This low magnitude range offers confidence that even if the design values are more prone to follow the higher velocities, the floodgate designs will still offer a safe margin below the 4.4 fps criteria.

Maximum velocity values are listed below for each configuration at the proposed floodgate locations. Using the 3 mph (4.4fps) navigation criteria limit (as used at the Western Closure Complex), configurations showing values less than 4.4 fps can be considered acceptable in terms of velocity. No head differential problems were noted. The vessel presence velocity acceleration simulations on the GIWW at Houma and Larose did show a significant increase in velocity compared to the gate-only conditions, but the accelerations were still below the 4.4 fps criteria. The system model does not show any significant water level rises due to the presence of the proposed gates. The two configuration options that exceed the velocity criteria are highlighted. In terms of velocity, including the simulated presence of a design vessel between the gates, all but two options (the single 175 ft gate at Houma and the 56 ft without sluice gates at Falgout) are viable. The final structure design, including environmental flow control structures, is provided in Table 70.

GIWW at Houma-
Existing condition- 1.09 fps.
Dual 125 ft sector gate configuration- 2.5 fps
Vessel presence in dual 125 ft sector gate configuration- 3.2 fps
Single 175 ft Sector Navigation Gate + 4 sluice gates open- 3.2 fps

Single 175 ft Sector and Sluice gates open with vessel presence- 3.8 fps
***Single 175 ft Sector Gate with Sluice Gates closed- 4.8 fps***

GIWW at Larose-
Existing condition- 0.78 fps.
125 ft Gate configuration- 3.0 fps
Vessel presence in 125 ft gate configuration- 3.5fps
175 ft Gate configuration- 2.1 fps
175 ft Gate configuration + sluice gates- 1.8 fps
Minors Canal-
Existing condition- 0.30 fps.
Gate configuration- 0.5 fps
Grand Bayou-
Existing condition- 0.58 fps.
Gate configuration with sluice gates open- 0.5 fps
Gate configuration with sluice gates closed- 1.1 fps
Note- The lower velocity with the proposed gate in place is due to the gate sill elevation that is lower than the surrounding channel bottom elevation.

Falgout Canal-
Existing condition- 0.91 fps.
Gate configuration with sluice gates open- 1.8 fps

***Gate configuration with sluice gates closed- 5.8 fps***

Bayou Dularge-
Existing condition- 1.3 fps.
Gate configuration 2.0 fps
Bayou Grand Caillou-
Existing condition- 0.51 fps.
Gate configuration with sluice gates open- 0.41 fps
Gate configuration with sluice gates closed- 1.1 fps
Note- The lower velocity with the proposed gate and sluice gates open is due to the gate sill elevation that is lower than the surrounding channel bottom elevation, offering an increase in channel cross section and resulting slower velocities. Also, the ERDC field data set shows substantially higher flows in the Houma Navigation Canal near Bayou Grand Caillou. Values shown here compare well with long-term data as shown in USGS paper 1672.
Maintenance Concerns-
Bayou Grand Caillou and Grand Bayou show lower gate plan constriction velocities than their existing condition because the gate sill elevation was deeper than the surrounding channel bottom elevations. MVN has experienced sedimentation problems at other project locations where a floodgate sill elevations was lower than surrounding channel elevations. However, MVN Operations evaluations expect no problems with the MTG sites, because of very low sediment influx and cleanout action from passing vessel propwash.

| Table 70 - Final Sizing Table for All Structures | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Reach | Name | Sector Gate Width (FT) | Sluice Gates # & W(FT) | Env. Structure Sluice Gates # and Diameter (FT) | Invert (FT) | 1% AEP LORR 2085 Elevation | 1% AEP LORR 2035 Elevation | 3% AEP LORR 2085 Elevation | 3% AEP LORR 2035 Elevation | | |
| Barrier (N of GIWW) | Levee | | | | | 20 | 14 | 13 | 9 | | |
| Barrier - Reach 4 | Bayou Black | 56 | none | | -12 | 23 | -- | 15 | -- | 20°40'25.61"N | 90°00'24.01"W |
| Barrier - Reach 4 | Environmental Control | | | 6- 6x6 | -4.5 | 23 | -- | 16 | -- | 29°40'21.22"N | 91°00'12.82"W |
| Barrier - Reach 4 | Environmental Control | | | 6- 6x6 | -4.5 | 23 | -- | 16 | -- | 29°39'40.52"N | 90°58'59.25"W |
| Barrier - Reach 3 | Environmental Control | | | 6- 6x6 | -4.5 | 23 | -- | 16 | -- | 29°38'48.20"N | 90°58'18.06"W |
| Barrier - Reach 3 | Shell Canal W | 56 | none | | -10 | 23 | -- | 16 | -- | 29°37'38.42"N | 90°56'46.97"W |
| Barrier - Reach 3 | Shell Canal E | 56 | none | | -12 | 23 | -- | 16 | -- | 29°37'26.51"N | 90°55'57.84"W |
| Barrier - Reach 3 | Elliot Jones Canal | 20 Stop Log | none | | -8 | 23 | -- | 16 | -- | 29°37'26.51"N | 90°55'57.84"W |
| Barrier - Reach 3 | Bayou Black Pump Station | FP & Butterfly Valve | | | | 23 | | 16 | | | |
| Barrier - Reach 3 | Environmental Control | | | 6- 6x6 | -4.5 | 23 | -- | 16 | -- | 29°36'37.32"N | 90°53'58.12"W |
| Barrier - Reach 3 | NAFTA | 56 | none | | -12 | 23 | -- | 16 | -- | 29°35'56.09"N | 90°52'32.23"W |
| Barrier - Reach 3 | Hanson Canal Pump Station | FP & Butterfly Valve | | | | 23 | -- | 16 | -- | | |
| Barrier - Reach 2 | Humphreys Canal | 20 Stop Log | none | | -8 | 23 | -- | 16 | -- | 29°35'58.50"N | 90°51'37.20"W |
| Barrier - Reach 2 | Environmental Control | | | 6- 6x6 | -4.5 | 23 | -- | 16 | -- | 29°21'21.41"N | 90°44'52.10"W |
| Barrier - Reach 2 | Environmental Control | | | 6- 6x6 | -4.5 | 23 | -- | 16 | -- | 29°34'57.17"N | 90°49'32.18"W |
| Barrier - Reach 2 | Environmental Control | | | 6- 6x6 | -4.5 | 23 | -- | 16 | -- | 29°34'10.65"N | 90°48'53.20"W |
| A-3 | GIWW at Houma | 175 | 6 @ 16' | | Sector Gate@-16'; sluice gates at-13 | 23 | -- | 16 | -- | 29°32'6.69"N | 90°47'33.38"W |
| A-3 (N of GIWW) | Levee | | | | | 19.5 | 14 | 13 | 9 | | |
| A-3 (S of GIWW) | Levee | | | | | 20.5 | 17.5 | 13 | 9 | | |
| A-3 | Minor's Canal | 56 | none | | -9 | 23 | -- | 16 | | 29°33'04.20"N | 90°47'51.69"W |
| A | Environmental Control | | | 6 - 6x6 | -4.5 | 23 | -- | 16.0 or 16.5? | -- | 29°29'06.36"N | 90°44'34.43"W |
| B | Levee | | | | | 20.5 | 17.5 | 13.5 | 11 | | |
| B | Marmande Canal | 30 | none | | -4 | 23 | -- | 16.5 | -- | 29°27'39.72"N | 90°45'49.93"W |
| B | Falgout Canal | 56 | 9 @ 16' | | -9 | 23 | -- | 16.5 | -- | 29°24'55.77"N | 90°47'14.29"W |
| E-2 | Levee | | | | | 23.5 | 21 | 15.5 | 14 | | |
| E-2 | Highway 315 Road Gate | Road Gate | | | | 25.5 | -- | 18 | -- | 29°24'31.38"N | 90°47'11.29"W |
| E-2 | Bayou Du Large | 56 | none | | -7 | 25.5 | -- | 18 | -- | 29°24'31.96"N | 90°47'12.53"W |
| E-2 | Environmental Control | | | 9 - 6x6 | -4.5 | 25.5 | -- | 18 | -- | 29°23'55.60"N | 90°44'46.40"W |
| E-1 | Levee | | | | | 23.5 | 21 | 15.5 | 14 | | |
| E-1 | Environmental Control | | | 9 - 6x6 | -4.5 | 25.5 | -- | 18 | -- | 29°24'26.31"N | 90°46'11.40"W |
| F-2 | Levee | | | | | 23.5 | 21 | 15.5 | 14 | | |
| F-1 | Levee | | | | | 23.5 | 21 | 15.5 | 14 | | |
| F-1 | Bayou Grand Caillou | 56 | 9 @ 16' | | -12 | 25.5 | -- | 18 | -- | 29°20'31.51"N | 90°44'21.49"W |
| F-1/G-1 | Houma Navigation Canal | 250' gate, 110' lock | | | -18 | 30.5 | -- | 22.5 | | 29°19'46.84"N | 90°43'48.06"W |
| G-1 | Levee | | | | | 24 | 22 | 17.5 | 16 | | |
| G-1 | Four Point Bayou Road Gate | Road Gate | | | | 30.5 | -- | 22.5 | -- | 29°19'10.56"N | 90°42'19.56"W |
| G-2 | Levee | | | | | 24 | 22 | 17.5 | 16 | | |
| G-2 | Four Point Bayou | 30 | none | | -6 | 30.5 | -- | 22.5 | -- | 29°19'10.28"N | 90°42'18.04"W |
| G-2 | Environmental Control | | | 6 - 6x6 | -4.5 | 30.5 | -- | 22.5 | -- | 29°19'02.84"N | 90°41'54.90"W |
| G-2 | Environmental Control | | | 4 - 6x6 | -4.5 | 30.5 | | 22.5 | | 29°18'58.09"N | 90°41'38.44"W |
| G-3 | Levee | | | | | 24 | 22 | 17.5 | 16 | | |
| G-3 | Environmental Control | | | 4 - 6x6 | | | | | | 29°18'46.71"N | 90°40'54.83"W |
| H-1 | Levee | | | | | 24 | 22 | 17.5 | 16 | | |
| H-1 | Environmental Control | | | 1 - 6x6 | -4.5 | 30.5 | -- | 22.5 | -- | 29°18'06.79"N | 90°40'14.73"W |

**Table 70 - Final Sizing Table for All Structures**

| Reach | Name | Sector Gate Width (FT) | Sluice Gates # & W(FT) | Env. Structure Sluice Gates # and Diameter (FT) | Invert (FT) | 1% AEP LORR 2085 Elevation | 1% AEP LORR 2035 Elevation | 3% AEP LORR 2085 Elevation | 3% AEP LORR 2035 Elevation | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| H-1 | Environmental Control | | | 6 - 6x6 | -4.5 | 30.5 | -- | 22.5 | -- | 29°17'52.15"N | 90°39'32.25"W |
| H-1 | Highway 56 Road Gate | Road Gate | | | | 30.5 | -- | 22.5 | -- | 29°17'44.88"N | 90°38'57.99"W |
| H-1/H-2 | Bayou Petit Caillou | 56 | 6 @ 16' | | -8 | 30.5 | -- | 22.5 | -- | 29°17'44.43"N | 90°38'54.62"W |
| H-2 | Levee | | | | | 25.5 | 23 | 19 | 16.5 | | |
| H-2 | Placid Canal | 56 | 6 @ 16' | | -8 | 31.5 | -- | 24 | -- | 29°18'31.63"N | 90°38'40.49"W |
| H-3 | Levee | | | | | 26.5 | 24 | 20 | 18 | | |
| H-3/I-1 | Bush Canal | 56 | 9 @ 16' | | -12 | 33 | -- | 25 | -- | 29°22'5.39"N | 90°36'7.40"W |
| I-1 | Levee | | | | | 26.5 | 24 | 20 | 18 | | |
| I-1/I-2 | Bayou Terrebonne | 56 | none | | -9 | 33 | -- | 25 | -- | 29°23'16.94"N | 90°35'17.03"W |
| I-1/I-3 | Highway 55 Road Gate | Road Gate | | | | 33 | -- | 25 | -- | 29°23'16.94"N | 90°35'17.03"W |
| I-2 | Levee | | | | | 26.5 | 24 | 20 | 18 | | |
| I-2 | Madison/Nettleton Pump Station | FP & Butterfly Valve | | | | 33 | -- | 25 | -- | | |
| I-3 | Levee | | | | | 26.5 | 24 | 20 | 18 | | |
| I-3/J-2 | Humble Canal | 56 | none | | -9 | 33 | -- | 25 | -- | 29°26'06.60"N | 90°33'42.43"W |
| J-2 | Levee | | | | | 26.5 | 24 | 20 | 18 | | |
| J-2 | Environmental Control | | | 4 - 5x10 | -3.5 | 33 | -- | 25 | -- | 29°26'12.21"N | 90°32'22.13"W |
| J-2 | Environmental Control | | | 4 - 5x10 | -3.5 | 33 | -- | 25 | -- | 29°26'33.45"N | 90°31'15.87"W |
| J-2 | Environmental Control | | | 5 - 5x10 | -3.5 | 33 | -- | 25 | -- | 29°27'20.46"N | 90°29'59.10"W |
| J-1 | Levee | | | | | 26.5 | 24 | 20 | 18 | | |
| J-3 | Levee | | | | | 26.5 | 24 | 20 | 18 | | |
| J-3 | Pointe-aux-Chenes Pump Station | FP & Butterfly Valve | | | | 33 | -- | 25 | -- | | |
| J-3 | Highway 665 Road Gate | Road Gate | | | | 33 | -- | 25 | -- | 29°25'04.07"N | 90°26'54.96"W |
| J-3/K | Bayou Pointe-aux-Chenes | 56 | none | | -6 | 33 | -- | 25 | -- | 29°25'04.78"N | 90°26'53.44"W |
| K | Levee | | | | | 25.5 | 22.5 | 17.5 | 16 | | |
| K | Environmental Control | | | 2 - 6x6 | -4.5 | 29.5 | -- | 21 | -- | 29°26'47.15"N | 90°26'49.85"W |
| K | Environmental Control | | | 2 - 6x6 | -4.5 | 29.5 | | 21 | | 29°27'56.00"N | 90°26'24.52"W |
| L-3 | Levee | | | | | 25.5 | 22.5 | 17.5 | 16 | | |
| L | Environmental Control | | | 6- 6x6 | -4.5 | 29.5 | -- | 21 | -- | 29°30'11.73"N | 90°25'9.78"W |
| L-3 | Grand Bayou | 56 | 9 @ 16' | | -9 | 29.5 | -- | 21 | -- | 29°31'06.00"N | 90°24'42.22"W |
| North of L | GIWW at Lafourche | 175 | 3 @ 16' | | Sector Gate@-16'; Sluice gates@-10') | 17.5 | -- | 15 | -- | 29°35'17.12"N | 90°22'21.06"W |

### 2.6.5 Reverse Load Case

#### 2.6.5.1 Background/Introduction

The proposed MTG navigational hydraulic structures will experience several different operational conditions and water levels during and after construction of the project. This document will address the methodology used to determine the reverse head load cases that will result from forces due to standing water on the protected side and flood side at each structure, which will produce a maximum differential head. The structures will be designed to handle these forces. Table 71 below provides the differential head for each of the 21 structures proposed along the levee alignment. An explanation is also included below the table, which summarizes the methodology used to determine the water surface elevations in this analysis and supporting documentation.

**Table 71 - Differential Head for Maximum Reverse Head Loads from Hurricanes**

| | Levee Reach | Structure | Flood Side WSEL (ft)* | 2085 3% AEP / 1% AEP Levee Protected Side WSEL (ft)* | 2085 3% AEP / 1% AEP Levee Differential Head (ft)* |
|---|---|---|---|---|---|
| **1** | Reach A | GIWW at Houma | -1.25 | 3.04[1] | 4.29 |
| **2** | | Minor's Canal | -1.25 | 2.54 | 3.79 |
| **3** | Reach B | Falgout Canal | -0.74 | 3.06 | 3.80 |
| **4** | Reach E | Bayou DuLarge | -0.74 | 3.06 | 3.80 |
| **5** | Reach F | Bayou Grand Calliou | -0.74 | 3.11 | 3.85 |
| **6** | Reach G | Houma Navigation Canal | -1.40 | 4.05[2] | 5.45 |
| **7** | | Bayou Fourpoints | -2.76 | 3.30 | 6.06 |
| **8** | Reach H | Bayou Petite Calliou | -2.76 | 3.49 | 6.25 |
| **9** | | Lapeyrouse Canal | -2.76 | 3.49 | 6.25 |
| **10** | | Placid Canal | -2.76 | 3.49 | 6.25 |
| **11** | Reach I | Bush Canal | -1.14 | 2.99 | 4.13 |
| **12** | | Bayou Terrebonne | -1.64 | 3.10 | 4.74 |
| **13** | | Humble Canal | -1.64 | 1.19 | 2.83 |
| **14** | Reach K | Bayou Pointe-aux-Chenes | -1.64 | 3.00 | 4.64 |
| **15** | | GIWW at Larose | -1.64 | 3.96[1] | 5.60 |
| **16** | Barrier Plan Reach 3 | Shell Canal E | -1.35 | 2.87 | 4.22 |
| **17** | | Shell Canal W | -1.35 | 2.87 | 4.22 |
| **18** | | Elliot Jones Canal | -1.35 | 3.28 | 4.63 |
| **19** | | NAFTA Canal | -1.35 | 3.28 | 4.63 |
| **20** | | Humphreys Canal | -1.35 | 3.28 | 4.63 |
| **21** | | Black Bayou Canal | -0.87 | 4.58 | 5.45 |

***Water surface elevations are referenced to NAVD88 datum, epoch 2004.65.**
[1] **An additional 0.50′ was added to the protected side elevation for wind setup on major waterbodies.**
[2] **An additional 1.00′ was added to the protected side elevation for wind setup on major waterbodies.**

#### 2.6.5.2 Reverse Load Case Discussion and Supporting Documentation

A reverse load case will be experienced at each structure when a hurricane changes path abruptly due to a change in wind direction. The water surface elevation on the flood side is decreased to an extremely low water surface elevation and the protected side is at a higher water surface elevation due to an interior rainfall event. It is important to note that the reverse heads are generally unlikely to occur, because the structures could normally be opened to prevent water levels from reaching the elevations indicated on the protected side. The worst case scenario is assumed, which is that the protected side design stages are modeled such that the structures cannot be opened due to mechanical or electrical malfunctions. This will result in the structure experiencing a maximum head differential. This analysis only represents static loads from water levels, when the structure is in closed position and do not include any dynamic loads from waves, or boat impacts, forces acting on the hull of the boat.

The differential heads were calculated by obtaining gage data for the flood side elevation and extracting the protected side elevation from the interior model. An exhaustive search of gage records and associated gage adjustments within the study area were obtained from both MVN's and USGS's stream gage websites to establish the flood side elevation.

An analysis was completed to determine the closest gage to each structure. From the gage data, the record annual low was extracted and adjusted to the correct datum. The resulting elevation was used for the flood side elevation at each structure.

The protected side elevations were determined from the results of the unsteady interior drainage (UNET) model developed for this study. The peak water surfaces elevation was determined at each structure for the 10% annual chance storm event, future conditions, for both the 3% AEP and 1% AEP alternatives. This was used in conjunction with the protected side elevations to calculate the differential head at each structure. The interior model considered the intermediate case of eustatic sea level rise rates for all future analysis years. The model reported no difference in water surface elevations between the 3% AEP and 1% AEP levee models. The protected side water surface elevation was increased to account for wind setup. An additional 0.5 foot and 1.0 foot was added at structures located along major waterbodies, Houma Navigational Canal and GIWW, respectively. Similar guidance was used on Inner Harbor Navigational Canal Lock and West Closure Complex projects to account for strong winds that pushes the water surface in one direction and causes the water to pile up on one side of the basin (on the protected side) when the structure is in closed position. The two values, the exterior and interior water surface elevations, were used to calculate the head differential values in Table 71.

## 2.6.6 Rip Rap Design

### 2.6.6.1 Introduction

The Hydraulics and Hydrologic Branch of the Corps of Engineers, MVN, was tasked to determine the size and location of rip rap needed to protect 28 structures along the proposed MTG project alignment from scour. For this analysis, the following means of scour were identified and analyzed- tidal currents, ship wake, ship propeller (prop) wash. For tropical event risk reduction, a standard rip rap size and layout developed by the Hurricane Protection Office is proposed for each structure, and will not be detailed here. At a location where rock is required simultaneously for tropical events and the requirements of this analysis, the larger size rock shall govern.

The methodology described here consisted of superimposing all of the discrete velocity components and sizing and locating the rip rap at each structure based on the resultant velocities. The analysis and results thereof are explained in the following dialogue.

### 2.6.6.2 Analysis

#### 2.6.6.2.1 Tidal Velocities

The US Army Engineer Research and Development Center developed an ADH (Adaptive Hydraulics) model to determine the maximum expected tidal velocities expected to occur through several structures. The resultant maximum tidal velocities are depicted in Figure 81. Because the configuration of the Barrier Alignment structures had not been completed by the time the modeling was done, the velocities developed by ERDC for similar structures and locations were adopted for this study.

It was quickly concluded that none of the environmental structures would need protection from tidal flows, since in addition to not having any navigational traffic; these structures would have to be sized so that the maximum velocity occurring through each is 2.6 ft/sec.

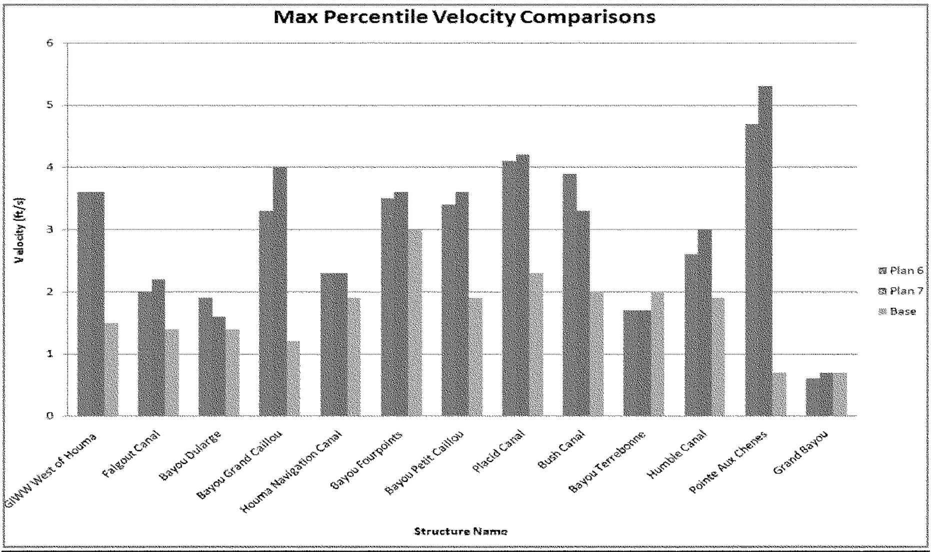


**Figure 81 - Maximum tidal velocities**

### 2.6.6.2.2 Passing Vessel – Resultant Velocities

The increase of stream velocities caused by the passing of a vessel is the resultant of two inputs- the velocity increase due to the vessel's propeller jet (prop wash) and the velocity increase due to the vessel's wake. The prop wash currents occurring at the bottom of the channel are dependent on such variables as vessel horsepower, prop diameter, speed of the vessel, and the vertical distance from the propeller to the channel bottom. The wake currents are a resultant of the bow wave velocity (a rapid decrease in velocity near the bow of the barges which is caused by the bow wave), displacement velocity (the rapid increase following the bow wave), and the return velocity. The point of interest along of the velocity distribution occurring during the vessel's passing is the maximum resultant velocity. Of note is the fact that the channel bottom is not subjected to the maximum wake velocity at the same time as the maximum propeller velocity. However, the results of applying this principle were negligible, and were not applied in this analysis.

The following steps summarize the process used to determine velocity increases, due to a passing vessel. Uncertainty is introduced for the structures in which the "large" vessel prototype was not used. For these structures, a smaller vessel with estimated design values (such as horsepower) was used. Also, the equations allow some uncertainty in their application for the Morganza structures (the equations were developed empirically during experimentation completed for the Illinois Water System). However, the equations were taken from the most in-depth and credible analysis completed (to-date) for the purpose of determining water bottom velocity influences along water bottoms due to commercial tows.

Steps to obtain resultant bottom velocity-

1. Arrange Eq. (1), the main resultant velocity equation.

   a. $V_{vessel} = V_{prop} + V_{wake}$ (Eq. 1)

   b. Variable Definitions (for Part 1)

      $V_{vessel}$ = Resultant max. bottom velocity increase due to passage of vessel

      $V_{prop}$ = Maximum velocity increase due to propeller action

      $V_{wake}$ = Velocity increase due to the wake of the ship

2. Determine "$V_{prop}$" for use in Eq. 1

   $$V_{prop} = E\left(\frac{D_p}{H_p}\right)V_2\,fn\left(\frac{V_a - V_g}{V_2}, \frac{D_p}{H_p}\right) \qquad \text{(Eq. 2)}$$

   a. Determine $fn\left(\frac{V_a - V_g}{V_2}, \frac{D_p}{H_p}\right)$ for use in Eq. 2

   $$fn\left(\frac{V_a - V_g}{V_2}, \frac{D_p}{H_p}\right) = 1 - cfunc\ abs\left(\frac{V_a - V_g}{V_2}\right)\left(\frac{H_p}{D_p}\right)^{1.5} \qquad \text{(Eq. 3)}$$

   b. Determine "$V_2$" for use in Eq. 2 and 3

   $$V_2 = \frac{1.13}{D_0}\sqrt{\frac{Thrust}{\rho}} \qquad \text{(Eq. 4)}$$

   c. Determine "Thrust" for use in Eq. 4

   $$EP_o = 23.57\,HP^{0.974} - 2.3(S)^2\,(HP)^{0.5} \qquad \text{(Eq. 5)}$$

   d. Variable Definitions (for Part 2)

. □□□ Water Densit

*abs* = Absolute Value
*cfunc* = Coefficient, .50 for open wheel propellers
$D_o$ = Jet diameter at the location of max. contraction of the jet, equal to .71 $D_p$ *for open wheel propellers*
$D_p$ = Propeller diameter
*fn* = Function
E = Empirical coefficient, .43 for open wheel and .58

for Kort nozzles
HP = Horsepower
$H_p$ = Vertical distance from center of propeller to channel bottom
$P_o$ = Thrust (lbs.)
S = Speed (m.p.h.)
$V_2$ = Velocity increase at propeller
$V_a$ = Channel velocity
$V_g$ = Vessel speed relative to ground

3. Determine $V_{wake}$ for use in Eq. 1.

a. Determine $V_{wake}$ for use in Eq. 1

$$V_{wake} = -0.78\ (Draft/Depth)^{1.81}\ (V_a - V_g) \qquad \text{(Eq. 7)}$$

The equations were applied in Microsoft Excel spreadsheets to determine the resultant maximum velocities. Summary tables and detailed tables for each structure can be furnished upon request. For each structure, the resultant ship velocities were superimposed on the tidal velocities to obtain the resultant maximum velocities (Eq. 8 and 9).

$$V_{result} = V_{prop} + V_{wake} + V_{tidal} \qquad \text{(Eq. 8)}$$

$$= V_{vessel} + V_{tidal} \qquad \text{(Eq. 9)}$$

### 2.6.6.2.3 Rock Sizes

After the resultant velocities were obtained the rock sizes were determined using the Isbach equation (the basic equation for the movement of stones through flowing water). This equation was incorporated into the Excel spreadsheet where the velocities were computed.

The resultant gradations are contained in Table 72. Evident from the table is the fact that not all of the structures need rip rap channel protections. The criteria was that protection would be necessary once velocities surpassed 8.4 ft./sec. This velocity represents a minimal value on the Isbach table (corresponding to the equation).

### 2.6.6.3 Results

Since no geotechnical information was available concerning the failure plane of the structures, it is recommended, as a conservative approach (for Feasibility Study purposes), to extend the rock out 150 feet upstream and downstream of each structure.

Regarding the top rock elevation in the channel, it was determined that the critical case for each structure is the reverse head scenario. This is because after an event causing reverse head and upon opening the gates to release interior drainage, a high flow of highly turbulent water would pass through the structure. In order to determine the upper extent of the rock along the channel cross section, a prior analysis (Alette, Washington, 2011) used to determine the reverse head load cases was used. In this analysis (2011), an unsteady interior drainage model was used to determine the maximum protected side water. The peak water surface elevations for the 10% annual chance storm event for year 2085 proposed conditions for the 1% and 3% AEP levee was extracted from the model and used to obtain the protected side elevations to calculate the differential head at each structure. The interior model considered the intermediate case of eustatic sea level rise rates for all future analysis years. The model reported no difference in water surface elevations between the 3% AEP and 1% AEP levee models. The protected side water surface elevation was increased to account for wind setup. An additional 0.5 foot and 1.0 foot was added at structures located along major waterbodies, Houma Navigational Canal and GIWW, respectively. Table 72 provides a summary of rip rap requirements. Additional data can be furnished upon request.

## Table 72 - Summary of Rip Rap Requirements

| It is recommended as a conservative approach (for Feasibility Study purposes), to extend the rock 150 feet in each direction along the channel centerline up to the top rock extent elevation. | | | | | |
|---|---|---|---|---|---|
| **Structure** | **Resultant bottom maximum velocity, ft/sec.** | **Rock required** | **$W_{50}$ weight, lbs.** | **Gradation - thickness (see Table 2)** | **Top rock extent elevation, NAVD 88** |
| Bayou Dularge | 7.2 | No | | | 3.1 |
| GIWW West of Houma | 4.4 | No | | | 3.0 |
| Falgout Canal | 7.3 | No | | | 3.1 |
| Bayou Grand Caillou | 9 | Yes | 16.3 | 3 | 3.1 |
| Bayou Petit Caillou | 8.7 | Yes | 13.1 | 3 | 3.5 |
| Placid Canal | 8.9 | Yes | 15.9 | 3 | 3.5 |
| Bush Canal | 6.1 | No | | | 3.0 |
| Bayou Terrebonne | 8 | No | | | 3.1 |
| Elliot Jones Canal | 4.2 | No | | | 3.3 |
| Humble Canal | 9 | Yes | 16 | 3 | 1.2 |
| Pointe-aux-Chenes | 9.9 | Yes | 29.4 | 5 | 3.0 |
| Grand Bayou | 6.7 | No | | | 3.0* |
| GIWW N. of Bayou Lafourche | 5.9 | No | | | 3.0* |
| Bayou Marmande | 10.7 | Yes | 45.8 | 6 | 3.1* |
| Bayou Black | 10.2 | Yes | 34.9 | 5 | 4.6 |
| NAFTA | 5.1 | No | | | 3.3 |
| Shell East | 5.1 | No | | | 2.9 |
| Shell West | 5 | No | | | 2.9 |
| Humphreys Canal | 8.6 | Yes | 12.5 | 3 | 3.3 |
| Bayou Fourpoints | 4.8 | No | | | 3.3 |
| Barrier Alignment - Sluice-Gate/Culvert 1 | Undetermined | Undetermined | 20** | 3 | 4.6* |
| Barrier Alignment - Sluice-Gate/Culvert 2 | Undetermined | Undetermined | 20** | 3 | 4.6* |
| Barrier Alignment - Sluice-Gate/Culvert 3 | Undetermined | Undetermined | 20** | 3 | 4.6* |
| Barrier Alignment - Sluice-Gate/Culvert 4 | Undetermined | Undetermined | 20** | 3 | 2.9* |
| Barrier Alignment - Sluice-Gate/Culvert 5 | Undetermined | Undetermined | 20** | 3 | 3.3* |
| Barrier Alignment - Sluice-Gate/Culvert 6 | Undetermined | Undetermined | 20** | 3 | 3.3* |
| Barrier Alignment - Sluice-Gate/Culvert 7 | Undetermined | Undetermined | 20** | 3 | 3.3* |
| Barrier Alignment - Sluice-Gate/Culvert 8 | Undetermined | Undetermined | 20** | 3 | 3.3* |

## 2.7 WATER QUALITY

### 2.7.1 System Wide Model for Salinity

TABS-MDS (TABS – Multi-Dimensional Sediment) is the ERDC version of RMA-10 with sediment transport. TABS-MDS performs one, two, and three-dimensional shallow water hydrodynamic calculations with salinity transport coupled to the hydrodynamics (King 1988). Due to the shallow nature of the bays and bayous in the system, along with the significant winds common for southern Louisiana, a high degree of mixing is prevalent in the system resulting in vertical homogeneity for the majority of the study area. Wang (1998) indicated that the Houma Navigational Canal could be partially to highly stratified, but the majority of the data shown in Wang (1998) and USGS (2008) indicate a partially stratified Houma Navigational Canal. Sensitivity model simulations were performed to determine the impact of performing 3D model simulations versus 2D model simulations for the Houma Navigational Canal. These sensitivities indicated that the stratification was limited in occurrence (temporally) and primarily located in the southern most extents of the Houma Navigational Canal. Therefore the 2D approach is adequate for the purposes of determining the impacts of the levee system on salinity. An existing mesh of the central southern Louisiana coast was provided to ERDC by the New Orleans district. This initial mesh was created for the Atchafalaya Bay Reevaluation study (Donnell, Letter, and Teeter, 1991) and later modified by Mr. David Elmore and again by Amena Henville (both of MVN) for the MTG project. This initial mesh provided by MVN, shown in Figure 82, extends from the Atchafalaya Bay (western boundary) to Port Fourchon (eastern boundary).

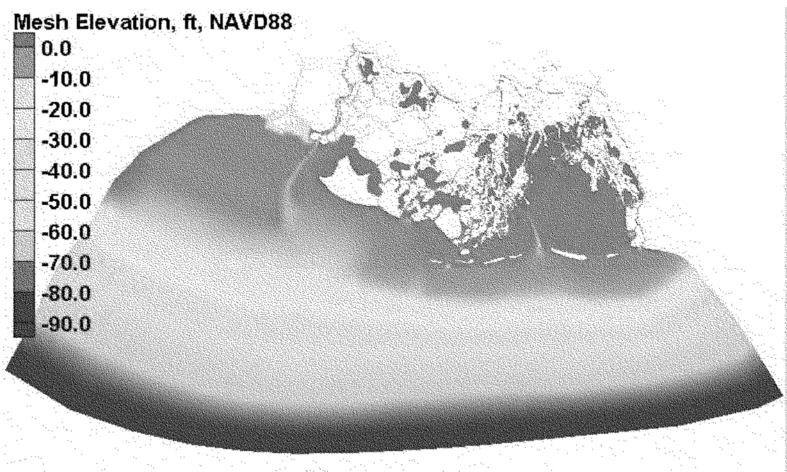


**Figure 82 - Initial Mesh**

The initial, schematized mesh required modification to properly model the salinity behavior of this very complex system. These mesh modifications resulted in a more detailed, accurate and stable numerical model, but at a significant cost in terms of computer run time as the new mesh contained a greatly increased spatial resolution. These modifications were essential, however, to achieve the salinity transport necessary to address the study goals. The western Vermilion Bays were also added to the model domain as they were deemed important as a storage mechanism for the large freshwater inflow from the Wax Lake Outlet and the Atchafalaya River. These grid modifications were performed in the Surface-water Modeling System, (SMS) (Brigham Young University, 2002), a graphical user interface developed by ERDC for use in setting up and running numerical models.

The existing conditions grid, Figure 83, used in the model simulations by ERDC contained 183,565 nodes and 52,968 elements. With the initiation of the Morganza project a comparison was performed between the Morganza mesh provided by MVN, the previous Atchafalaya River mesh (Atchafalaya Bay Reevaluation study), and the ADCIRC mesh (sl15v3_2007_r09a) used for hurricane surge modeling. The bathymetry used in the numerical model was a combination of these three sources. A detailed description of the bathymetry data used from each mesh to generate the Morganza bathymetry used in the model simulations can be furnished upon request.

FTN and CHT reviewed the numerical model mesh and made several recommendations for improvements. These consisted primarily of including/removing different connections throughout the model domain (e.g. channel A is should be connected to channel B, or channel A should not be connected to channel B). All of these recommendations were accepted and implemented in the model. Additional recommendations were made to add additional marsh coverage. Some strategically located marsh areas were added, but including all marsh areas was impractical. Adding all the recommended marsh areas would result in a mesh that would possess an extreme computational burden requiring an excessive amount of time to obtain model results. During the validation process, preliminary results were vetted to project stake holders, and their detailed knowledge of various locations in the study area was used to improve the model until a consensus was reached.

It should be noted that the intended purpose of this model is to model the hydrodynamic and salinity behavior of the system for normal tidal conditions (extreme surge conditions were considered in Cialone, et al. 2009) and therefore roads, levees, and other high elevation areas were not detailed in the model domain. During normal tidal periods, these areas are never inundated and therefore convey no flow making their inclusion in the model unnecessary.

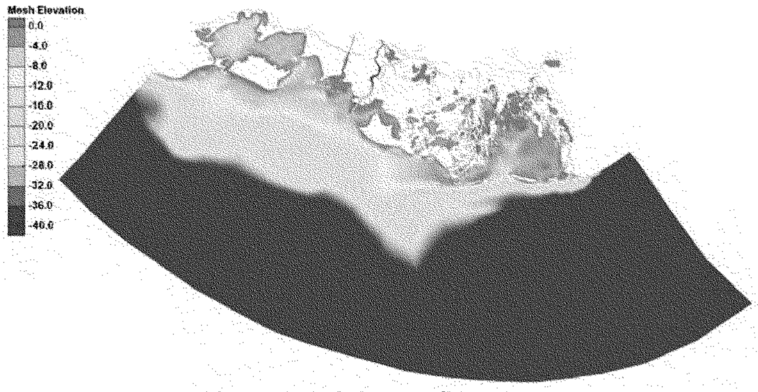


**Figure 83 - Existing Conditions Mesh**

#### 2.7.1.1 Validation

The Engineering Research and Development Center (ERDC) produced a validated (hydrodynamics and salinity) numerical model that would be used to make base versus plan comparisons. The numerical model was then used to determine the resulting salinity and hydrodynamic circulation patterns due to the proposed MTG levee system. A summary of the results of the model validation are provided in this section and the full methodology and analysis can be furnished upon request.

##### 2.7.1.1.1 Results

The salinity comparisons are satisfactory. As expected some gages compare better than others, but the basic behavior of the system is replicated very well. The exact values may not be exactly matched, but the trends tend to be simulated accurately. Some gages experience sudden large spikes in the salinity values and this behavior is also reproduced in the model results. Due to the large uncertainty in the model boundary conditions and the model bathymetry, these comparisons are as well as can be expected. For base versus plan relative comparisons, the numerical model is sufficiently validated.

##### 2.7.1.1.2 Conclusions

Tide ranges in the northernmost sections of the model are over-estimated. Tide ranges in the remaining portions of the model are accurately replicated (with the exception of Lake Boudreaux, see below).

The tide range for Lake Boudreaux is underestimated by the model. Upon further analysis, it was observed that the field data indicated that the tide range in Lake Boudreaux was ~1.25 ft whereas the tide range in Bayou Petit Caillou was ~1.00 ft and the tide range at the Houma Navigation Canal gage was ~0.75 ft. Since these are the two primary means for flow to enter Lake Boudreaux, it is believed that the tide measurements in Lake Boudreaux should not be this high and therefore the gage is in error explaining the less than ideal comparisons at this location.

The numerical model does a good job of replicating the extreme events that occur during the first five months of 2004 (see Bayou Terrebonne, Houma Navigational Canal, Bayou Petit Caillou, etc comparison plots). The error metrics for the water surface elevation comparisons indicate an good replication of the field by the numerical model with average values of 0.87 for the correlation coefficient, 0.28 ft for the RMS error, and 0.92 for the Willmott coefficient.

The model does a good job replicating the mean flow measurement at Bayou Penchant, GIWW at Houma, Bayou Grand Caillou, GIWW at Bay Wallace, and GIWW at Larose. The flood flow is slightly under estimated at the Houma Navigation Canal location. As expected the error metrics for the discharge values are not as favorable as the water surface elevations, but are still acceptable with values of 0.63 for the correlation coefficient, 1761 cfs for the RMS error, and 0.72 for the Willmott coefficient.

The numerical model is slightly under estimating the salinity intrusion into Caillou Lake. The salinity comparisons for the Houma Navigation Canal show a good replication of the types of events (sudden spikes in salinity and quick returns to freshwater) that occur for this area. The magnitudes of the events are sometimes over/under estimated but the events occurring in the field are replicated to some degree in the model. The salinities for the eastern portion of the model (Pointe-aux-Chenes, Grand Bayou Canal) are over estimated in the model, but not by an unreasonable amount. The error metrics for some of the salinity gages are less than ideal. For gages with salinities residing mostly at/near 0 ppt, the correlation coefficient and Willmott coefficients are skewed toward lower values due to the relatively few non-zero model and field values.

While some of the previously shown comparisons could be improved, numerous factors indicate that significant improvements are unlikely. Those factors consist primarily of the vast domain of the model in conjunction with the numerous uncertainties present in the boundary condition specification. It is believed that the current validation is sufficient to make base versus plan comparisons. The numerical model should be very accurate in determining the salinity impact of proposed plan alterations in terms of resulting direction of change (i.e., expected to be very accurate in determining if the salinity in an area will increase or decrease). The numerical model will be less accurate determining the magnitude of change (base versus plan) for a given area. While it is believed that the magnitude of these changes in salinity will be reasonably accurate, a significant uncertainty is believed to exist in this regard. It should also be noted that the magnitude of the actual salinity value will have a significant amount of uncertainty and therefore should not be used to make any type of determinations.

### 2.7.1.2 Plan Comparison of Alternatives

#### 2.7.1.2.1 Introduction

The validated model (McAlpin, 2011) was modified to include three proposed levee configurations. The validation period (2004 calendar year) from McAlpin, 2011 was used to compare the existing conditions and all three plan configurations. A comprehensive analysis was performed on the water surface elevations, discharges, and salinities to obtain an approximate indication of the resulting behavior of the system if the proposed changes were to occur.

The validated (hydrodynamics and salinity) TABS-MDS mesh was used as the starting point in generating the plan condition meshes (McAlpin, 2011). The existing conditions mesh (Figure 83) was modified to include the impermeable levee along with all proposed structures to be located along the levee. Plan 1 will be discussed in detail with plans 2 and 3 being discussed as slight modifications to plan 1. Full model development details can be furnished upon request.

#### 2.7.1.2.2 Base Versus Plan Comparisons

Extensive base (existing conditions) versus plan comparisons were performed. These comparisons were separated into three categories to better facilitate the comparisons. The first category consists of comparison of the residual (average) water levels and salinities. The second comparison was done by looking at a time series of the water surface elevations and salinities at a number of discrete points throughout the study area. The third comparison consisted of comparing discharges between the base and plan conditions at a number of locations.

A comparison was performed on the average salinity values for the base and plan conditions. In an effort to observe any seasonal changes to the system, the average values were obtained for:

1. January to March for 2004
2. April to June for 2004
3. July to September for 2004
4. October to December for 2004

These comparisons show that the changes in the average salinity values due to the new levee system are minor (less than 1 ppth in most areas). The changes in average water surface elevations were determined to be minor as well (less than 0.1 ft in most areas). There are some localized areas that experience greater changes. It should be noted that the results from the January to March time period should be used with caution as this period is still being influenced by the initially specified salinity field. The results are provided here in Table 73 and Table 74 respectively. Discharge results are presented in Figure 84. Detailed comparison plots can be furnished upon request.

**Table 73 - Minimum, Maximum, and Mean Water Surface Elevations for the Base and Plans 1 – 3 for the 2004 calendar year simulations**

| | Base | | | Plan 1 | | | Plan 2 | | | Plan 3 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Point Number | Min (ft) | Max (ft) | Mean (ft) | Min (ft) | Max (ft) | Mean (ft) | Min (ft) | Max (ft) | Mean (ft) | Min (ft) | Max (ft) | Mean (ft) |
| 1 | -2.44 | 2.69 | -0.16 | -2.45 | 2.70 | -0.16 | -2.45 | 2.71 | -0.16 | -2.63 | 2.73 | -0.19 |
| 2 | -2.10 | 2.71 | -0.13 | -2.11 | 2.73 | -0.14 | -2.13 | 2.75 | -0.14 | -2.68 | 2.83 | -0.18 |
| 3 | -1.96 | 2.71 | -0.11 | -1.97 | 2.73 | -0.11 | -1.98 | 2.75 | -0.11 | -2.71 | 2.90 | -0.16 |
| 4 | -1.71 | 2.59 | -0.05 | -1.66 | 2.52 | -0.05 | -1.66 | 2.54 | -0.05 | -1.04 | 2.01 | 0.07 |
| 5 | -1.12 | 2.42 | 0.11 | -1.11 | 2.39 | 0.11 | -1.10 | 2.40 | 0.11 | -0.91 | 2.32 | 0.15 |
| 6 | -1.11 | 2.60 | 0.13 | -1.11 | 2.59 | 0.13 | -1.10 | 2.58 | 0.13 | -0.91 | 2.39 | 0.16 |
| 7 | -1.11 | 2.62 | 0.10 | -1.11 | 2.59 | 0.09 | -1.10 | 2.60 | 0.10 | -0.98 | 2.34 | 0.11 |
| 8 | -0.99 | 2.63 | 0.23 | -0.99 | 2.60 | 0.23 | -0.98 | 2.60 | 0.23 | -0.82 | 2.38 | 0.25 |
| 9 | -0.81 | 2.61 | 0.39 | -0.81 | 2.58 | 0.39 | -0.80 | 2.59 | 0.40 | -0.67 | 2.40 | 0.41 |
| 10 | -0.55 | 2.61 | 0.65 | -0.55 | 2.59 | 0.65 | -0.55 | 2.60 | 0.65 | -0.48 | 2.46 | 0.66 |
| 11 | -2.56 | 2.68 | -0.17 | -2.56 | 2.68 | -0.17 | -2.56 | 2.69 | -0.17 | -2.66 | 2.70 | -0.18 |
| 12 | -2.35 | 2.80 | -0.17 | -2.35 | 2.80 | -0.17 | -2.35 | 2.80 | -0.17 | -2.37 | 2.81 | -0.19 |
| 13 | -2.24 | 2.81 | -0.16 | -2.24 | 2.81 | -0.16 | -2.24 | 2.82 | -0.16 | -2.23 | 2.85 | -0.17 |
| 14 | -1.93 | 2.84 | -0.13 | -1.91 | 2.85 | -0.13 | -1.91 | 2.86 | -0.13 | -1.50 | 2.84 | -0.10 |
| 15 | -2.06 | 2.81 | -0.19 | -2.05 | 2.81 | -0.19 | -2.05 | 2.82 | -0.19 | -1.97 | 2.82 | -0.18 |
| 16 | -1.85 | 2.85 | -0.16 | -1.82 | 2.86 | -0.16 | -1.84 | 2.86 | -0.16 | -1.63 | 2.85 | -0.13 |
| 17 | -2.13 | 2.76 | -0.20 | -2.13 | 2.76 | -0.20 | -2.13 | 2.76 | -0.20 | -2.08 | 2.77 | -0.19 |
| 18 | -1.83 | 2.76 | -0.09 | -1.77 | 2.74 | -0.09 | -1.79 | 2.75 | -0.09 | -1.18 | 2.59 | 0.00 |
| 19 | -1.66 | 2.85 | -0.14 | -1.61 | 2.86 | -0.13 | -1.65 | 2.86 | -0.14 | -1.46 | 2.81 | -0.08 |
| 20 | -1.50 | 2.30 | -0.12 | -1.28 | 2.34 | -0.04 | -1.47 | 2.30 | -0.12 | -1.08 | 2.17 | 0.03 |
| 21 | -1.86 | 2.88 | -0.11 | -1.78 | 2.84 | -0.09 | -1.76 | 2.85 | -0.09 | -1.62 | 2.82 | -0.07 |
| 22 | -2.06 | 2.93 | -0.18 | -2.06 | 2.93 | -0.18 | -2.06 | 2.93 | -0.18 | -2.03 | 2.94 | -0.18 |
| 23 | -1.82 | 3.12 | -0.14 | -1.82 | 3.12 | -0.14 | -1.82 | 3.12 | -0.14 | -1.81 | 3.13 | -0.14 |
| 24 | -0.79 | 2.15 | 0.19 | -0.82 | 2.15 | 0.18 | -0.80 | 2.14 | 0.19 | -0.74 | 2.08 | 0.20 |
| 25 | -0.83 | 2.33 | 0.23 | -0.86 | 2.33 | 0.22 | -0.84 | 2.32 | 0.22 | -0.78 | 2.21 | 0.23 |
| 26 | -0.79 | 2.46 | 0.33 | -0.81 | 2.44 | 0.32 | -0.80 | 2.44 | 0.33 | -0.72 | 2.31 | 0.33 |
| 27 | -1.13 | 2.16 | 0.09 | -1.13 | 2.15 | 0.09 | -1.10 | 2.15 | 0.10 | -0.95 | 2.12 | 0.13 |
| 28 | -1.24 | 2.26 | 0.04 | -1.25 | 2.23 | 0.03 | -1.22 | 2.25 | 0.04 | -0.98 | 2.09 | 0.10 |
| 29 | 0.27 | 1.80 | 0.47 | 0.27 | 1.62 | 0.46 | 0.27 | 1.61 | 0.47 | 0.27 | 1.61 | 0.48 |
| 30 | -2.45 | 2.81 | -0.18 | -2.47 | 2.83 | -0.18 | -2.47 | 2.83 | -0.18 | -2.49 | 2.83 | -0.18 |
| 31 | -2.40 | 2.77 | -0.16 | -2.39 | 2.75 | -0.16 | -2.39 | 2.75 | -0.16 | -2.50 | 2.76 | -0.17 |
| 32 | -1.04 | 2.82 | -0.07 | -1.03 | 2.84 | -0.07 | -1.08 | 2.87 | -0.09 | -1.04 | 2.93 | -0.09 |

| | Base | | | Plan 1 | | | Plan 2 | | | Plan 3 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Point Number | Min (ft) | Max (ft) | Mean (ft) | Min (ft) | Max (ft) | Mean (ft) | Min (ft) | Max (ft) | Mean (ft) | Min (ft) | Max (ft) | Mean (ft) |
| 33 | -1.36 | 2.81 | -0.07 | -1.32 | 2.79 | -0.07 | -1.47 | 2.83 | -0.10 | -1.35 | 2.93 | -0.09 |
| 34 | -1.70 | 2.37 | -0.08 | -1.65 | 2.29 | -0.08 | -1.64 | 2.30 | -0.08 | -1.09 | 1.96 | 0.03 |
| 35 | 0.11 | 2.26 | 0.34 | 0.11 | 2.17 | 0.34 | 0.11 | 2.18 | 0.34 | 0.12 | 2.03 | 0.36 |
| 36 | -1.48 | 2.90 | -0.09 | -1.45 | 2.62 | -0.09 | -0.68 | 1.80 | -0.01 | -1.50 | 2.73 | -0.11 |
| 37 | -1.49 | 2.06 | -0.09 | -1.43 | 1.98 | -0.09 | -1.43 | 1.98 | -0.08 | -1.18 | 1.91 | -0.04 |
| 38 | -1.92 | 2.46 | -0.16 | -1.62 | 2.13 | -0.13 | -1.62 | 2.13 | -0.13 | -1.40 | 2.08 | -0.10 |
| 39 | -2.02 | 2.87 | -0.14 | -2.06 | 2.92 | -0.14 | -2.07 | 2.93 | -0.14 | -1.97 | 2.92 | -0.13 |
| 40 | -2.00 | 3.01 | -0.13 | -2.02 | 3.05 | -0.14 | -2.03 | 3.06 | -0.14 | -1.93 | 3.05 | -0.13 |
| 41 | -2.02 | 2.98 | -0.14 | -2.04 | 3.00 | -0.14 | -2.05 | 3.01 | -0.14 | -1.95 | 3.00 | -0.13 |
| 42 | -1.81 | 2.52 | -0.12 | -1.73 | 2.33 | -0.11 | -1.73 | 2.33 | -0.11 | -1.47 | 2.27 | -0.08 |
| 43 | -1.96 | 2.97 | -0.13 | -1.92 | 2.79 | -0.13 | -1.93 | 2.79 | -0.13 | -1.76 | 2.77 | -0.11 |
| 44 | -1.65 | 2.24 | -0.12 | -1.59 | 2.16 | -0.12 | -1.58 | 2.16 | -0.11 | -1.42 | 2.06 | -0.07 |
| 45 | -1.88 | 3.23 | -0.15 | -1.84 | 3.28 | -0.15 | -1.87 | 3.29 | -0.15 | -1.82 | 3.27 | -0.15 |
| 46 | -1.68 | 3.10 | -0.12 | -1.62 | 3.27 | -0.12 | -1.65 | 3.33 | -0.13 | -1.57 | 3.27 | -0.11 |
| 47 | -1.66 | 3.08 | -0.11 | -1.60 | 3.13 | -0.11 | -1.63 | 3.16 | -0.11 | -1.53 | 3.11 | -0.10 |
| 48 | 0.44 | 3.09 | 0.56 | 0.44 | 2.03 | 0.55 | N/A | N/A | N/A | 0.44 | 2.02 | 0.55 |
| 49 | -1.72 | 3.06 | -0.14 | -1.67 | 3.27 | -0.14 | -1.72 | 3.38 | -0.14 | -1.64 | 3.27 | -0.13 |
| 50 | -1.74 | 3.11 | -0.15 | -1.82 | 3.32 | -0.15 | -1.86 | 3.42 | -0.15 | -1.79 | 3.31 | -0.14 |
| 51 | 0.16 | 3.17 | 0.36 | 0.16 | 2.12 | 0.35 | N/A | N/A | N/A | 0.16 | 2.11 | 0.35 |
| 52 | -1.57 | 2.89 | -0.09 | -1.52 | 2.92 | -0.09 | -1.55 | 2.95 | -0.09 | -1.44 | 2.86 | -0.08 |
| 53 | 0.18 | 2.29 | 0.36 | 0.18 | 2.06 | 0.36 | N/A | N/A | N/A | 0.18 | 2.05 | 0.36 |
| 54 | -1.56 | 2.26 | -0.16 | -1.51 | 2.07 | -0.16 | -1.53 | 2.21 | -0.17 | -1.49 | 2.06 | -0.16 |
| 55 | -1.15 | 2.22 | -0.06 | -1.77 | 2.25 | -0.12 | -0.96 | 2.20 | -0.02 | -1.75 | 2.20 | -0.12 |
| 56 | -2.33 | 3.03 | -0.18 | -2.28 | 3.00 | -0.18 | -2.12 | 3.02 | -0.18 | -2.27 | 3.00 | -0.18 |
| 57 | -2.33 | 2.98 | -0.19 | -2.32 | 2.99 | -0.19 | -2.34 | 3.02 | -0.19 | -2.31 | 2.99 | -0.19 |
| 58 | -2.33 | 3.15 | -0.19 | -2.32 | 3.16 | -0.19 | -2.34 | 3.17 | -0.19 | -2.31 | 3.16 | -0.19 |
| 59 | -2.36 | 3.19 | -0.20 | -2.35 | 3.20 | -0.20 | -2.37 | 3.21 | -0.20 | -2.35 | 3.20 | -0.20 |
| 60 | -2.23 | 2.88 | -0.20 | -2.22 | 2.89 | -0.20 | -2.23 | 2.89 | -0.20 | -2.22 | 2.89 | -0.19 |
| 61 | -2.28 | 2.92 | -0.19 | -2.27 | 2.93 | -0.19 | -2.28 | 2.94 | -0.19 | -2.27 | 2.93 | -0.19 |
| 62 | -2.25 | 2.61 | -0.18 | -2.24 | 2.64 | -0.18 | -2.26 | 2.68 | -0.19 | -2.24 | 2.63 | -0.18 |
| 63 | -2.10 | 2.58 | -0.17 | -2.09 | 2.62 | -0.17 | -2.11 | 2.66 | -0.17 | -2.09 | 2.61 | -0.17 |
| 64 | -2.34 | 2.83 | -0.18 | -2.32 | 2.86 | -0.18 | -2.35 | 2.91 | -0.18 | -2.31 | 2.86 | -0.18 |
| 65 | -0.42 | 1.94 | 0.06 | -0.53 | 2.04 | 0.01 | -0.35 | 1.74 | 0.10 | -0.53 | 2.02 | 0.01 |
| 66 | -0.60 | 2.46 | 0.00 | -0.95 | 2.20 | -0.10 | -0.01 | 1.60 | 0.40 | -0.94 | 2.19 | -0.10 |
| 67 | -2.34 | 2.68 | -0.18 | -2.31 | 2.73 | -0.18 | -2.35 | 2.80 | -0.18 | -2.30 | 2.73 | -0.18 |
| 68 | -2.14 | 2.66 | -0.19 | -2.13 | 2.70 | -0.19 | -2.15 | 2.75 | -0.19 | -2.12 | 2.69 | -0.19 |

| | Base | | | Plan 1 | | | Plan 2 | | | Plan 3 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Point Number | Min (ft) | Max (ft) | Mean (ft) | Min (ft) | Max (ft) | Mean (ft) | Min (ft) | Max (ft) | Mean (ft) | Min (ft) | Max (ft) | Mean (ft) |
| 69 | -1.04 | 2.73 | -0.14 | -1.04 | 2.77 | -0.14 | -1.04 | 2.82 | -0.14 | -1.04 | 2.76 | -0.14 |
| 70 | -2.34 | 2.81 | -0.20 | -2.33 | 2.85 | -0.20 | -2.35 | 2.89 | -0.20 | -2.32 | 2.84 | -0.20 |
| 71 | -1.88 | 2.62 | -0.16 | -1.84 | 2.66 | -0.16 | -1.93 | 2.76 | -0.17 | -1.81 | 2.65 | -0.15 |
| 72 | -1.01 | 2.57 | -0.05 | -1.76 | 2.27 | -0.15 | -0.16 | 1.61 | 0.37 | -1.74 | 2.25 | -0.14 |
| 73 | -1.77 | 2.66 | -0.16 | -1.71 | 2.68 | -0.15 | -1.79 | 2.74 | -0.16 | -1.65 | 2.66 | -0.15 |
| 74 | -1.58 | 2.61 | -0.13 | -1.58 | 2.58 | -0.14 | -1.64 | 2.62 | -0.14 | -1.52 | 2.54 | -0.13 |
| 75 | -0.96 | 2.60 | -0.09 | -0.98 | 2.53 | -0.10 | -0.92 | 2.55 | -0.09 | -0.96 | 2.50 | -0.09 |
| 76 | -1.53 | 2.54 | -0.13 | -1.52 | 2.52 | -0.13 | -1.57 | 2.55 | -0.13 | -1.47 | 2.47 | -0.13 |
| 77 | -1.28 | 1.93 | -0.11 | -1.28 | 1.92 | -0.11 | -1.28 | 1.92 | -0.11 | -1.22 | 1.86 | -0.11 |
| 78 | -1.26 | 2.12 | -0.09 | -1.26 | 2.12 | -0.09 | -1.26 | 2.12 | -0.09 | -1.19 | 2.02 | -0.09 |

**Table 74 - Minimum, Maximum, and Mean Salinities for the Base and Plans 1 – 3 for the 2004 calendar year simulations**

| | Base | | | Plan 1 | | | Plan 2 | | | Plan 3 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Point Number | Min (ppt) | Max (ppt) | Mean (ppt) | Min (ppt) | Max (ppt) | Mean (ppt) | Min (ppt) | Max (ppt) | Mean (ppt) | Min (ppt) | Max (ppt) | Mean (ppt) |
| 1 | 0.03 | 28.19 | 15.84 | 0.03 | 28.16 | 15.93 | 0.02 | 28.17 | 15.85 | 0.64 | 28.37 | 20.81 |
| 2 | 0.01 | 27.49 | 11.86 | 0.01 | 27.39 | 11.93 | 0.01 | 27.40 | 11.83 | 0.36 | 27.75 | 18.67 |
| 3 | 0.00 | 27.08 | 8.35 | 0.00 | 26.96 | 8.46 | 0.00 | 26.97 | 8.31 | 0.01 | 27.40 | 14.87 |
| 4 | 0.00 | 26.84 | 4.53 | 0.00 | 26.47 | 4.66 | 0.00 | 26.51 | 4.39 | 0.00 | 23.23 | 1.45 |
| 5 | 0.00 | 20.94 | 0.83 | 0.00 | 20.25 | 0.78 | 0.00 | 20.78 | 0.80 | 0.00 | 1.34 | 0.04 |
| 6 | 0.00 | 11.31 | 0.24 | 0.00 | 10.25 | 0.21 | 0.00 | 10.57 | 0.22 | 0.00 | 1.91 | 0.02 |
| 7 | 0.00 | 13.28 | 0.12 | 0.00 | 13.33 | 0.11 | 0.00 | 13.27 | 0.12 | 0.00 | 12.07 | 0.12 |
| 8 | 0.00 | 7.28 | 0.08 | 0.00 | 5.47 | 0.05 | 0.00 | 6.40 | 0.06 | 0.00 | 3.32 | 0.02 |
| 9 | 0.00 | 3.29 | 0.02 | 0.00 | 2.28 | 0.01 | 0.00 | 2.84 | 0.02 | 0.00 | 0.86 | 0.00 |
| 10 | 0.00 | 1.77 | 0.01 | 0.00 | 1.14 | 0.01 | 0.00 | 1.47 | 0.01 | 0.00 | 0.15 | 0.00 |
| 11 | 1.15 | 27.87 | 17.00 | 1.09 | 27.83 | 17.09 | 1.11 | 27.85 | 16.98 | 3.01 | 28.18 | 21.17 |
| 12 | 0.46 | 27.14 | 12.63 | 0.40 | 27.10 | 12.68 | 0.45 | 27.12 | 12.59 | 0.30 | 27.60 | 16.46 |
| 13 | 0.19 | 26.76 | 9.12 | 0.11 | 26.70 | 9.13 | 0.19 | 26.72 | 9.07 | 0.01 | 27.18 | 12.02 |
| 14 | 0.01 | 26.12 | 5.58 | 0.00 | 25.91 | 5.50 | 0.02 | 26.21 | 5.63 | 0.00 | 26.13 | 4.05 |
| 15 | 0.19 | 27.75 | 11.11 | 0.18 | 27.69 | 10.92 | 0.19 | 27.70 | 11.10 | 0.08 | 27.91 | 10.89 |
| 16 | 0.06 | 23.97 | 5.49 | 0.03 | 22.65 | 4.83 | 0.06 | 23.95 | 5.54 | 0.00 | 17.12 | 2.12 |
| 17 | 0.03 | 27.84 | 8.61 | 0.03 | 27.83 | 8.48 | 0.03 | 27.83 | 8.60 | 0.02 | 27.86 | 8.11 |
| 18 | 0.00 | 26.72 | 5.31 | 0.00 | 26.54 | 5.23 | 0.00 | 26.69 | 5.29 | 0.00 | 24.79 | 2.73 |

| | Base | | | Plan 1 | | | Plan 2 | | | Plan 3 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Point Number | Min (ppt) | Max (ppt) | Mean (ppt) | Min (ppt) | Max (ppt) | Mean (ppt) | Min (ppt) | Max (ppt) | Mean (ppt) | Min (ppt) | Max (ppt) | Mean (ppt) |
| 19 | 0.11 | 23.037 | 5.28 | 0.01 | 21.49 | 4.53 | 0.12 | 22.96 | 5.37 | 0.00 | 13.87 | 1.54 |
| 20 | 0.18 | 17.77 | 5.05 | 0.00 | 14.57 | 3.21 | 0.18 | 17.82 | 5.16 | 0.00 | 4.61 | 0.81 |
| 21 | 0.00 | 24.74 | 2.09 | 0.00 | 23.84 | 2.14 | 0.00 | 24.55 | 2.04 | 0.00 | 17.97 | 0.61 |
| 22 | 0.00 | 24.77 | 3.57 | 0.00 | 24.75 | 3.58 | 0.00 | 24.78 | 3.58 | 0.00 | 23.83 | 3.28 |
| 23 | 0.00 | 14.81 | 1.28 | 0.00 | 14.79 | 1.28 | 0.00 | 14.83 | 1.28 | 0.00 | 13.50 | 1.19 |
| 24 | 0.00 | 6.38 | 0.81 | 0.00 | 6.14 | 0.78 | 0.00 | 6.38 | 0.81 | 0.00 | 2.59 | 0.24 |
| 25 | 0.00 | 1.39 | 0.06 | 0.00 | 1.10 | 0.05 | 0.00 | 1.20 | 0.06 | 0.00 | 0.34 | 0.01 |
| 26 | 0.00 | 2.74 | 0.03 | 0.00 | 1.95 | 0.02 | 0.00 | 2.43 | 0.02 | 0.00 | 0.81 | 0.00 |
| 27 | 0.00 | 25.63 | 2.27 | 0.00 | 25.12 | 2.31 | 0.00 | 25.58 | 2.21 | 0.00 | 14.16 | 0.57 |
| 28 | 0.00 | 26.63 | 2.96 | 0.00 | 26.31 | 3.01 | 0.00 | 26.31 | 2.87 | 0.00 | 16.70 | 0.70 |
| 29 | 0.00 | 25.58 | 3.50 | 0.00 | 25.25 | 3.75 | 0.00 | 25.40 | 3.45 | 0.00 | 14.87 | 1.03 |
| 30 | 1.94 | 25.92 | 13.55 | 2.02 | 25.92 | 13.88 | 2.02 | 25.90 | 13.76 | 0.83 | 26.08 | 12.79 |
| 31 | 0.05 | 26.29 | 11.29 | 0.05 | 26.01 | 11.11 | 0.04 | 26.10 | 11.01 | 0.19 | 27.01 | 12.08 |
| 32 | 0.16 | 25.68 | 10.68 | 0.21 | 25.22 | 10.48 | 0.10 | 25.61 | 10.57 | 1.49 | 26.26 | 16.71 |
| 33 | 0.08 | 25.80 | 8.15 | 0.13 | 24.83 | 8.07 | 0.03 | 25.42 | 7.78 | 1.05 | 26.58 | 15.43 |
| 34 | 0.00 | 26.77 | 5.06 | 0.00 | 26.26 | 5.18 | 0.00 | 26.26 | 4.95 | 0.00 | 22.66 | 2.08 |
| 35 | 0.00 | 25.87 | 1.59 | 0.00 | 25.70 | 1.60 | 0.00 | 25.70 | 1.57 | 0.00 | 17.93 | 1.23 |
| 36 | 0.17 | 23.52 | 8.10 | 0.35 | 21.93 | 7.75 | 0.40 | 12.46 | 4.74 | 0.40 | 24.65 | 14.77 |
| 37 | 1.28 | 20.64 | 7.61 | 1.31 | 20.35 | 7.68 | 1.33 | 20.26 | 7.55 | 0.15 | 21.42 | 6.06 |
| 38 | 0.75 | 24.08 | 9.58 | 0.11 | 25.69 | 9.93 | 0.10 | 25.79 | 9.83 | 0.17 | 26.82 | 9.96 |
| 39 | 1.36 | 23.54 | 9.91 | 1.45 | 23.42 | 10.12 | 1.43 | 23.38 | 9.99 | 0.18 | 23.56 | 8.73 |
| 40 | 1.95 | 23.13 | 10.68 | 1.96 | 22.90 | 10.80 | 1.96 | 22.79 | 10.64 | 1.42 | 23.50 | 9.50 |
| 41 | 0.84 | 22.12 | 8.30 | 0.95 | 22.04 | 8.59 | 0.98 | 21.93 | 8.45 | 0.20 | 22.68 | 7.29 |
| 42 | 1.26 | 21.72 | 7.97 | 1.31 | 21.85 | 8.28 | 1.31 | 21.76 | 8.15 | 0.17 | 22.63 | 6.94 |
| 43 | 0.80 | 21.34 | 7.06 | 0.86 | 21.38 | 7.58 | 0.83 | 21.26 | 7.45 | 0.13 | 22.05 | 6.46 |
| 44 | 0.73 | 16.98 | 5.19 | 0.73 | 17.01 | 5.38 | 0.73 | 16.93 | 5.27 | 0.21 | 17.77 | 3.82 |
| 45 | 0.27 | 20.92 | 6.33 | 0.26 | 20.69 | 6.19 | 0.21 | 20.44 | 5.98 | 0.28 | 21.25 | 5.79 |
| 46 | 0.00 | 20.12 | 3.74 | 0.00 | 19.84 | 3.56 | 0.00 | 19.49 | 3.31 | 0.00 | 20.41 | 3.63 |
| 47 | 0.00 | 20.72 | 3.07 | 0.00 | 20.23 | 2.84 | 0.00 | 19.92 | 2.67 | 0.00 | 20.85 | 3.07 |
| 48 | 0.16 | 18.84 | 3.06 | 0.23 | 13.94 | 2.94 | N/A | N/A | N/A | 0.23 | 14.74 | 3.10 |
| 49 | 0.22 | 19.15 | 4.57 | 0.22 | 18.74 | 4.14 | 0.21 | 18.24 | 3.89 | 0.22 | 19.34 | 4.12 |
| 50 | 0.30 | 15.06 | 4.77 | 0.30 | 15.10 | 4.31 | 0.30 | 14.04 | 4.26 | 0.30 | 15.82 | 4.28 |
| 51 | 0.34 | 14.27 | 3.90 | 0.33 | 12.51 | 3.63 | N/A | N/A | N/A | 0.33 | 13.36 | 3.70 |
| 52 | 0.00 | 20.23 | 2.11 | 0.00 | 19.72 | 1.98 | 0.00 | 19.43 | 1.91 | 0.00 | 20.43 | 2.35 |
| 53 | 0.84 | 13.41 | 5.87 | 0.83 | 12.70 | 5.50 | N/A | N/A | N/A | 0.83 | 13.49 | 5.38 |
| 54 | 0.71 | 13.64 | 5.87 | 0.75 | 13.00 | 5.61 | 0.75 | 12.72 | 5.58 | 0.76 | 13.82 | 5.49 |

| | Base | | | Plan 1 | | | Plan 2 | | | Plan 3 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Point Number | Min (ppt) | Max (ppt) | Mean (ppt) | Min (ppt) | Max (ppt) | Mean (ppt) | Min (ppt) | Max (ppt) | Mean (ppt) | Min (ppt) | Max (ppt) | Mean (ppt) |
| 55 | 0.00 | 20.52 | 3.18 | 0.00 | 21.03 | 4.13 | 0.00 | 21.07 | 2.43 | 0.00 | 21.56 | 4.08 |
| 56 | 0.28 | 21.66 | 6.48 | 0.22 | 21.85 | 8.25 | 0.17 | 21.80 | 6.02 | 0.19 | 22.32 | 8.01 |
| 57 | 0.62 | 22.12 | 10.67 | 0.68 | 22.13 | 10.96 | 0.56 | 21.98 | 10.42 | 0.67 | 22.57 | 10.59 |
| 58 | 2.06 | 23.50 | 13.17 | 1.94 | 23.51 | 13.21 | 2.14 | 23.40 | 13.21 | 1.93 | 23.92 | 12.78 |
| 59 | 2.39 | 24.73 | 15.24 | 2.39 | 24.74 | 15.24 | 2.40 | 24.72 | 15.34 | 2.39 | 24.98 | 14.85 |
| 60 | 0.44 | 23.37 | 12.69 | 0.45 | 23.41 | 12.65 | 0.44 | 23.41 | 12.79 | 0.45 | 23.65 | 12.34 |
| 61 | 0.36 | 20.42 | 11.35 | 0.36 | 20.42 | 11.31 | 0.36 | 20.49 | 11.46 | 0.36 | 20.74 | 11.00 |
| 62 | 0.26 | 21.02 | 8.33 | 0.26 | 21.03 | 8.35 | 0.25 | 21.03 | 8.40 | 0.26 | 21.35 | 8.10 |
| 63 | 0.44 | 20.36 | 8.04 | 0.44 | 20.42 | 8.09 | 0.44 | 20.30 | 8.22 | 0.44 | 20.93 | 7.83 |
| 64 | 0.23 | 21.71 | 9.40 | 0.41 | 21.75 | 9.52 | 0.22 | 21.64 | 9.53 | 0.41 | 22.20 | 9.20 |
| 65 | 0.90 | 7.40 | 3.16 | 0.90 | 16.21 | 7.65 | 0.84 | 6.60 | 2.47 | 0.90 | 16.79 | 7.44 |
| 66 | 0.13 | 19.79 | 3.74 | 0.10 | 19.56 | 3.72 | 0.15 | 1.45 | 0.41 | 0.08 | 20.16 | 3.66 |
| 67 | 0.03 | 20.45 | 4.81 | 0.03 | 20.42 | 4.96 | 0.00 | 20.19 | 4.93 | 0.03 | 20.96 | 4.83 |
| 68 | 0.25 | 12.95 | 4.91 | 0.25 | 12.80 | 4.94 | 0.25 | 13.47 | 5.14 | 0.25 | 13.51 | 4.81 |
| 69 | 0.15 | 14.40 | 3.95 | 0.15 | 14.39 | 3.93 | 0.15 | 14.84 | 4.06 | 0.15 | 15.11 | 3.84 |
| 70 | 0.06 | 13.16 | 3.34 | 0.06 | 13.12 | 3.31 | 0.06 | 13.44 | 3.41 | 0.06 | 13.81 | 3.24 |
| 71 | 0.00 | 17.29 | 2.40 | 0.00 | 16.75 | 2.38 | 0.00 | 17.15 | 2.50 | 0.00 | 17.35 | 2.41 |
| 72 | 0.00 | 16.82 | 2.41 | 0.00 | 16.61 | 2.36 | 0.15 | 3.44 | 0.46 | 0.00 | 17.26 | 2.40 |
| 73 | 0.00 | 14.18 | 1.69 | 0.00 | 13.87 | 1.65 | 0.00 | 13.93 | 1.78 | 0.00 | 17.01 | 1.73 |
| 74 | 0.00 | 14.31 | 1.40 | 0.00 | 14.02 | 1.37 | 0.00 | 13.71 | 1.47 | 0.00 | 17.17 | 1.49 |
| 75 | 0.00 | 10.93 | 1.39 | 0.00 | 10.90 | 1.25 | 0.00 | 12.70 | 1.01 | 0.00 | 15.06 | 1.37 |
| 76 | 0.00 | 14.39 | 1.22 | 0.00 | 14.10 | 1.21 | 0.00 | 13.84 | 1.29 | 0.00 | 17.28 | 1.35 |
| 77 | 0.00 | 17.67 | 0.65 | 0.00 | 17.64 | 0.65 | 0.00 | 17.55 | 0.65 | 0.00 | 20.79 | 0.80 |
| 78 | 0.00 | 13.26 | 0.58 | 0.00 | 13.05 | 0.57 | 0.00 | 12.84 | 0.58 | 0.00 | 16.60 | 0.72 |

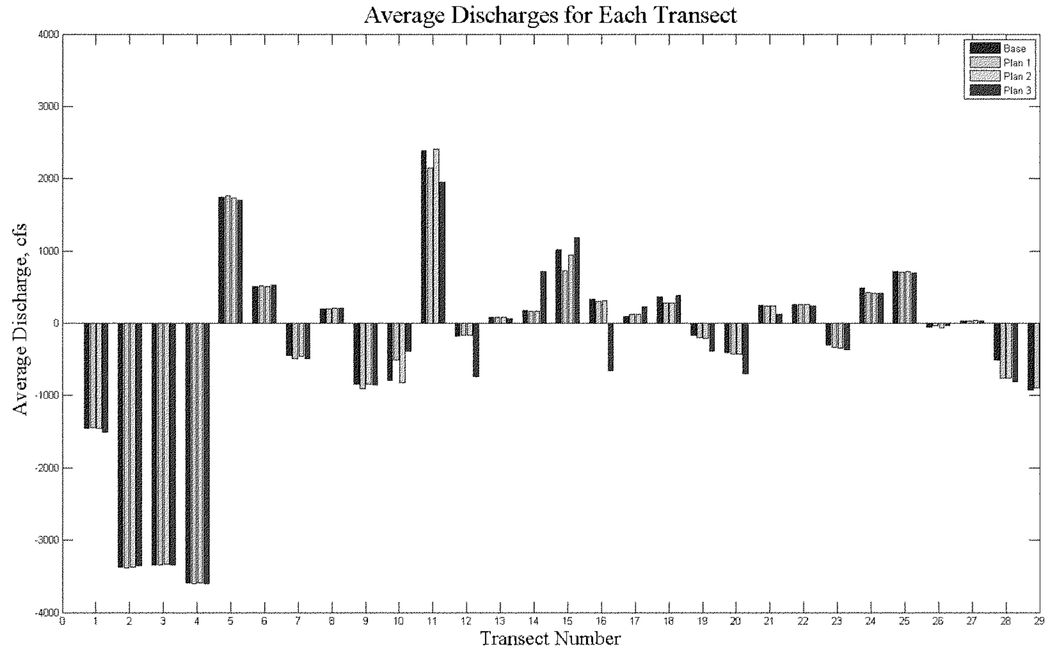


**Figure 84 - Average discharges for all 29 transects for 2004**

### 2.7.1.2.3 Summary

#### 2.7.1.2.3.1 Water Surface Elevation Changes

There was minimal or no change in the water surface elevations between the base and the plans for points: 1, 2, 11, 12, 13, 15, 16, 17, 21, 22, 23, 30, 31, 32, 39, 40, 41, 43, 45, 46, 47, 49, 50, 52, 56, 57, 58, 59, 60, 61, 62, 63, 64, 67, 68, 69, 70, 71, 73, 74, 75, 76, 77 and 78.

Plan 3 has a higher tide range for points 3, 65, 66, and 72 and a lower tide range for points 4, 5, 6, 7, 8, 9, 10, 14, 18, 19, 24, 25, 26, 27, 28, 29, 34, 35, 37, 42 and 44 with minimal change in tide range for plans 1 and 2
.
Plans 1 has an increased tide range and higher mean water level for point 20 (south of Falgout Canal) while plan 3 has an increased mean water level and a slightly reduced tide range. Plan 2 is similar to the base in mean water level and tide range. Point 33 has a slightly increased tide range for all plan conditions with the largest increase occurring with plan 2. Point 36 has a reduced tide range for all plans with a significant reduction occurring in plan 2 along with an increase in the mean water level.
Point 38 and 54 has a reduced tide range for all plans.

North of the proposed Houma Navigational Canal structure and lock, plan 3 has a significantly decreased tide range compared to the base and plans 1 and 2 (see point 4). The percentage of tide range reduction is increased for points farther north along the Houma Navigational Canal (HNC) as additional channels compensate for the elimination of flow up the HNC.

Points 48, 51 and 53 have reduced tide ranges for plans 1 and 3 with plan 2 having no tidal signal due to the ponding occurring in these areas for this configuration. Plans 1 and 3 have an increased tide range for points 55 and 65 with plan 2 having a similar tide range but a higher mean water level.

Points 66 and 72 have a higher tide range for plans 1 and 3 with a very minimal tide for plan 2. Plan 2 does have an increased mean water level. The mean water level for point 20 is increased for plans 1 and 3 with the plan 2 mean water level unchanged. Plans 1 and 3 have decreased mean water levels for points 55, 65, 66, and 72 while plan 2 has increased mean water levels.

Plan 3 has decreased mean water levels for points 2 and 3 and increased mean water levels for points 4, 5, 6, 18, 19, 21, 27, 28, 34, 37, 38, 42 and 44.

#### 2.7.1.2.3.2 Salinity Changes

Points 7, 8, 9, 10, 17, 23, 25, 26, 46, 47 and 76 have minimal differences in salinity. Plan 1 had salinity increases for points 38, 41, 42, 43, 55, 56, 57 and 65 with salinity decreases for points 16, 19, 20, 31, 48, 49, 50, 51, 53, 54 and 75. The remaining points had minimal differences in the salinity for plan 1. The bold points are locations with average salinity changes of greater than 0.5 ppt for plan 1.

Plan 2 had salinity increases for points 38, 41, 42, 43, 64, 67, 68, 69, 70, 71, 73, and 74 with salinity decreases for points 31, 33, 36, 45, 49, 50, 52, 54, 55, 56, 57, 65, 66, 72 and 75. The remaining points had minimal differences in the salinity for plan 2. The bold points are locations with average salinity changes of greater than 0.5 ppt for plan 2.

Plan 3 had salinity increases for points 1, 2, 3, 11, 12, 13, 31, 32, 33, 36, 38, 52, 55, 56, 65, 77 and 78 with salinity decreases for points 4, 5, 6, 14, 15, 16, 18, 19, 20, 21, 22, 24, 27, 28, 29, 30, 34, 35, 37, 39, 40, 41, 42, 43, 44, 45, 49, 50, 53, 54, 58, 59, 60, 61, 62, 63 and 64. The remaining points had minimal differences in the salinity for plan 3. The bold points are locations with average salinity changes of greater than 0.5 ppt for plan 3.

#### 2.7.1.2.3.3 Discharge Changes

Transects 6, 8, 22, 23, 25 and 26 show minimal differences between the existing conditions and all plan configurations.

Plan 1 discharge changes (compared to the base) are primarily in the vicinity of Falgout Canal. For Falgout Canal, the environmental structures connecting to the south provide an additional avenue for water to leave the system and therefore draw water from adjacent areas.

All plan configurations have slightly higher discharges ranges for Transects 17, 18 and 19.

Plan 3 has significant, wide-ranging changes to the flow of water occurring in the system. Due to the closing of the Houma Navigational Canal (HNC) lock and gate structure, flow is diverted to areas to the east and west of the HNC. This includes increased flows to the west (along Falgout Canal) and to the east (into Lake Boudreaux).

#### 2.7.1.2.4 Conclusions

From the base versus plan comparisons discussed previously, some conclusions can be drawn. Through proper management of the planned structures a number of different salinity results, both beneficial and not, can be accomplished. From looking at the combination of results, it can be determined that through proper operation of the structures the proposed levee system will have a minimal effect on the global salinity values.

Plan 1 possesses minimal global salinity changes with the largest changes occurring in the marsh area south of Falgout Canal. This area is newly connected to Falgout Canal allowing for a new freshwater inflow to this area which in turn reduces the salinities (~3 ppt) with the largest benefit occurring during the winter months and minimal benefit occurring during the summer months. Globally the salinities changes tend to be less than 1 ppt with some larger localized salinity changes.

Plan 2 has minimal global salinity changes (less than 2 ppt) with some increased salinities possible in localized areas newly cutoff by the proposed levee system. Plan 2 has some areas that possess no connection to the remainder of the domain (due to closed environmental structures) and therefore will remain stagnant with constant water levels and salinities.

Plan 3 has noticeable salinity changes along the Houma Navigational Canal. The salinities are increased along the southern portion (~5 ppt) and lowered north of the Houma Navigational Canal structure. The Falgout Canal and Lake Boudreaux areas are freshened as the closed HNC structure forces the freshwater flow to divert along other avenues thereby freshening the surrounding areas.

Sensitivity simulations (not included in this report) demonstrated the importance of the two GIWW structures. Reducing the size of the western structure reduces the freshwater inflow able to enter the Morganza levee system and thereby increases the salinities in the study area. Conversely reducing the size of the eastern GIWW at Larose structure reduces the amount of freshwater able to leave the system and therefore decreases the salinities in the study area. While navigational concerns require certain structure sizes for these two areas, those simulations exhibit the type of control the new levee system will provide the operators. The complete plan comparison report can be furnished upon request.

The systemwide model did not include sea level rise. The systemwide model is currently being converted from TABS-MDS to ADH to investigate all RSLR cases.

## 2.7.2 Environmental Water Quality Assessment

### 2.7.2.1 Affected Environment

#### 2.7.2.1.1 Introduction

This resource is institutionally significant because of the Clean Water Act, as amended, the Pollution Prevention Act, the Safe Drinking Water Act, and the Water Resources Planning Act. This resource is technically significant to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. This resource is publicly significant because of the desire for clean water and water related activities such as boating, swimming, fishing, and as a source of potable water for human and animal consumption.

##### 2.7.2.1.1.1 Study Area Description

The study area (Figure 85), located approximately 60 miles southwest of New Orleans in southeast Louisiana, covers approximately 1,891 square miles and includes portions of Lafourche and Terrebonne Parish. It is bounded by the Louisiana State Highway 311 and Bayou du Large to the west, Bayou Lafourche to the north and east, and the Gulf of Mexico to the south. The area includes the lower reach of the Terrebonne Basin, and is included in the abandoned Lafourche delta lobe. It includes barrier islands, open water, marsh, cypress and tupelo swamp, bottomland hardwood forest, farmland, and industry, residential, and other developed areas. There is very little topographical relief in the area. Like much of southeast Louisiana, the area contains many abandoned distributaries of the Mississippi River and their associated natural levees. In addition, the study area includes some of the most heavily used navigation waterways in the state of Louisiana (the Houma Navigation Canal and the Gulf Intracoastal Waterway).

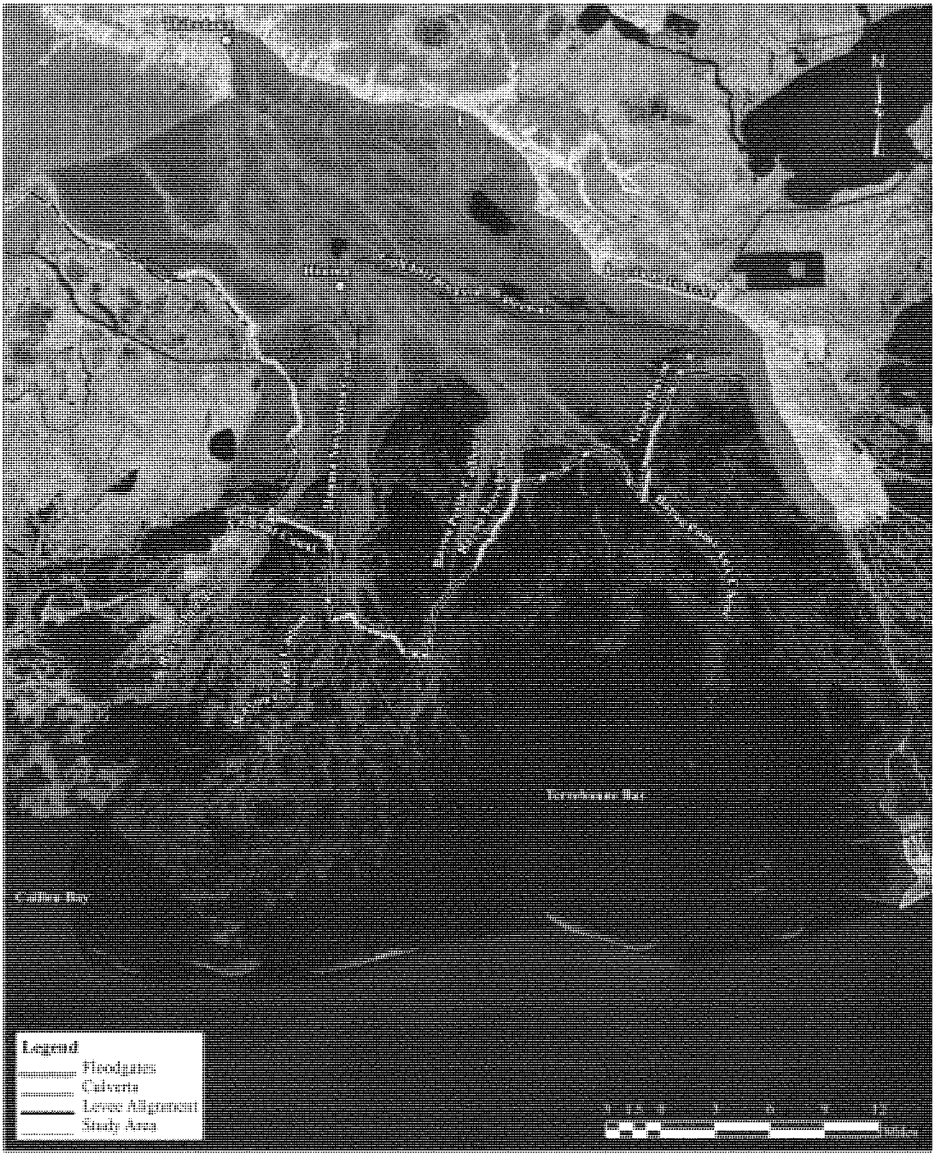


Figure 55 - Study area and project features

Development within the study area occurs along alluvial ridges, with the most significant development occurring in the cities of Houma and Thibodeaux. Undeveloped areas reveal characteristics of a transgressive delta lobe- wetlands which transition from swamp to marsh with increasing salinity gradient with proximity to the Gulf of Mexico, below which are several narrow, low profile barrier islands which are separated from the mainland marshes by a growing expanse of shallow coastal lakes and bays.

#### 2.7.2.1.1.2 **Project Description**

The proposed project includes the construction of 77 miles of earthen levees, 21 floodgate structures proposed for the navigable waterways, 21 environmental water control structures, and a lock on the Houma Navigational Canal near Dulac (Figure 85). The proposed sector gates and tidal exchange structures will help reduce saltwater intrusion, reduce flood damage, minimize adverse impacts on commercial navigation, and allow water to flow between the interior and exterior marshes of the system. Approximately 61 of the 77 miles of the proposed levee alignment will follow existing hydraulic barriers such as natural ridges, roadbeds, and levees, so as to avoid generating unnecessary impacts to the ecosystem within the study area from the construction of hurricane risk reduction features.

For levee construction, adjacent borrow material will be used during the first of 3 to 4 levee lifts for levee reaches B, E, F, G, H, I, J, and K. Borrow material will be excavated using a bucket dredge, with the top 5 feet of organic material unsuitable for use as levee fill being placed on the flood side of the levee for marsh construction, and the underlying 15 ft of material being stockpiled for drying, and then placed according to Hurricane Storm Damage Risk Reduction System compaction criteria. Borrow material for subsequent lifts would be hauled in from offsite borrow sources.

#### 2.7.2.1.1.3 **Study Area Water Quality Influences**

Water quality in the study area is a factor of area topography/bathymetry, water budget, coastal processes, local climate, tropical activity, and human activities. Study area elevation is predominated by a gradual downward slope with proximity to the Gulf of Mexico. Prominent topographic/bathymetric features include several abandoned Mississippi River distributaries and associated ridges, oil exploration and navigation canals and associated spoil banks, coastal lakes and bays, coastal wetlands, open water areas associated with deteriorated wetlands, barrier islands, and developed upland terrain.

Major water sources for the study area include the Gulf of Mexico, the Atchafalaya and

Mississippi Rivers, and precipitation. Major conduits for water exchange between the Gulf of Mexico and the study area include Falgout Canal, Bayou Grand Caillou, Houma Navigation Canal, Bayou Petite Caillou, and Bayou Terrebonne. The Gulf Intracoastal Waterway traverses the study area, and is a conduit for Atchafalaya River water (USGS 2003). Normal annual precipitation in the vicinity of the study area is 62 inches per year, with monthly averages ranging between 3.6 inches in April to 7.9 inches in July (NOAA 2012). Tropical storms and hurricanes produce significant time condensed rainfall totals that can cause major flooding and disrupt trends in water quality for affected areas.

Point and nonpoint water quality inputs to the basin include those occurring in the study area and in the Mississippi and Atchafalaya River watersheds, as the study area receives water input from these rivers. Primary point sources originating within the study area include package plant or other permitted small flows discharges, onsite treatment systems, total retention domestic sewage lagoons, municipal point source discharges, marina/boating sanitary on vessel discharges, industrial point source discharges, petroleum/natural gas activities, and sanitary sewer overflows (LDEQ 2011). Primary nonpoint sources originating within the study area include urban runoff/storm sewers, managed pasture grazing, non irrigated crop production, rangeland grazing, and municipal nonpoint sources (urbanized high density areas). The most significant nonpoint pollution sources for the Mississippi and Atchafalaya rivers include pesticide and fertilizer application, while primary point sources include industrial and municipal point source discharges.

Coastal processes and activities also affect study area water quality. Coastal wetlands have a significant effect on study area water quality, and are affected by these processes and activities. Wetlands have the ability to remove constituents such as nutrients, suspended sediments, organic matter, and metals from the water column. Wetlands have the ability to act as a permanent sink for these constituents through burial into substrate or release into the atmosphere. They also serve as a beneficial or detrimental source for constituents, and can change from a sink to a source for items such as nutrients or organic carbon through alterations to nutrient loading, hydrologic regime, burning, and vegetation change (Johnson 2004). The amount of time a wetland has been subjected to chemical loading can also influence whether it is a source or sink for certain constituents. For example, chronic loadings of elevated concentrations can result in saturation for a particular chemical after a number of years (Mitsch and Gosselink 2000). Wetlands modification of water column constituent concentrations varies seasonally with changes in wetland plant metabolism, species distribution, and density.

Wetland area within the study area has been decreasing in part as a result of the abandonment of the Lafourche delta lobe. Coastal processes such as erosion (day to day and storm induced) and subsidence are natural processes which promote wetland loss in a decaying delta. Wetland area in the study area has been declining at an increased rate over the past century, which is likely a result of anthropogenic factors such as hydrologic modification, sea level rise, freshwater and sediment deprivation, shoreline erosion, herbivory, localized salinity intrusion/salinity stress, and hydrocarbon extraction (Steyer et. al 2008; Couvillion et. al 2011).

### 2.7.2.1.2 Methods, Criteria, and Guidelines for Evaluation of Sediment and Water Quality

#### 2.7.2.1.2.1 Water Quality

#### 2.7.2.1.2.2 Louisiana Water Quality Inventory

The Clean Water Act (CWA) established a process for states to develop information on the quality of their water resources. Section 305(b) requires that each state develop a program to monitor the quality of its surface and groundwater and prepare a report describing the status of its water quality. Section 303(d) requires states to list impaired waterbodies where water quality standards are not met and designated uses are not fully supported, and to develop a Total Maximum Daily Load (TMDL) for those waterbodies. The Louisiana Water Quality Inventory Report- Integrated Report, prepared by the Louisiana Department of Environmental Quality (LDEQ), is the current form of biennial reporting of the status of Louisiana waters in accordance with CWA sections 305(b) and 303(d).

For the purpose of water quality monitoring and assessment and development of TMDLs, Louisiana is divided into twelve major watershed basins, and each basin is further divided into waterbody subsegments. This subsegment approach divides the state's waters into discrete hydrologic units. The waterbody subsegment system within each watershed basin provides a workable framework to evaluate the State's waters. Subsegments are periodically added or removed as water quality standards related to a subsegment or group of subsegments are revised.

Section 305(b) of the Clean Water Act requires, among other items, a water quality assessment for each subsegment, which includes a description of each subsegment and the extent to which their waters provide for the protection and propagation of fish and wildlife and allow for recreational activities in and on the water (USEPA 2011). All assessments are prepared using existing and readily available water quality data and information in order to comply with rules and regulations under Section 305(b) of the Clean Water Act.

Subsequently, Section 303(d) of the Clean Water Act requires the identification, listing, and ranking for development of Total Maximum Daily Loads (TMDLs) for waters that do not meet applicable water quality standards after implementation of technology based controls. By definition, a TMDL is the maximum amount of a pollutant that can be discharged into a water body from all sources (both point and non point) and still maintain water quality standards.

Louisiana Water Quality Standards (LAC 33-IX.1123) define eight designated uses for surface waters, including- primary contact recreation; secondary contact recreation; fish and wildlife propagation; drinking water supply; oyster propagation; agriculture; outstanding natural resource; and limited aquatic life and wildlife use. Principal designated uses for Louisiana waterbodies include primary contact recreation, secondary contact recreation, and fish and wildlife propagation. The definitions for these primary uses are-

Primary Contact Recreation—any recreational or other water contact activity involving prolonged or regular full body contact with the water and in which the probability of ingesting appreciable amounts of water is considerable. Examples of this type of water use include swimming, skiing, and diving.

Secondary Contact Recreation—any recreational or other water contact activity in which prolonged or regular full body contact with the water is either incidental or accidental, and the probability of ingesting appreciable amounts of water is minimal. Examples of this type of water use include fishing, wading, and boating.

Fish and Wildlife Propagation—the use of water for aquatic habitat, food, resting, reproduction, cover, and/or travel corridors for any indigenous wildlife and aquatic life species associated with the aquatic environment. This use also includes the maintenance of water quality at a level that prevents damage to indigenous wildlife and aquatic life species associated with the aquatic environment and contamination of aquatic biota consumed by humans. The use subcategory of limited aquatic life and wildlife recognizes the natural variability of aquatic habitats, community requirements, and local environmental conditions. Limited aquatic life and wildlife use may be designated for water bodies having habitat that is uniform in structure and morphology, with most of the regionally expected aquatic species absent, low species diversity and richness, and/or a severely imbalanced trophic structure. Aquatic life able to survive and/or propagate in such water bodies includes species tolerant of severe or variable environmental conditions. Water bodies that might qualify for the limited aquatic life and wildlife use subcategory include intermittent streams, and naturally dystrophic and man made water bodies with characteristics including, but not limited to, irreversible hydrologic modification, anthropogenically and irreversibly degraded water quality, uniform channel morphology, lack of channel structure, uniform substrate, lack of riparian structure, and similar characteristics making the available habitat for aquatic life and wildlife suboptimal.

Designated uses and criteria for each water body subsegment are listed in the Louisiana Water Quality Standards. Designated uses have a specific suite of ambient water quality parameters used to assess their support. Data and information collected from within or immediately downstream of a waterbody subsegment are used to evaluate each subsegment's designated uses. Where more than one parameter and criterion define a designated use, support for each use is defined by the designated use's poorest performing parameter (most severely impaired). Likewise, where data from more than one sample station are available, the most severely impaired station is used to make the assessment.

Following statistical determination of a water body's designated use support, along with a determination of the chemical parameters in the water body subsegment which might be impaired, a determination is then made as to which Integrated Report Category (IRC) the suspected water body impairment combination (WIC) should be placed in. A WIC is simply one impairment affecting one waterbody subsegment. Based on the IR Category, it is possible that either a TMDL is required, or has been completed, for a particular subsegment.

In addition to use of numerical data, LDEQ regional staff members are asked for input regarding significant suspected sources of impairment, or whether impairment due solely to natural sources is occurring. Numerical data alone can suggest impairment for some Louisiana water bodies when in fact there is no impairment or the impairment is due exclusively to natural causes. Using best professional judgment, regional staff familiar with the area suggest one or more suspected sources for a waterbody subsegment's impairment.

Total maximum daily loads (TMDLs) indicate that the majority of the pollutant load entering state waters comes from nonpoint sources of pollution; therefore, LDEQ is implementing a watershed based approach to reducing those loads in the water bodies where TMDLs have been completed. Presently, LDEQ utilizes both regulatory and non regulatory mechanisms to control nonpoint sources of pollution. Urban storm water for cities with populations of 50,000 or greater and construction sites of one acre or more are regulated through the LPDES permit program. Home sewage treatment systems are regulated through the LDHH. LDEQ's Water Quality Assessment Division (WQAD) currently houses the state's Nonpoint Source Management Program, which has been successful in implementing voluntary programs for forestry and agricultural sources of pollution. This has been done through coordination with other concerned agencies, such as the Louisiana Department of Agriculture and Forestry (LDAF), the U.S. Natural Resource Conservation Service (NRCS), and the Louisiana State University (LSU) AgCenter. LDEQ will continue to monitor state waters through the four year cyclic process to determine whether the current implementation strategy is successful in restoring and maintaining water quality and the designated uses within Louisiana.

#### 2.7.2.1.2.3 **Louisiana Pollutant Discharge Elimination System (LPDES)**

Louisiana's water quality regulations require permits for the discharge of pollutants from any point source into waters of the state of Louisiana. This surface water discharge permitting system is administered under the Louisiana Pollutant Discharge Elimination System (LPDES) program.

LPDES permits are official authorization developed and promulgated by the Office of Environmental Services of LDEQ. The LPDES permit establishes the wasteload content of wastewaters discharged into waters of the state. The permitting process allows the state to control the amounts and types of wastewaters discharged into its surface waters, in order to meet water quality standards. In 1996 LDEQ assumed responsibility for administering the permitting, compliance, and enforcement activities of the National Pollutant Discharge Elimination System (NPDES) from the U.S. Environmental Protection Agency (USEPA).

#### 2.7.2.1.2.4 **Louisiana Nonpoint Source Management Plan**

Nonpoint source pollution is a type of pollution which is generated during rainfall events, and includes, among other things, agricultural and urban runoff. Section 319 of the Clean Water Act requires that state develop a nonpoint source management plan to reduce and control nonpoint sources of pollution from the various types of land uses that contribute to water quality problems across the United States. Louisiana has determined that agriculture, forestry, urban runoff, home sewage systems, sand and gravel mining, construction, and hydromodification all contribute to nonpoint source pollution problems across the state. Nonpoint source pollution is the largest remaining type of water pollution that needs to be addressed within Louisiana, and across the nation, in order to restore full support for designated uses of impaired waterbodies.

Louisiana's Nonpoint Source Program is managed by the LDEQ, and the goal of the program is to provide education regarding nonpoint source pollution and nonpoint source pollution prevention. The state of Louisiana has applied for and received Section 319 funds to implement both statewide and watershed projects to address nonpoint source pollution.

#### 2.7.2.1.2.5 Water Quality Criteria

Water quality criteria are elements of state water quality standards expressed as constituent concentrations, levels, or narrative statements representing the quality of water supporting a particular designated use. When criteria are met, water quality will protect the designated use. Louisiana has both general and numeric criteria in LAC 33-IX.1113. General criteria are expressed in a narrative form (in concise statements) and include aesthetics, color, suspended solids, taste and odor, toxic substances (in general), oil and grease, foam, nutrients, turbidity, flow, radioactive materials, and biological and aquatic community integrity. Numeric criteria are generally expressed as concentrations (e.g., weight measured per liter) or scientific units and include pH, chlorides, sulfates, total dissolved solids, dissolved oxygen, temperature, bacteria, and specific toxic substances.

The USEPA has published national criteria recommendations for a number of substances, and states may incorporate these without modifications into their water quality standards. However, while states generally use USEPA guidance and recommendations in developing and adopting their own criteria, they are allowed the flexibility to develop their own methodology as well. USEPA guidance is under continuous development and revision. States review and incorporate these developments and revisions into their water quality standards as appropriate.

Human health criteria provide guidelines that specify the potential risk of adverse effects to humans due to substances in the water. Factors considered include body weight, risk level, fish consumption, drinking water intake, and incidental ingestion while swimming. Categories of criteria are then developed for each toxic substance for public drinking water supply, non drinking water (swimming), and non swimming water.

Aquatic life criteria are designed to protect all aquatic life, including plants and animals. There are two types of criteria- acute, for short term exposures (e.g., spills); and chronic for long term or permanent exposures. One or both of the acute and chronic criteria may be related to other water quality characteristics, such as pH, temperature, or hardness. Separate criteria are also developed for fresh and salt waters. The federal water quality standards regulations allow states to develop numerical criteria or modify USEPA's recommended criteria to account for site specific or other scientifically defensible factors.

#### 2.7.2.1.2.6 Sediment Quality

The National Oceanic and Atmospheric Administration (NOAA) has developed Screening Quick Reference Tables, or SQuiRTs, to help evaluate potential risks from contaminated water, sediment, or soil (NOAA 2008). The suite of sediment screening benchmarks provided in these tables are for different biological and toxicological

endpoints, some of which (such as PEL, T50, and ERM screening values) represent levels at which a high probability of adverse effects or toxicity for benthic organisms exposed to whole sediment are expected. Further definitions of screening benchmarks are available at:
http://response.restoration.noaa.gov/faq_topic.php?faq_topic_id=6#tecpec.

Although they are not regulated, these benchmarks provide a useful means of assessing sediment chemistry to determine whether or not acute or chronic exposure of benthic organisms to whole sediments may result in adverse biological effects or mortality.

### 2.7.2.1.3 Study Area Historical Water Quality

#### 2.7.2.1.3.1 Louisiana Water Quality Inventory

In order to assess historical water quality of the study area, a review of historical water quality inventories for waterbody subsegments within the study area was conducted. Table 75 and Figure 86 depict all subsegments included in the study area.

## Table 75 - Study area subsegments

| Subsegment | Subsegment Description |
|---|---|
| 120202 | Bayou Black-From ICWW to Houma |
| 120203 | Bayou Boeuf-From Lake Palourde to ICWW |
| 120207 | Thibodaux Swamp-Forested wetland located in Lafourche and Terrebonne Parishes, 6.2 miles southwest of Thibodaux, east of Terrebonne-Lafourche Drainage Canal, and north of Southern Pacific Railroad; also called Pointe Au Chene Swamp |
| 120301 | Bayou Terrebonne-From Thibodaux to ICWW in Houma |
| 120302 | Bayou Folse-From headwaters to Company Canal |
| 120303 | Bayou L'Eau Bleu-From Company Canal to ICWW |
| 120304 | Intracoastal Waterway-From Houma to LaRose |
| 120403 | Intracoastal Waterway-From Bayou Boeuf Locks to Bayou Black in Houma; includes segments of Bayous Boeuf, Black and Chene |
| 120405 | Lake Hache and Lake Theriot |
| 120406 | Lake de Cade |
| 120501 | Bayou Grand Caillou-From Houma to Bayou Pelton |
| 120502 | Bayou Grand Caillou-From Bayou Pelton to Houma Navigation Canal (Estuarine) |
| 120503 | Bayou Petit Caillou-From Bayou Terrebonne to LA-24 bridge |
| 120504 | Bayou Petit Caillou-From LA-24 bridge to Boudreaux Canal (Estuarine) |
| 120505 | Bayou Du Large-From Houma to Marmande Canal |
| 120506 | Bayou Du Large-From Marmande Canal to 1/2 mile north of St. Andrews Mission (Estuarine) |
| 120507 | Bayou Chauvin-From Ashland Canal to Lake Boudreaux (Estuarine) |
| 120508 | Houma Navigation Canal-From Bayou Pelton to 1 mile south of Bayou Grand Caillou (Estuarine) |
| 120509 | Houma Navigation Canal-From Houma to Bayou Pelton |
| 120601 | Bayou Terrebonne-From Houma to Company Canal (Estuarine) |
| 120602 | Bayou Terrebonne-From Company Canal to Humble Canal (Estuarine) |
| 120603 | Company Canal-From ICWW to Bayou Terrebonne |
| 120604 | Bayou Blue-From ICWW to Grand Bayou Canal |
| 120605 | Bayou Pointe au Chien-From headwaters to St. Louis Canal |
| 120606 | Bayou Blue-From Grand Bayou Canal to Bully Camp Canal (Estuarine) |
| 120701 | Bayou Grand Caillou-From Houma Navigation Canal to Caillou Bay (Estuarine) |
| 120702 | Bayou Petite Caillou-From Boudreaux Canal to Houma Navigation Canal (Estuarine) |
| 120704 | Bayou Terrebonne-From Humble Canal to Lake Barre (Estuarine) |
| 120705 | Houma Navigation Canal-From 1/2 mile south of Bayou Grand Caillou to Terrebonne Bay (Estuarine) |
| 120706 | Bayou Blue-From Bully Camp Canal to Lake Raccourci (Estuarine) |
| 120707 | Lake Boudreaux |
| 120709 | Bayou Petite Caillou-From Houma Navigation Canal to Terrebonne Bay |
| 120801 | Caillou Bay |
| 120802 | Terrebonne Bay |
| 120803 | Timbalier Bay |
| 120804 | Lake Barre |
| 120805 | Lake Pelto |

Clean Water Act Section 305(b) listings of study area subsegments, from 1996 to 2010, were included in the review. For each subsegment, an average designated use support value was calculated. The calculated average support values were a function of designated use and level of support. Support levels for each combination of subsegment, year, and designated use were as follows-

0- subsegment not supporting designated use
1- subsegment fully supporting designated use

The average support value calculated for each subsegment serves as a simplistic representation for waterbody subsegment health with respect to designated uses (with zero being the least healthy value possible, and one being the most). In order to develop a visual representation of the long term health of each subsegment with respect to designated uses, the average support values for subsegments were color coded in 20th percentile increments. Table 76 and Figure 86 illustrate the average support values for each subsegment. For Table 76, subsegments were grouped based on their predominant orientation with respect to the proposed MTG project levee alignment (flood or protected side) to illustrate the overall disparity in waterbody health with respect to designated uses. A significant portion (15 of 16) of the subsegments in the lowest 40th percentile are predominantly located within the proposed levee alignment. In general, this disparity is present because the portion of the study area north of the proposed levee alignment is more developed (and therefore subject to a higher volume of point and nonpoint sources of pollution), while the portion south of the proposed levee alignment is more tidally influenced (and therefore frequently flushed with ocean water).

# MORGANZA TO THE GULF OF MEXICO, LOUISIANA DRAFT PAC DRAFT ENGINEERING APPENDIX

## Table 76 - 1996-2010 average support values

| Flood or Protected Side | Subsegment | Average of Support, 1996-2010 |
|---|---|---|
| Flood | 120203 | 0.957 |
| | 120403 | 0.818 |
| | 120405 | 0.722 |
| | 120406 | 0.957 |
| | 120506 | 0.522 |
| | 120701 | 0.806 |
| | 120702 | 0.680 |
| | 120704 | 0.720 |
| | 120705 | 0.920 |
| | 120706 | 0.920 |
| | 120709 | 0.840 |
| | 120801 | 0.913 |
| | 120802 | 0.957 |
| | 120803 | 0.913 |
| | 120804 | 0.913 |
| | 120805 | 0.870 |
| Protected | 120202 | 0.548 |
| | 120207 | 1 |
| | 120301 | 0.208 |
| | 120302 | 0.553 |
| | 120303 | 0.667 |
| | 120304 | 0.789 |
| | 120501 | 0.444 |
| | 120502 | 0.548 |
| | 120503 | 0.522 |
| | 120504 | 0.387 |
| | 120505 | 0.556 |
| | 120507 | 0.333 |
| | 120508 | 0.742 |
| | 120509 | 0.839 |
| | 120601 | 0.500 |
| | 120602 | 0.387 |
| | 120603 | 0.944 |
| | 120604 | 0.556 |
| | 120605 | 0.444 |
| | 120606 | 0.556 |
| | 120707 | 0.739 |

| | |
|---|---|
| (darkest shading) | = 0-20th Percentile |
| (dark shading) | = 20th-40th Percentile |
| (medium shading) | = 40th-60th Percentile |
| (light shading) | = 60th-80th Percentile |
| (lightest shading) | = 80th-100th Percentile |

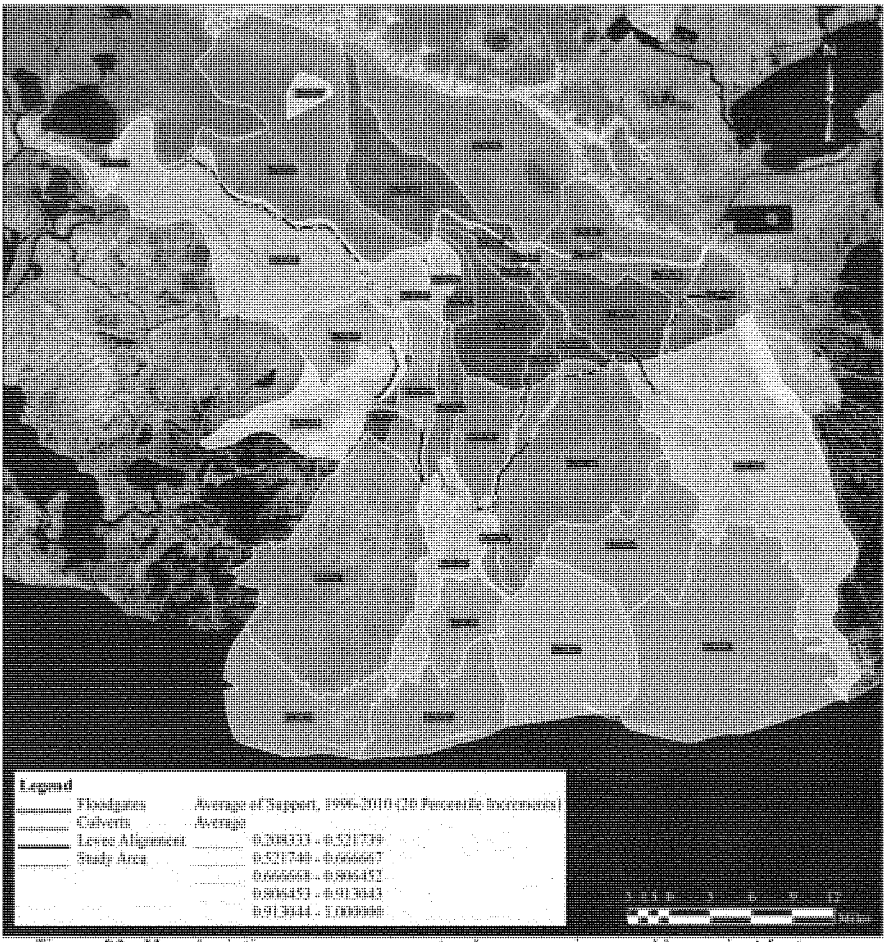

Figure 56 - Map depicting average support values superimposed by project features

In order to both determine the most prevalent water quality issues present in the study area and determine which water quality parameters should be summarized for the depiction of historical water quality for the study area, the same collection of historical Clean Water Act Section 305(b) listings was reviewed to determine the most prevalent historical causes and sources of subsegment impairment (Table 77 and Table 78). Between 1996 and 2010, the most common suspected cause of impairment was low dissolved oxygen, followed by Fecal Coliform, non native aquatic plants, total phosphorus, nitrate plus nitrite nitrogen, and nutrients, while the most common suspected source of impairment was package plant of other permitted small flows discharges, followed by introduction of non native organisms, on site treatment systems, total retention domestic sewage lagoons, unknown sources, and natural sources. When subsegments are grouped based on their predominant orientation with respect to the proposed level alignment, leading suspected causes between flood and protected side remain similar, while sources differ (for example, introduction of non native organisms is a more significant suspected source north of the proposed levee alignment, which petroleum/natural gas activities is a more significant suspected source of impairment south of the proposed levee alignment).

**Table 77 - Frequency of suspected causes of impairment, 1996-2010**

| Suspected Cause of Impairment | Count |
|---|---|
| Dissolved Oxygen | 124 |
| Fecal Coliform | 114 |
| Non-Native Aquatic Plants | 80 |
| Total Phosphorus | 47 |
| Nitrate/Nitrite | 47 |
| Nutrients | 37 |
| Chloride | 31 |
| Oil and Grease | 31 |
| Turbidity | 23 |
| Mercury | 23 |
| Priority Organics | 20 |
| Metals | 19 |
| Total Dissolved Solids | 15 |
| Sulfates | 11 |
| Total Suspended Solids | 10 |
| Radiation | 9 |
| Flow Alteration | 7 |
| Pesticides | 5 |
| Taste and Odor | 5 |
| Siltation | 5 |
| Habitat Alteration | 5 |
| pH | 4 |
| Color | 2 |
| Unknown | 2 |
| Arsenic | 2 |
| Nonpriority Organics | 2 |
| Total Toxics | 1 |

| Flood or Protected Side | Suspected Cause of Impairment | Count |
|---|---|---|
| Flood | Fecal Coliform | 37 |
| | Dissolved Oxygen | 21 |
| | Nutrients | 16 |
| | Priority Organics | 14 |
| | Oil and Grease | 14 |
| | Non-Native Aquatic Plants | 13 |
| | Metals | 10 |
| | Mercury | 9 |
| | Radiation | 9 |
| | Chloride | 8 |
| | Turbidity | 7 |
| | Habitat Alteration | 3 |
| | pH | 3 |
| | Total Suspended Solids | 2 |
| | Total Phosphorus | 2 |
| | Nitrate/Nitrite | 2 |
| | Taste and Odor | 2 |
| | Flow Alteration | 1 |
| | Siltation | 1 |
| Protected | Dissolved Oxygen | 103 |
| | Fecal Coliform | 77 |
| | Non-Native Aquatic Plants | 67 |
| | Nitrate/Nitrite | 45 |
| | Total Phosphorus | 45 |
| | Chloride | 23 |
| | Nutrients | 21 |
| | Oil and Grease | 17 |
| | Turbidity | 16 |
| | Total Dissolved Solids | 15 |
| | Mercury | 14 |
| | Sulfates | 11 |
| | Metals | 9 |
| | Total Suspended Solids | 8 |
| | Flow Alteration | 6 |
| | Priority Organics | 6 |
| | Pesticides | 5 |
| | Siltation | 4 |
| | Taste and Odor | 3 |
| | Arsenic | 2 |
| | Habitat Alteration | 2 |
| | Unknown | 2 |
| | Nonpriority Organics | 2 |
| | Color | 2 |
| | Total Toxics | 1 |
| | pH | 1 |

**MORGANZA TO THE GULF OF MEXICO, LOUISIANA DRAFT PAC DRAFT ENGINEERING APPENDIX**

## Table 78 - Frequency of suspected sources of impairment, 1996-2010

| Suspected Source of Impairment | Count |
|---|---|
| Package Plant or Other Permitted Small Flows Discharges | 121 |
| Introduction of Non-native Organisms (Accidental or Intentional) | 85 |
| On-site Treatment Systems (Septic Systems and Similar Decentralized Systems) | 80 |
| Total Retention Domestic Sewage Lagoons | 67 |
| Source Unknown | 64 |
| Natural Sources | 54 |
| Municipal Point Source Discharge | 50 |
| Marina/Boating Sanitary On-vessel Discharges | 43 |
| Industrial Point Source Discharge | 42 |
| Petroleum/natural Gas Activities | 40 |
| Urban Runoff/Storm Sewers | 32 |
| Other Spill Related Impacts | 30 |
| Managed Pasture Grazing | 29 |
| Sanitary Sewer Overflows (Collection System Failures) | 27 |
| Non-irrigated Crop Production | 16 |
| Forced Drainage Pumping | 16 |
| Channelization | 15 |
| Upstream Source | 15 |
| Natural Conditions - Water Quality Standards Use Attainability Analyses Needed | 15 |
| Drought-Related Impacts | 12 |
| Rangeland Grazing | 12 |
| Unspecified Land Disturbance | 11 |
| Flow Alterations from Water Diversions | 11 |
| Municipal (Urbanized High Density Area) | 10 |
| Wildlife Other than Waterfowl | 9 |
| Unspecified Domestic Waste | 9 |
| Contaminated Sediments | 9 |
| Combined Sewer Overflows | 8 |
| Dredging | 8 |
| Sewage Discharges in Unsewered Areas | 8 |
| Agriculture | 8 |
| Atmospheric Deposition - Toxics | 8 |
| Site Clearance (Land Development or Redevelopment) | 7 |
| Changes in Tidal Circulation/Flushing | 7 |
| Unspecified Urban Stormwater | 6 |
| Industrial/Commercial Site Stormwater Discharge (Permitted) | 6 |
| Streambank Modifications/Destabilization | 5 |
| Waterfowl | 4 |
| Sources Outside State Jurisdiction or Borders | 4 |
| Non-Point Source | 4 |
| Unpermitted Discharge (Domestic Wastes) | 3 |
| Sediment Resuspension (Clean Sediment) | 3 |
| Seafood Processing Operations | 2 |
| Hazardous Waste | 2 |
| Internal Nutrient Recycling | 2 |
| Hydromodification | 2 |
| Changes in Ordinary Stratification and Bottom Water Hypoxia/Anoxia | 2 |
| Aquaculture | 1 |
| Drainage/Filling/Loss of Wetlands | 1 |

| Flood or Protected Side | Suspected Source of Impairment | Count |
|---|---|---|
| Flood | Package Plant or Other Permitted Small Flows Discharges | 29 |
| | Petroleum/natural Gas Activities | 24 |
| | Source Unknown | 24 |
| | Marina/Boating Sanitary On-vessel Discharges | 19 |
| | Industrial Point Source Discharge | 16 |
| | Managed Pasture Grazing | 15 |
| | Total Retention Domestic Sewage Lagoons | 15 |
| | Other Spill Related Impacts | 15 |
| | On-site Treatment Systems (Septic Systems and Similar Decentralized Systems) | 15 |
| | Natural Sources | 15 |
| | Introduction of Non-native Organisms (Accidental or Intentional) | 13 |
| | Municipal Point Source Discharge | 9 |
| | Atmospheric Deposition - Toxics | 7 |
| | Urban Runoff/Storm Sewers | 7 |
| | Upstream Source | 7 |
| | Channelization | 6 |
| | Rangeland Grazing | 6 |
| | Non-irrigated Crop Production | 6 |
| | Sewage Discharges in Unsewered Areas | 5 |
| | Agriculture | 5 |
| | Dredging | 5 |
| | Natural Conditions - Water Quality Standards Use Attainability Analyses Needed | 4 |
| | Flow Alterations from Water Diversions | 4 |
| | Industrial/Commercial Site Stormwater Discharge (Permitted) | 4 |
| | Contaminated Sediments | 4 |
| | Combined Sewer Overflows | 3 |
| | Waterfowl | 3 |
| | Sources Outside State Jurisdiction or Borders | 3 |
| | Internal Nutrient Recycling | 2 |
| | Changes in Ordinary Stratification and Bottom Water Hypoxia/Anoxia | 2 |
| | Site Clearance (Land Development or Redevelopment) | 2 |
| | Streambank Modifications/Destabilization | 2 |
| | Wildlife Other than Waterfowl | 2 |
| | Unspecified Domestic Waste | 2 |
| | Unspecified Urban Stormwater | 2 |
| | Hazardous Waste | 1 |
| | Non-Point Source | 1 |
| Protected | Package Plant or Other Permitted Small Flows Discharges | 92 |
| | Introduction of Non-native Organisms (Accidental or Intentional) | 72 |
| | On-site Treatment Systems (Septic Systems and Similar Decentralized Systems) | 65 |
| | Total Retention Domestic Sewage Lagoons | 52 |
| | Municipal Point Source Discharge | 41 |
| | Source Unknown | 40 |
| | Natural Sources | 39 |
| | Sanitary Sewer Overflows (Collection System Failures) | 27 |
| | Industrial Point Source Discharge | 26 |
| | Urban Runoff/Storm Sewers | 25 |
| | Marina/Boating Sanitary On-vessel Discharges | 24 |
| | Forced Drainage Pumping | 16 |
| | Petroleum/natural Gas Activities | 16 |
| | Other Spill Related Impacts | 15 |
| | Managed Pasture Grazing | 14 |
| | Drought-Related Impacts | 12 |
| | Unspecified Land Disturbance | 11 |
| | Natural Conditions - Water Quality Standards Use Attainability Analyses Needed | 11 |
| | Municipal (Urbanized High Density Area) | 10 |
| | Non-irrigated Crop Production | 10 |
| | Channelization | 9 |
| | Upstream Source | 8 |
| | Unspecified Domestic Waste | 7 |
| | Flow Alterations from Water Diversions | 7 |
| | Changes in Tidal Circulation/Flushing | 7 |
| | Wildlife Other than Waterfowl | 7 |
| | Rangeland Grazing | 6 |
| | Contaminated Sediments | 5 |
| | Combined Sewer Overflows | 5 |
| | Site Clearance (Land Development or Redevelopment) | 5 |
| | Unspecified Urban Stormwater | 4 |
| | Streambank Modifications/Destabilization | 3 |
| | Agriculture | 3 |
| | Sediment Resuspension (Clean Sediment) | 3 |
| | Non-Point Source | 3 |
| | Unpermitted Discharge (Domestic Wastes) | 3 |
| | Dredging | 3 |
| | Sewage Discharges in Unsewered Areas | 3 |
| | Hydromodification | 2 |
| | Seafood Processing Operations | 2 |
| | Industrial/Commercial Site Stormwater Discharge (Permitted) | 2 |
| | Drainage/Filling/Loss of Wetlands | 1 |
| | Sources Outside State Jurisdiction or Borders | 1 |
| | Waterfowl | 1 |
| | Hazardous Waste | 1 |
| | Aquaculture | 1 |
| | Atmospheric Deposition - Toxics | 1 |

#### 2.7.2.1.3.2 Historical Water Quality Monitoring

In addition to review and summary of the historical Clean Water Act Section 305(b) listings for the study area, historical water quality monitoring data was reviewed and summarized to determine water quality trends in the study area.

Four (4) LDEQ long term water quality monitoring stations exist in the study area, as depicted in Table 79 and Figure 95. Stations are increasing in salinity gradient from station 37, 113, 110, to 114, with station 37 being the only station on the flood side of the proposed levee alignment. In general, water quality monitoring data for these stations was collected monthly until 1998, and thereafter was collected monthly for one out of every four years.

**Table 79 - LDEQ long term water quality monitoring station descriptions**

| Station ID | Latitude | Longitude | Station Description | Monitoring Interval | |
|---|---|---|---|---|---|
| | | | | Begin | End |
| 37 | 29.233329 | -90.666674 | Houma Navigation Canal south of Cocodrie, Louisiana | 3/6/1978 | 12/10/1990 |
| 110 | 29.598606 | -90.718614 | Bayou Terrebonne at Houma, Louisiana | 6/1/1958 | 8/4/2008 |
| 113 | 29.382771 | -90.715279 | Bayou Grand Caillou at Dulac, Louisiana | 3/6/1978 | 8/3/2011 |
| 114 | 29.684717 | -90.998618 | Bayou Black at Gibson, Louisiana | 6/1/1958 | 2/1/2005 |

Figure 87 through Figure 92 depict long term water quality monitoring results and trends for these stations, for the parameters most frequently cited as suspected causes of impairment for subsegments included in the study area.

For dissolved oxygen (Figure 87), trendlines for all stations indicate that dissolved oxygen levels have improved for all sites (although, as with this and most other parameters, r-squared values for all stations are generally less than .1). Trendlines for Fecal Coliform levels (Figure 88 and Figure 89) for all stations except 114 indicate decreasing trends in Fecal Coliform levels. Station 114 had several high measurements of Fecal Coliform density between 1993 and 1998, which might explain the positive slope of the trendline for this station. Overall, mildly decreasing trends are observed for total phosphorus, for all stations (Figure 90). Kjeldahl nitrogen trendlines are consistently decreasing, and the trendline for station 110 has a relatively high r-squared value of .125 (Figure 92). Nitrate plus nitrite trendlines suggest very little change in long term nitrate plus nitrogen concentrations has occurred over the past thirty years at these stations (Figure 91). Overall, these figures suggest that dissolved oxygen and fecal coliform levels have improved within the past thirty years.

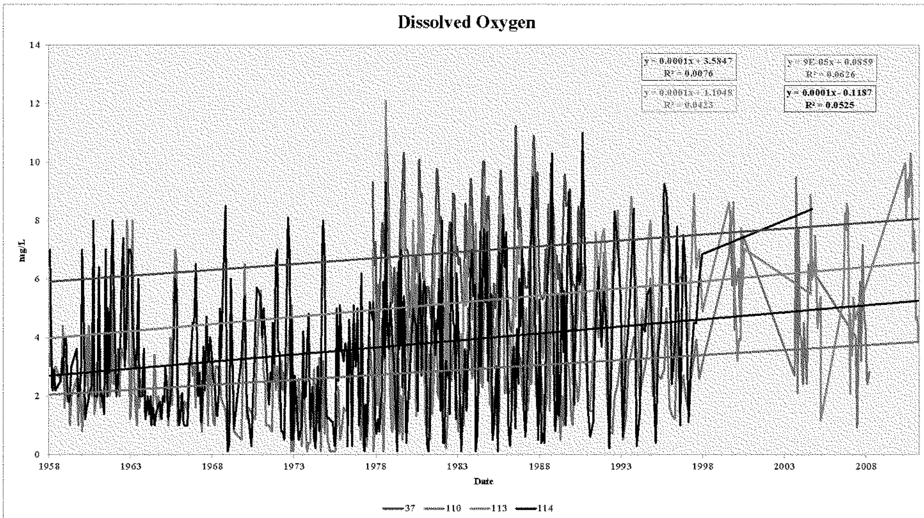


**Figure 87 - Study area long term dissolved oxygen monitoring data plots and trends**

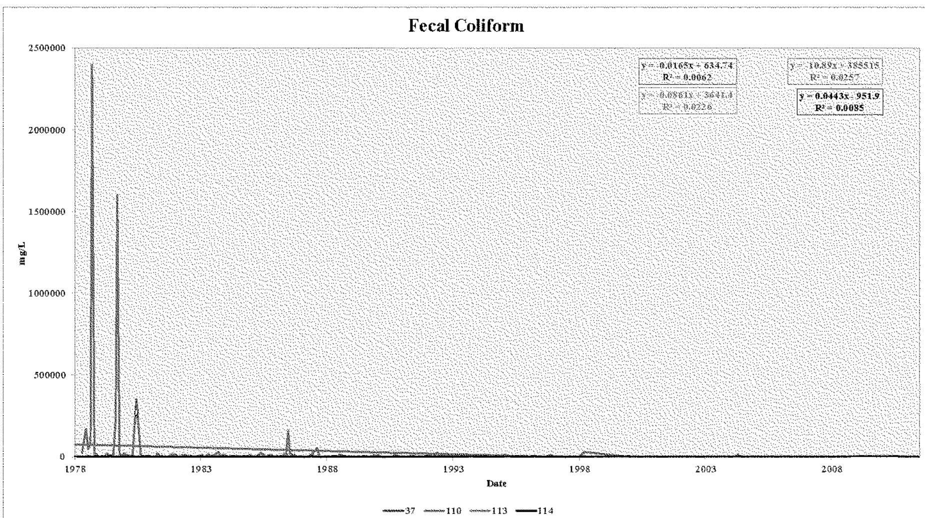


**Figure 88 - Study area long term Fecal Coliform monitoring data plots and trends**

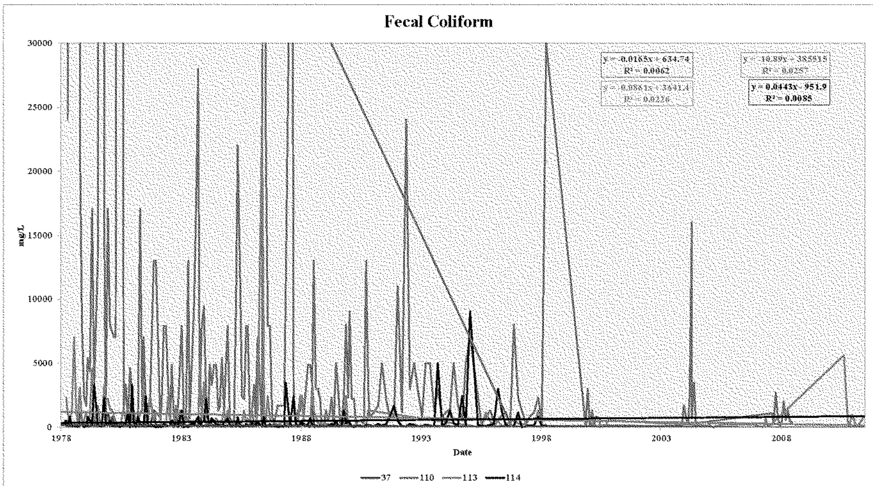


Figure 89 - Study area long term Fecal Coliform monitoring data plots and trends (reduced y-axis scale)

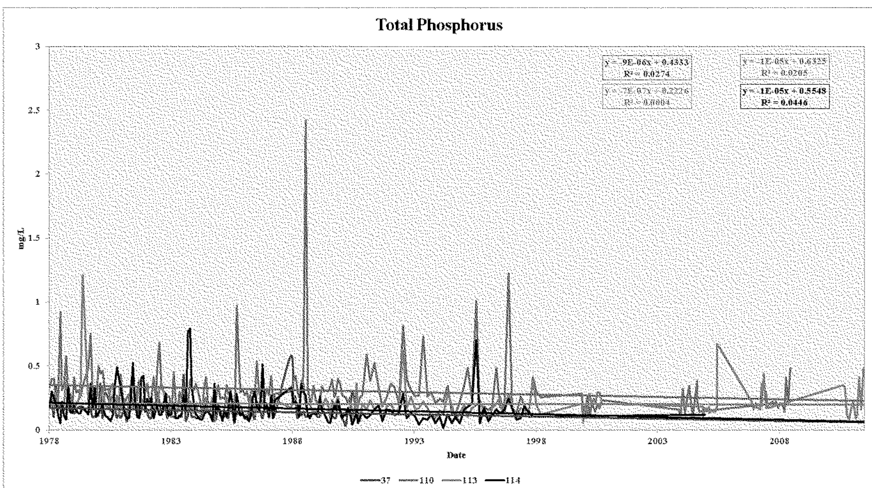


Figure 90 - Study area long term total phosphorus monitoring data plots and trends

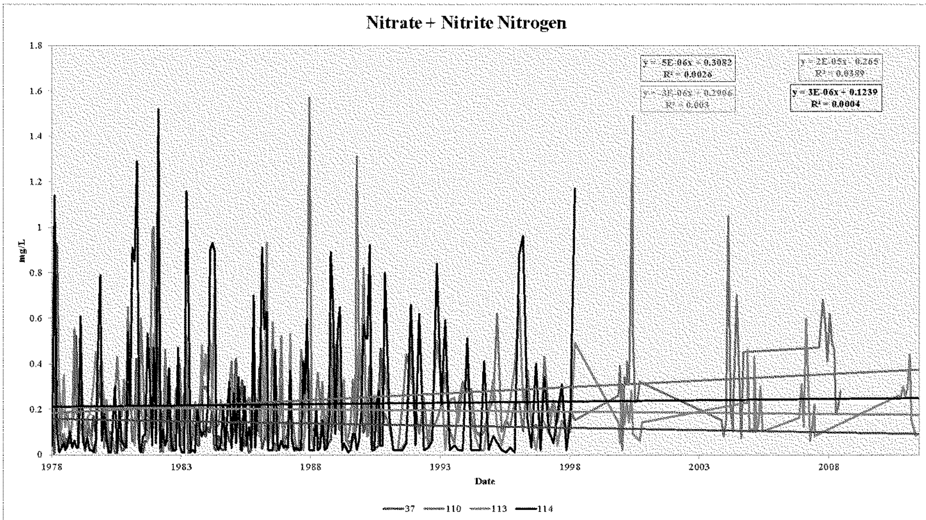


**Figure 91 - Study area long term nitrate plus nitrite monitoring data plots and trends**

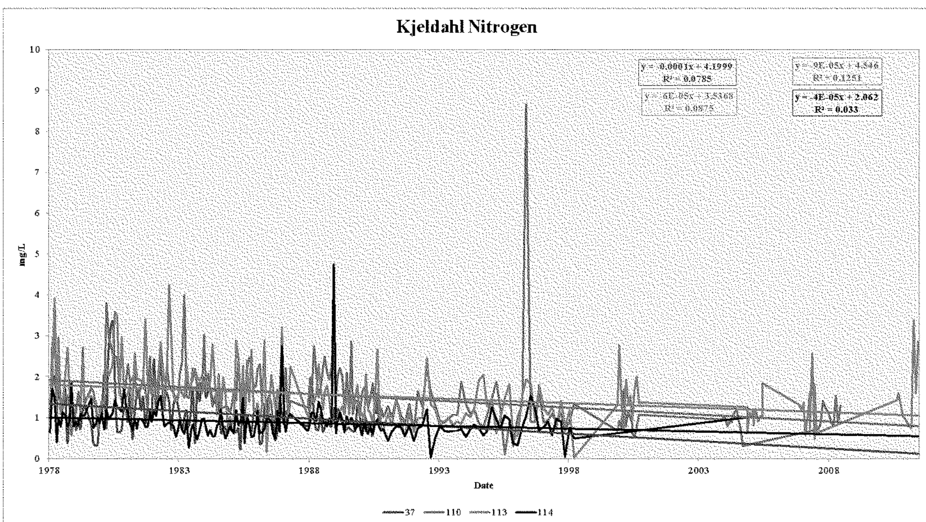


**Figure 92 - Study area long term Kjeldahl nitrogen monitoring data plots and trends**

### 2.7.2.1.4 Study Area Existing Water and Sediment Quality

#### 2.7.2.1.4.1 Louisiana Water Quality Inventory

Figure 93 depicts overall subsegment support for the 2010 Louisiana Water Quality Inventory, for subsegments included in the study area. Subsegments shaded green are fully supporting all designated uses, while subsegments shaded orange are fully supporting some, but not all, designated uses. Consistent with long term trends, most subsegments fully supporting all designated uses are located on the flood side of the proposed levee alignment.

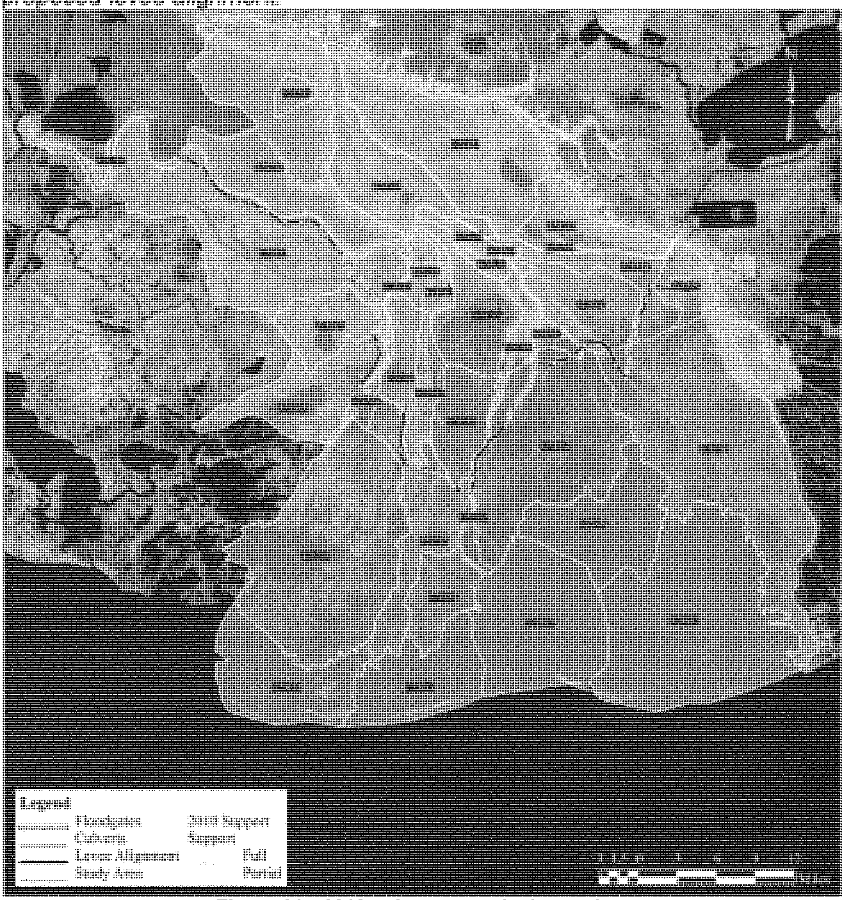


**Figure 93 - 2010 subsegment designated use support**

### 2.7.2.1.4.2 LPDES Permitted Discharges

Figure 94 depicts the locations of point source discharges permitted under the LPDES. Clearly, the majority of these permitted discharges occur on the protected side of the proposed levee alignment, in developed areas. Over 70% of these permitted discharges occur in the subsegments in the lowest 40th percentile with respect to average subsegment support; approximately 88% of the permitted discharges occur on the protected side of the proposed levee alignment.

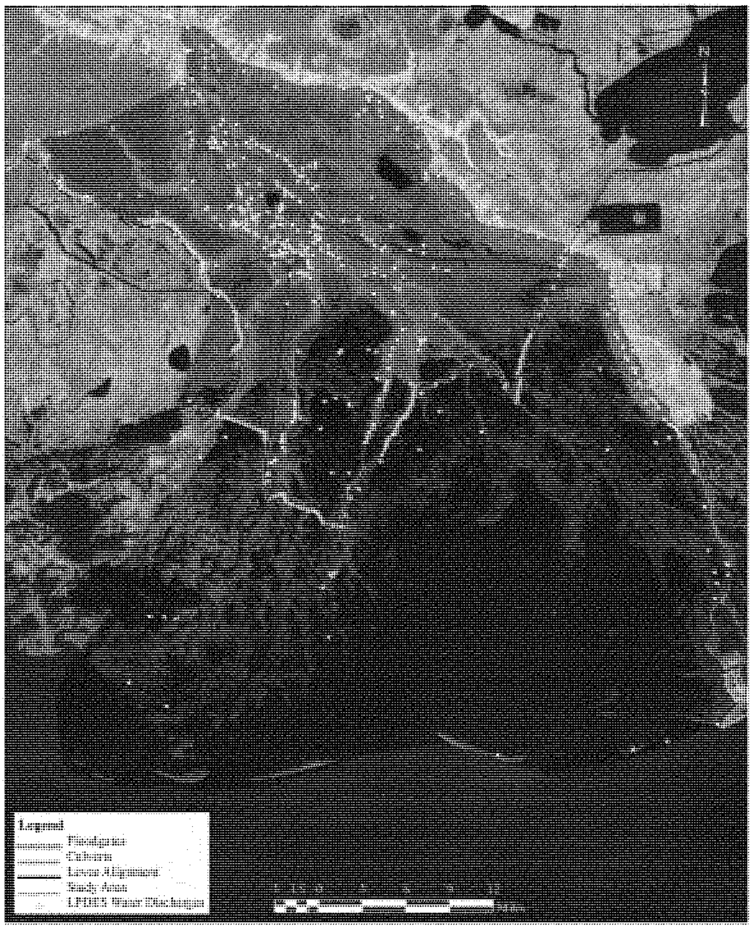

Figure 94 - Locations of LPDES permitted discharges within the study area

### 2.7.2.1.4.3 Project specific Water and Sediment Sampling

In addition to the review of Clean Water Act Section 305(b) listings and historical water quality monitoring data, project specific sediment, water, and elutriate chemistry data was collected. Water and sediment samples were collected from a total of twelve (12) sites between January 31st and February 2nd, 2011 (see Table 80 and Figure 95).

**Table 80 - Project specific water and sediment sampling sites**

| Station ID | Latitude | Longitude | Station Description | Sampling Date |
|---|---|---|---|---|
| Site 1 | 29.650000 | -90.872500 | Munson's World Famous Swamp Tours, north of Barrier Alignment | 1/31/2011 |
| Site 2 | 29.548056 | -90.791111 | Near canal with bridge crossing, 1/2 miles east of Minors Canal | 1/31/2011 |
| Site 3 | 29.417500 | -90.784722 | Canal by upper Bayou du Large pump station | 1/31/2011 |
| Site 4 | 29.335556 | -90.843333 | Floodgate near end of Bayou Dularge Road | 2/1/2011 |
| Site 5 | 29.389739 | -90.733056 | South of east end of Falgout Canal | 2/1/2011 |
| Site 6 | 29.384444 | -90.729167 | Houma Navigation Canal and Falgout Road | 2/1/2011 |
| Site 7 | 29.302222 | -90.670000 | Highway 57 northwest of Rabbit Bayou – location of proposed culvert with sluice gates | 2/1/2011 |
| Site 8 | 29.387500 | -90.587778 | Flood side of Mason Canal Road at proposed Bayou Terrebonne floodgate | 2/1/2011 |
| Site 9 | 29.437836 | -90.565075 | Near dock at Humble Canal, west of Humble Canal floodgate | 2/1/2011 |
| Site 10 | 29.430833 | -90.587778 | Pump station, Oak Point Road off of Highway 65 | 2/2/2011 |
| Site 11 | 29.474122 | -90.435028 | Shoreline of Grand Bayou Canal at proposed Grand Bayou floodgate | 2/2/2011 |
| Site 12 | 29.543889 | -90.402778 | Off Highway 24 across from shipyard in GIWW, at proposed Grand Bayou floodgate | 2/2/2011 |

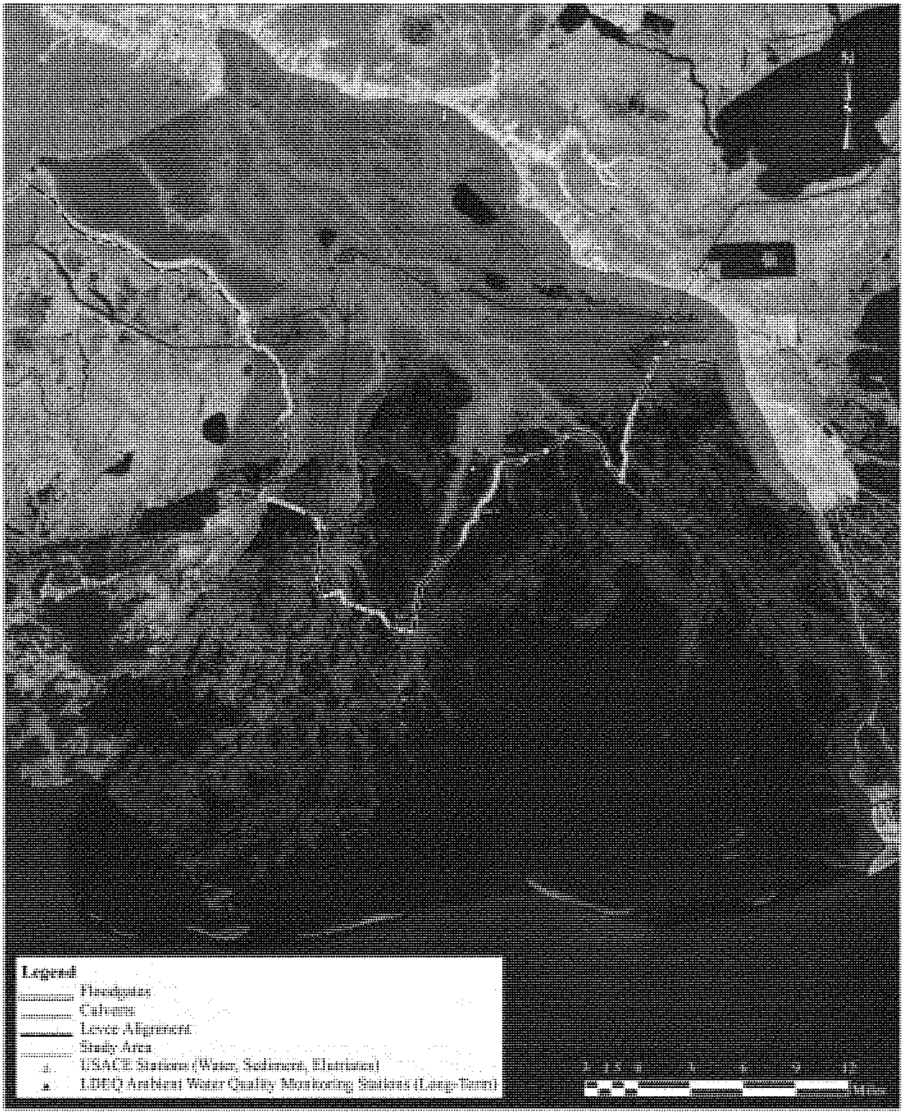


**Figure 95 - Project specific water and sediment sampling sites and LDEQ long term monitoring stations**

The purpose of data collection was to ensure proposed dredged material disposal activities associated with the proposed project do not have adverse environmental effects on the receiving aquatic environment. Disposal of dredged material should not exceed State or Federal water quality criteria outside of the established mixing zone in order to comply with the section 404(b)(1) guidelines and in order to ensure 401 water quality certification. Evaluation of sediment chemistry was performed to determine whether sediment has the potential to result in mortality of mobile benthic organisms. Evaluation of water and elutriate chemistry is typically performed to determine whether the proposed discharge of dredged material effluent exceeds State and/or Federal water quality criteria outside of the State enforced mixing zone, and therefore may result in toxicity to water column organisms. Sample preparation and testing is performed in accordance with the Inland and/or Upland Testing Manual (USEPA 1998; USACE 2003), depending on the proposed dredged material disposal method.

Table 81 displays the chemical classes included in the analysis of sediment, water, and elutriates, the latter of which is a mixture of dredging site water and sediment at proportions intended to replicate those of hydraulic dredging. Up to five (5) herbicides, fourteen (14) inorganic/general chemistry parameters, twenty one (21) metals, twenty four (24) pesticides, seven (7) PCB congeners, nine (9) PAHs, fifty eight (58) semi volatile organic compounds, fifty four (54) volatile organic compounds, and total petroleum hydrocarbons were included in the analyses. As a disclaimer, analysis of elutriates for project specific sampling and analysis does not suggest adjacent borrow would be hydraulically placed for levee construction; in contrast, and as described in section 2.7.1.1.2, material would be mechanically excavated and dewatered prior to placement. Therefore, elutriate test results have little bearing on predicted water column impacts during placement of adjacent borrow for levee fill. In addition, the type of elutriate test conducted (modified elutriate or standard elutriate) was not specified in the laboratory report. In summary, the purpose and type of elutriate testing conducted for this project was not specified, however results of testing is being provided herein.

**Table 81 - Chemical classes included in sediment, water, and elutriate analysis**

| Chemical Class | Sediment | Water | Elutriate |
|---|---|---|---|
| Herbicides | X | X | X |
| Inorganic/General Chemistry | X | X | X |
| Metals | X | X | X |
| Pesticides | X | X | X |
| Polychlorinated Biphenyls | X | X | X |
| Polycyclic Aromatic Hydrocarbons | X | X | X |
| Semi-Volatile Organic Compounds | X | X | X |
| Total Petroleum Hydrocarbons | X | X | X |
| Volatile Organic Compounds | X | X | |

### 2.7.2.1.4.4 Water and Elutriate Quality

Water and elutriate chemistry data was compared with applicable State and Federal water quality criteria to determine whether results exceeded these criteria. Salinity data from LDEQ water quality monitoring stations in proximity to project specific sampling sites was used to estimate the salinity regime of these sites, in order to determine applicable water quality criteria (LDEQ water quality criteria exists for freshwater, brackish, and marine waters, while EPA water quality criteria exists for freshwater and marine waters). Table 82 through Table 85 below display exceedances of water quality criteria for water and elutriates. In most cases, values exceeding criteria are not measured values, but are instead estimates, as results were below the laboratory reporting limit (in other words, the concentration was below that which the laboratory could quantify with confidence).

For freshwater sites (Table 82 and Table 83), the only exceedances for measured values are for copper (Site 1 elutriate), iron (Site 1 elutriate, Site 2 water, Site 12 elutriate and water), lead (Site 1 elutriate, site 12 elutriate), and mercury (site 1 elutriate). These measured elutriate concentrations, which are for exceedances of chronic water quality criteria, are within one order of magnitude of criteria.

Results below the laboratory reporting limit, when estimated as one half of the laboratory reporting limit, exceeded acute criteria for cadmium, p,p'-DDD, and toxaphene, for all freshwater sites and both analytical mediums (water and elutriates), and chronic criteria for cadmium, mercury, p,p'-DDD, p,p'-DDT, endrin, heptachlor, heptachlor epoxide, methoxyclor, toxaphene, and hexachlorobutadiene for all freshwater sites and both analytical mediums.

**Table 82 - Exceedances of water quality criteria for freshwater sites (excludes State hardness dependent metals criteria)**

| | | | Freshwater | | | | | | Water Quality Criteria | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | LDEQ | | EPA | |
| | | | Site 1 | | Site 2 | | Site 12 | | Freshwater | | Freshwater | |
| Chemical Class | Parameter | Units | Elutriate | Water | Elutriate | Water | Elutriate | Water | Acute | Chronic | Acute | Chronic |
| Metals | Cadmium | µg/L | 2.50 | 2.50 | 2.50 | 2.50 | 2.50 | 2.50 | b | | 2 | 0.25 |
| | Copper | µg/L | 17.0 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | b | | | 9 |
| | Iron | µg/L | 1,700 | 930 | 220 | 1,100 | 4,000 | 2,800 | | | | 1,000 |
| | Lead | µg/L | 14.0 | 1.50 | 1.50 | 1.50 | 4.80 | 1.50 | b | | 65 | 2.5 |
| | Mercury | µg/L | 0.220 | 0.100 | 0.100 | 0.100 | 0.100 | 0.100 | 2.04 | 0.012 | 1.4 | 0.77 |
| Pesticides | DDD, p,p'- | µg/L | 0.0500 | 0.0500 | 0.0500 | 0.0500 | 0.0500 | 0.0500 | 0.03 | 0.006 | | |
| | DDT, p,p'- | µg/L | 0.0500 | 0.0500 | 0.0500 | 0.0500 | 0.0500 | 0.0500 | 1.1 | 0.001 | 1.1 | 0.001 |
| | Endrin | µg/L | 0.0500 | 0.0500 | 0.0500 | 0.0500 | 0.0500 | 0.0500 | 0.086 | 0.0375 | 0.086 | 0.036 |
| | Heptachlor | µg/L | 0.0250 | 0.0250 | 0.0250 | 0.0250 | 0.0250 | 0.0250 | 0.52 | 0.0038 | 0.52 | 0.0038 |
| | Heptachlor Epoxide | µg/L | 0.0250 | 0.0250 | 0.0250 | 0.0250 | 0.0250 | 0.0250 | | | 0.52 | 0.0038 |
| | Methoxychlor | µg/L | 0.0500 | 0.0500 | 0.0500 | 0.0500 | 0.0500 | 0.0500 | | | | 0.03 |
| | Toxaphene | µg/L | 0.850 | 0.850 | 0.850 | 0.850 | 0.850 | 0.850 | 0.73 | 0.0002 | 0.73 | 0.0002 |
| Semi-Volatile Organic Compounds | Hexachlorobutadiene | µg/L | 5.00 | 3.75 | 5.00 | 3.75 | 5.00 | 3.75 | 5.1 | 1.02 | | |

**Table 83 - Exceedances of State hardness dependent metals criteria**

| | | Parameter | | | | | | | | | | LDEQ Water Quality Criteria for Metals (Hardness-Dependent for Freshwater/Brackish Criteria) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Cadmium µg/L | | Copper µg/L | | Lead µg/L | | Nickel µg/L | | Zinc µg/L | | Cadmium | | Copper | | Lead | | Nickel | | Zinc | |
| Salinity Regime | Station ID | Elutriate | Water | Elutriate | Water | Elutriate | Water | Elutriate | Water | Elutriate | Water | Acute | Chronic | Acute | Chronic | Acute | Chronic | Acute | Chronic | Acute | Chronic |
| Freshwater | Site 1 | 25 | 2.5 | 17 | 5 | 14 | 1.5 | 16 | 7.5 | 35 | 6 | 22.1 | 0.944 | 14.7 | 10.0 | 29.5 | 2.02 | 1,155 | 128 | 93.4 | 85.3 |

For brackish sites (Table 84 and Table 85), the only measured concentration exceeding criteria was for ammonia (Site 5, elutriate).

Results below the laboratory reporting limit, when estimated as one half of the laboratory reporting limit, exceeded acute criteria for copper, silver, p,p'-DDD, beta-endosulfan, endrin, toxaphene, and hexachlorobutadiene for all brackish sites and both analytical mediums, and chronic criteria for copper, mercury, silver, p,p'-DDD, p,p'-DDT, dieldrin, alpha-endosulfan, beta-endosulfan, endrin, heptachlor, heptachlor epoxide, methoxychlor, toxaphene, and hexachlorobutadiene for all brackish sites and both analytical mediums.

**Table 84 - Exceedances of water quality criteria for brackish sites**

| | | |
|---|---|---|
| [illegible] | [illegible] | [illegible] |

**Table 85 - Exceedances of Federal criteria for ammonia**

| | | Nitrogen, Ammonia mg/L | | Marine | |
|---|---|---|---|---|---|
| Salinity Regime | Station ID | Elutriate | Water | Acute | Chronic |
| Brackish | Site 5 | [illegible] | 0.066 | 25 | 3.7 |

For marine sites (Table 86), no exceedances of measured values were reported. Results below the laboratory reporting limit, when estimated as one half of the laboratory reporting limit, exceeded acute criteria for silver, beta-endosulfan, endrin, toxaphene, and hexachlorobutadiene for all marine sites and both mediums, and chronic criteria for mercury, silver, p,p'-DDT, dieldrin, alpha-endosulfan, beta-endosulfan, endrin, heptachlor, heptachlor epoxide, methoxychlor, toxaphene, and hexachlorobutadiene for all marine sites and both mediums.

**Table 86 - Exceedances of water quality criteria for marine sites**

| | | | Marine | | | | Water Quality Criteria | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | LDEQ | | EPA | |
| | | | Site 7 | | Site 11 | | Marine | | Marine | |
| Chemical Class | Parameter | Units | Elutriate | Water | Elutriate | Water | Acute | Chronic | Acute | Chronic |
| Metals | Mercury | µg/L | 0.100 | 0.260 | 0.100 | 0.100 | 2 | 0.025 | 1.8 | 0.94 |
| | Silver | µg/L | 2.50 | 2.50 | 2.50 | 2.50 | | | 1.9 | |
| Pesticides | DDT, p,p'- | µg/L | 0.0500 | 0.0500 | 0.0500 | 0.0500 | 0.13 | 0.001 | 0.13 | 0.001 |
| | Dieldrin | µg/L | 0.0500 | 0.0500 | 0.0500 | 0.0500 | 0.71 | 0.0019 | 0.71 | 0.0019 |
| | Endosulfan, alpha- | µg/L | 0.0250 | 0.0250 | 0.0250 | 0.0250 | 0.034 | 0.0087 | 0.034 | 0.0087 |
| | Endosulfan, beta- | µg/L | 0.0500 | 0.0500 | 0.0500 | 0.0500 | | | 0.034 | 0.0087 |
| | Endrin | µg/L | 0.0500 | 0.0500 | 0.0500 | 0.0500 | 0.037 | 0.0023 | 0.037 | 0.0023 |
| | Heptachlor | µg/L | 0.0250 | 0.0250 | 0.0250 | 0.0250 | 0.053 | 0.0036 | 0.053 | 0.0036 |
| | Heptachlor Epoxide | µg/L | 0.0250 | 0.0250 | 0.0250 | 0.0250 | | | 0.053 | 0.0036 |
| | Methoxychlor | µg/L | 0.0500 | 0.0500 | 0.0500 | 0.0500 | | | | 0.03 |
| | Toxaphene | µg/L | 0.850 | 0.850 | 0.850 | 0.850 | 0.21 | 0.0002 | 0.21 | 0.0002 |
| Semi-Volatile Organic Compounds | Hexachlorobutadiene | µg/L | 5.00 | 3.75 | 5.00 | 3.75 | 1.6 | 0.32 | | |

## 2.7.2.1.4.5 Sediment Quality

Table 87 through Table 89 displays exceedances of NOAA sediment screening values. In most cases, values exceeding screening values are not measured values, but are instead estimates, as results were below the laboratory reporting limit.

For freshwater sites (Table 87), the measured concentrations for arsenic, copper, nickel, and zinc exceeded freshwater Lowest Effect Level (LEL) screening values at all freshwater sites, while the measured value for mercury at Site 12 exceeded the freshwater LEL screening value.

Results below the laboratory reporting limit, when estimated as one half of the laboratory reporting limit, exceeded sediment screening values at all freshwater sites for the following parameters- antimony, mercury, silver, aldrin, gamma-BHC, p,p'-DDD, p,p'-DDE, p,p'-DDT, dieldrin, endrin, heptachlor epoxide, toxaphene acenaphthene, acenaphthalene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, benzo(k)fluoranthene, phenanthrene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorene, and naphthalene.

## Table 87 - Exceedances of sediment screening values for freshwater sites

| | | | Freshwater | | | NOAA Sediment Screening Values for Freshwater Sediment<br>Predicted Toxicity Gradient — Increasing → | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chemical Class | Parameter | Units | Site 1 | Site 2 | Site 12 | ARCS Hyalella TEL | TEL | TEC | LEL | PEL | PEC | SEL | UET |
| Metals | Antimony | µg/kg | 1,950 | 2,800 | 4,350 | | | | | | | | 3,000 M |
| | Arsenic | µg/kg | 6,600 | 4,400 | 6,400 | 10,798 | 5,900 | 9,790 | 6,000 | 17,000 | 33,000 | 33,000 | 17,000 I |
| | Copper | µg/kg | 21,100 | 16,300 | 31,700 | 28,012 | 35,700 | 31,600 | 16,000 | 197,000 | 149,000 | 110,000 | 86,000 I |
| | Mercury | µg/kg | 55.0 | 75.0 | 255 | | 174 | 180 | 200 | 486 | 1,060 | 2,000 | 560 M |
| | Nickel | µg/kg | 19,600 | 16,000 | 25,600 | 19,514 | 18,000 | 22,700 | 16,000 | 36,000 | 48,600 | 75,000 | 43,000 H |
| | Silver | µg/kg | 325 | 465 | 800 | | | | 500 | | | | 4,500 H |
| | Zinc | µg/kg | 81,500 | 61,100 | 152,000 | 98,000 | 123,000 | 121,000 | 120,000 | 315,000 | 459,000 | 820,000 | 520,000 M |
| Pesticides | Aldrin | µg/kg | 1.15 | 1.60 | 2.75 | | | | 2.00 | | | 80.0 | 40.0 I |
| | BHC, gamma- | µg/kg | 1.15 | 1.60 | 2.75 | | 0.940 | 2.37 | 3.00 | 1.38 | 4.99 | 10.0 | 9.00 I |
| | DDD, p,p'- | µg/kg | 2.25 | 3.10 | 5.35 | | 3.54 | 4.88 | 8.00 | 8.51 | 28.0 | 60.0 | 60.0 I |
| | DDE, p,p'- | µg/kg | 2.25 | 3.10 | 5.35 | | 1.42 | 3.16 | 5.00 | 6.75 | 31.3 | 190 | 50.0 I |
| | DDT, p,p'- | µg/kg | 2.25 | 3.10 | 5.35 | | 1.19 c | 4.16 | 8.00 | 4.77 c | 62.9 | 710 | 50.0 I |
| | Dieldrin | µg/kg | 2.25 | 3.10 | 5.35 | | 2.85 | 1.90 | 2.00 | 6.67 | 61.8 | 910 | 300 I |
| | Endrin | µg/kg | 2.25 | 3.10 | 5.35 | | 2.67 | 2.22 | 3.00 | 62.4 | 207 | 1,300 | 500 I |
| | Heptachlor Epoxide | µg/kg | 1.15 | 1.60 | 2.75 | | 0.600 | 2.47 | 5.00 | 2.74 | 16.0 | 50.0 | 30.0 I |
| | Toxaphene | µg/kg | 22.4 | 31.2 | 53.5 | | 0.100 c | | | | | | |
| Polycyclic Aromatic Hydrocarbons | Acenaphthene | µg/kg | 224 | 312 | 535 | | 6.71 c | | | 88.9 c | | | 290 M |
| | Acenaphthylene | µg/kg | 224 | 312 | 535 | | 5.87 c | | | 128 c | | | |
| | Anthracene | µg/kg | 224 | 312 | 535 | 10.0 | 46.9 c | 57.2 | 220 | 245 c | 845 | 3,700 | 260 M |
| | Benzo(a)anthracene | µg/kg | 224 | 312 | 535 | 15.7 | 31.7 | 108 | 320 | 385 | 1,050 | 14,800 | 500 I |
| | Benzo(a)pyrene | µg/kg | 224 | 312 | 535 | 32.4 | 31.9 | 150 | 370 | 782 | 1,450 | 14,400 | 700 I |
| | Benzo(g,h,i)perylene | µg/kg | 224 | 312 | 535 | | | | 170 | | | 3,200 | 300 M |
| | Benzo(k)fluoranthene | µg/kg | 224 | 312 | 535 | 27.2 | | | 240 | | | 13,400 | 13,400 B |
| | Phenanthrene | µg/kg | 224 | 312 | 535 | 18.7 | 41.9 | 204 | 560 | 515 | 1,170 | 9,500 | 800 I |
| Semi-Volatile Organic Compounds | Chrysene | µg/kg | 224 | 312 | 535 | 26.8 | 57.1 | 166 | 340 | 862 | 1,290 | 4,600 | 800 I |
| | Dibenzo(a,h)anthracene | µg/kg | 224 | 312 | 535 | 10.0 | 6.22 c | 33.0 | 60.0 | 135 c | | 1,300 | 100 M |
| | Fluoranthene | µg/kg | 224 | 312 | 535 | 31.5 | 111 | 423 | 750 | 2,355 | 2,230 | 10,200 | 1,500 M |
| | Fluorene | µg/kg | 224 | 312 | 535 | 10.0 | 21.2 c | 77.4 | 190 | 144 c | 536 | 1,600 | 300 M |
| | Naphthalene | µg/kg | 113 | 157 | 271 | 14.7 | 34.6 c | 176 | | 391 c | 561 | | 600 I |

For brackish sites (Table 88), sediment screening values were exceeded for measured or estimated (j-flagged, not below the laboratory reporting limit) concentrations of aluminum (AET at all sites), antimony (T20 at sites 8, 9, and 10; T50 at sites 3, 4, and 5), arsenic (ERL at Site 9), barium (TEL at sites 3, 4, 5, 6, 9, and 10), cobalt (AET at Site 9), copper (TEL at sites 3, 4, and 5; ERL at Site 6), manganese (AET at sites 3, 4, 6, 8, 9, and 10), nickel (TEL at sites 3, 4, 8, and 10; ERL at sites 5, 6, and 9), zinc (T20 at sites 4, 5, and 6; TEL at Site 3), benzo(a)anthracene (ERL at Site 3), benzo(a)pyrene (T50 at Site 3), benzo(b)fluoranthene (T20 at sites 4 and 8; T50 at Site 3), benzo(g,h,i)perylene (T20 at Site 3), phenanthrene (PEL at Site 5), chrysene (ERL at Site 3), fluoranthene (TEL at sites 3 and 6), pyrene (ERL at Site 3; TEL at Site 6), and Indeno(1,2,3-cd)pyrene (T20 at Site 3). With the exception of the measured phenanthrene concentration for Site 5, no measured values exceeded PEL or ERM screening values.

Results below the laboratory reporting limit, when estimated as one half of the laboratory reporting limit, exceeded sediment screening values at all brackish sites for the following parameters- mercury, silver, gamma-BHC, p,p'-DDD, p,p'-DDE, p,p'-DDT, dieldrin, heptachlor, heptachlor epoxide, toxaphene, acenaphthene, acenaphthylene, anthracene, benzo(k)fluoranthene, benzoic acid, benzyl alcohol, bis(2-ethylhexyl) phthalate, butyl benzyl phthalate, o-cresol, p-cresol, dibenzo(a,h)anthracene, dibenzofuran, 2,4-dimethylphenol, fluorine, hexachlorobenzene, 2-methylnaphthalene, naphthalene, nitrobenzene, and n-nitrosodiphenylamine. For benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, phenanthrene, chrysene, fluoranthene, pyrene, and indeno(1,2,3-cd)pyrene, estimated concentrations for sites with results below the laboratory reporting limit also exceeded sediment screening values.

**Table 88 - Exceedances of sediment screening values for brackish sites**

| Chemical Class | Parameter | Units | Brackish Site 3 | Site 4 | Site 5 | Site 6 | Site 8 | Site 9 | Site 10 | NOAA Sediment Screening Values for Marine Sediment (Predicted Toxicity Gradient — Increasing) T20 | TEL | ERL | T50 | PEL | ERM | AET | Eco Tox EqP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Metals | Aluminum | µg/kg | 11,400,000 | 12,100,000 | 16,200,000 | 12,800,000 | 6,390,000 | 12,200,000 | 9,020,000 | | | | | | | 0.0180 N | |
| | Antimony | µg/kg | 2,850 | 3,200 | 5,250 | 2,600 | 1,800 | 1,900 | 1,900 | 630 | | | 2,400 | | | 9,300 E | |
| | Arsenic | µg/kg | 5,500 | 3,300 | 4,500 | 6,800 | 4,000 | 16,200 | 6,100 | 7,400 | 7,240 | 8,200 | 20,000 | 41,600 | 70,000 | 35,000 B | |
| | Barium | µg/kg | 313,000 | 181,000 | 212,000 | 375,000 | 106,000 | 359,000 | 322,000 | | 130,100 # | | | | | | |
| | Cobalt | µg/kg | 8,300 | 5,400 | 8,900 | 9,000 | 6,500 | 23,600 | 6,700 | | | | | | | 10,000 N | |
| | Copper | µg/kg | 22,400 | 21,400 | 23,600 | 28,700 | 10,300 | 16,600 | 16,300 | 32,000 | 18,700 | 34,000 | 94,000 | 108,000 | 270,000 | 390,000 MO | |
| | Manganese | µg/kg | 395,000 | 383,000 | 253,000 | 678,000 | 519,000 | 1,100,000 | 349,000 | | | | | | | 260,000 N | |
| | Mercury | µg/kg | 85.0 | 90.0 | 140 | 75.0 | 55.0 | 60.0 | 55.0 | 140 | 130 | 150 | 480 | 700 | 710 | 410 M | |
| | Nickel | µg/kg | 17,600 | 17,100 | 23,100 | 21,900 | 15,900 | 25,000 | 17,200 | 15,000 | 15,900 | 20,900 | 47,000 | 42,800 | 51,600 | 110,000 EL | |
| | Silver | µg/kg | 475 | 530 | 800 | 430 | 308 | 330 | 315 | 230 | 730 | 1,000 | 1,100 | 1,770 | 3,700 | 3,100 B | |
| | Zinc | µg/kg | 128,000 | 108,000 | 121,000 | 115,000 | 70,300 | 71,400 | 76,600 | 94,000 | 124,000 | 150,000 | 245,000 | 271,000 | 410,000 | 410,000 I | |
| Pesticides | BHC, gamma- | µg/kg | 1.80 | 1.95 | 2.95 | 1.60 | 1.15 | 1.25 | 1.20 | | 0.320 | | | 0.990 | | 4.80 N | 3.70 |
| | DDD, p,p'- | µg/kg | 3.55 | 3.80 | 5.75 | 3.05 | 2.25 | 2.40 | 2.30 | | 1.22 | 2.00 | | 7.81 | 20.0 | 16.0 I | |
| | DDE, p,p'- | µg/kg | 3.55 | 3.80 | 5.75 | 3.05 | 2.25 | 2.40 | 2.30 | | 2.07 | 2.20 | | 374 | 27.0 | 9.00 I | |
| | DDT, p,p'- | µg/kg | 3.55 | 3.80 | 5.75 | 3.05 | 2.25 | 2.40 | 2.30 | | 1.19 | 1.00 | | 4.77 | 7.00 | 12.0 E | |
| | Dieldrin | µg/kg | 3.55 | 3.80 | 5.75 | 3.05 | 2.25 | 2.40 | 2.30 | 0.830 | 0.720 | 0.0200 | 2.90 | 4.30 | 8.00 | 1.90 E | |
| | Heptachlor | µg/kg | 1.80 | 1.95 | 2.95 | 1.60 | 1.15 | 1.25 | 1.20 | | | | | | | 0.300 B | |
| | Heptachlor Epoxide | µg/kg | 1.80 | 1.95 | 2.95 | 1.60 | 1.15 | 1.25 | 1.20 | 0.600 c | | | | 2.74 c | | | |
| | Toxaphene | µg/kg | 35.5 | 38.0 | 57.5 | 30.6 | 22.5 | 24.1 | 22.9 | | 0.100 c | | | | | | 28.0 |
| Polycyclic Aromatic Hydrocarbons | Acenaphthene | µg/kg | 353 | 380 | 575 | 306 | 225 | 241 | 229 | 19.0 | 6.71 | 16.0 | 116 | 88.9 | 500 | 130 E | |
| | Acenaphthylene | µg/kg | 353 | 380 | 575 | 306 | 225 | 241 | 229 | 14.0 | 5.87 | 44.0 | 140 | 128 | 640 | 71.0 E | |
| | Anthracene | µg/kg | 353 | 380 | 575 | 306 | 225 | 241 | 229 | 34.0 | 46.9 | 85.3 | 290 | 245 | 1,100 | 280 E | |
| | Benzo(a)anthracene | µg/kg | 288 | 380 | 575 | 306 | 225 | 241 | 229 | 61.0 | 74.8 | 261 | 466 | 693 | 1,600 | 960 E | |
| | Benzo(a)pyrene | µg/kg | 637 | 380 | 575 | 306 | 225 | 241 | 229 | 69.0 | 88.8 | 430 | 520 | 763 | 1,600 | 1,100 E | |
| | Benzo(b)fluoranthene | µg/kg | 1,130 | 182 | 575 | 306 | 185 | 241 | 229 | 130 | | | 1,107 | | | 1,800 EI | |
| | Benzo(g,h,i)perylene | µg/kg | 292 | 380 | 575 | 306 | 225 | 241 | 229 | 67.0 | | | 497 | | | 670 M | |
| | Benzo(k)fluoranthene | µg/kg | 366 | 380 | 575 | 306 | 225 | 241 | 229 | 70.0 | | | 537 | | | 1,800 EI | |
| | Phenanthrene | µg/kg | 142 | 380 | 575 | 306 | 225 | 241 | 229 | 68.0 | 86.7 | 240 | 455 | 544 | 1,500 | 660 E | |
| Semi-Volatile Organic Compounds | Benzoic Acid | µg/kg | 353 | 380 | 575 | 306 | 225 | 241 | 229 | | | | | | | 65.0 O | |
| | Benzyl Alcohol | µg/kg | 353 | 380 | 575 | 306 | 225 | 241 | 229 | | | | | | | 52.0 B | |
| | Bis(2-Ethylhexyl) Phthalate | µg/kg | 353 | 380 | 575 | 306 | 225 | 241 | 229 | | 182 | | | 2,647 | | 1,300 I | |
| | Butyl Benzyl Phthalate | µg/kg | 353 | 380 | 575 | 306 | 225 | 241 | 229 | | | | | | | 63.0 M | 1,100 |
| | Chrysene | µg/kg | 476 | 380 | 575 | 306 | 225 | 241 | 229 | 82.0 | 108 | 384 | 650 | 846 | 2,800 | 950 E | |
| | Cresol, o- | µg/kg | 353 | 380 | 575 | 306 | 225 | 241 | 229 | | | | | | | 8.00 B | |
| | Cresol, p- | µg/kg | 353 | 380 | 575 | 306 | 225 | 241 | 229 | | | | | | | 100 B | |
| | Dibenzo(a,h)anthracene | µg/kg | 353 | 380 | 575 | 306 | 225 | 241 | 229 | 19.0 | 6.22 | 63.4 | 113 | 135 | 260 | 230 OM | |
| | Dibenzofuran | µg/kg | 353 | 380 | 575 | 306 | 225 | 241 | 229 | | | | | | | 110 E | 2,000 |
| | Dimethylphenol, 2,4- | µg/kg | 353 | 380 | 575 | 306 | 225 | 241 | 229 | | | | | | | 18.0 N | |
| | Fluoranthene | µg/kg | 591 | 380 | 575 | 124 | 225 | 241 | 229 | 119 | 113 | 600 | 1,034 | 1,494 | 5,100 | 1,300 E | |
| | Fluorene | µg/kg | 353 | 380 | 575 | 306 | 225 | 241 | 229 | 19.0 | 21.2 | 19.0 | 114 | 144 | 540 | 120 E | 540 |
| | Hexachlorobenzene | µg/kg | 353 | 380 | 575 | 306 | 225 | 241 | 229 | | | | | | | 6.00 B | |
| | Methylnaphthalene, 2- | µg/kg | 353 | 380 | 575 | 306 | 225 | 241 | 229 | 21.0 | 20.2 | 70.0 | 128 | 201 | 670 | 64.0 E | |
| | Naphthalene | µg/kg | 179 | 193 | 288 | 155 | 114 | 122 | 116 | 30.0 | 34.6 | 160 | 217 | 391 | 2,100 | 230 E | 480 |
| | Nitrobenzene | µg/kg | 353 | 380 | 575 | 306 | 225 | 241 | 229 | | | | | | | 21.0 N | |
| | N-Nitrosodiphenylamine | µg/kg | 353 | 380 | 575 | 306 | 225 | 241 | 229 | | | | | | | 28.0 I | |
| | Pyrene | µg/kg | 796 | 380 | 575 | 198 | 225 | 241 | 229 | 125 | 153 | 665 | 932 | 1,398 | 2,600 | 2,400 E | |
| | Pyrene, Indeno (1,2,3-cd) | µg/kg | 345 | 380 | 575 | 306 | 225 | 241 | 229 | 68.0 | | | 488 | | | 600 M | |

For marine sites (Table 89), sediment screening values were exceeded for measured concentrations of aluminum (T20 at Site 11; T50 at Site 7), arsenic (ERL at Site 11), barium (TEL at Site 11), cobalt (AET at Site 11), copper (TEL at both sites), manganese (AET at both sites), and nickel (ERL at both sites), and for the estimated (j-flagged, not below the laboratory reporting limit) concentration of butyl benzyl phthalate at Site 7. No measured values exceeded PEL or ERM screening values.

Results below the laboratory reporting limit, when estimated as one half of the laboratory reporting limit, exceeded sediment screening values at both marine sites for the following parameters- silver, gamma-BHC, p,p'-DDD, p,p'-DDE, p,p'-DDT, dieldrin, heptachlor, heptachlor epoxide, toxaphene, acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, phenanthrene, benzoic acid, benzyl alcohol, bis(2-ethylhexyl) phthalate, butyl benzyl phthalate, o-cresol, p-cresol, dibenzo(a,h)anthracene, dibenzofuran, 2,4-dimethylphenol, fluoranthene, fluorene, hexachlorobenzene, 2-methylnaphthalene, naphthalene, nitrobenzene, n-nitrosodiphenylamine, pyrene, and indeno(1,2,3-cd)pyrene. The concentration for butyl benzyl phthalate at Site 11, when estimated as one-half of the laboratory reporting limit, also exceeded the AET screening value.

**Table 89 - Exceedances of sediment screening values for marine sites**

| | | | Marine | | NOAA Sediment Screening Values for Marine Sediment — Predicted Toxicity Gradient — Increasing → | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chemical Class | Parameter | Units | Site 7 | Site 11 | T20 | TEL | ERL | T50 | PEL | ERM | AET | Eco Tox EqP |
| Metals | Aluminum | µg/kg | 8,770,000 | 14,100,000 | | | | | | | 0.0180 N | |
| | Antimony | µg/kg | 4,100 | 2,200 | 630 | | | 2,400 | | | 9,300 E | |
| | Arsenic | µg/kg | 4,500 | 10,300 | 7,400 | 7,240 | 8,200 | 20,000 | 41,600 | 70,000 | 35,000 B | |
| | Barium | µg/kg | 95,500 | 201,000 | | 130,100 # | | | | | | |
| | Cobalt | µg/kg | 7,200 | 10,900 | | | | | | | 10,000 N | |
| | Copper | µg/kg | 20,600 | 22,200 | 32,000 | 18,700 | 34,000 | 94,000 | 108,000 | 270,000 | 390,000 MO | |
| | Manganese | µg/kg | 307,000 | 630,000 | | | | | | | 260,000 N | |
| | Nickel | µg/kg | 35,200 | 26,400 | 15,000 | 15,900 | 20,900 | 47,000 | 42,800 | 51,600 | 110,000 EL | |
| | Silver | µg/kg | 700 | 365 | 230 | 730 | 1,000 | 1,100 | 1,770 | 3,700 | 3,100 B | |
| Pesticides | BHC, gamma- | µg/kg | 2.30 | 1.25 | | 0.320 | | | 0.990 | | 4.80 N | 3.70 |
| | DDD, p,p'- | µg/kg | 4.50 | 2.40 | | 1.22 | 2.00 | | 7.81 | 20.0 | 16.0 I | |
| | DDE, p,p'- | µg/kg | 4.50 | 2.40 | | 2.07 | 2.20 | | 374 | 27.0 | 9.00 I | |
| | DDT, p,p'- | µg/kg | 4.50 | 2.40 | | 1.19 | 1.00 | | 4.77 | 7.00 | 12.0 E | |
| | Dieldrin | µg/kg | 4.50 | 2.40 | 0.830 | 0.720 | 0.0200 | 2.90 | 4.30 | 8.00 | 1.90 E | |
| | Heptachlor | µg/kg | 2.30 | 1.25 | | | | | | | 0.300 B | |
| | Heptachlor Epoxide | µg/kg | 2.30 | 1.25 | 0.600 c | | | | 2.74 c | | | |
| | Toxaphene | µg/kg | 45.1 | 24.1 | | 0.100 c | | | | | | 28.0 |
| Polycyclic Aromatic Hydrocarbons | Acenaphthene | µg/kg | 451 | 241 | 19.0 | 6.71 | 16.0 | 116 | 88.9 | 500 | 130 E | |
| | Acenaphthylene | µg/kg | 451 | 241 | 14.0 | 5.87 | 44.0 | 140 | 128 | 640 | 71.0 E | |
| | Anthracene | µg/kg | 451 | 241 | 34.0 | 46.9 | 85.3 | 290 | 245 | 1,100 | 280 E | |
| | Benzo(a)anthracene | µg/kg | 451 | 241 | 61.0 | 74.8 | 261 | 466 | 693 | 1,600 | 960 E | |
| | Benzo(a)pyrene | µg/kg | 451 | 241 | 69.0 | 88.8 | 430 | 520 | 763 | 1,600 | 1,100 E | |
| | Benzo(b)fluoranthene | µg/kg | 451 | 241 | 130 | | | 1,107 | | | 1,800 EI | |
| | Benzo(g,h,i)perylene | µg/kg | 451 | 241 | 67.0 | | | 497 | | | 670 M | |
| | Benzo(k)fluoranthene | µg/kg | 451 | 241 | 70.0 | | | 537 | | | 1,800 EI | |
| | Phenanthrene | µg/kg | 451 | 241 | 68.0 | 86.7 | 240 | 455 | 544 | 1,500 | 660 E | |
| Semi-Volatile Organic Compounds | Benzoic Acid | µg/kg | 451 | 241 | | | | | | | 65.0 O | |
| | Benzyl Alcohol | µg/kg | 451 | 241 | | | | | | | 52.0 B | |
| | Bis(2-Ethylhexyl) Phthalate | µg/kg | 382 | 144 | | 182 | | | 2,647 | | 1,300 I | |
| | Butyl Benzyl Phthalate | µg/kg | 551 | 241 | | | | | | | 63.0 M | 1,100 |
| | Chrysene | µg/kg | 451 | 241 | 82.0 | 108 | 384 | 650 | 846 | 2,800 | 950 E | |
| | Cresol, o- | µg/kg | 451 | 241 | | | | | | | 8.00 B | |
| | Cresol, p- | µg/kg | 451 | 241 | | | | | | | 100 B | |
| | Dibenzo(a,h)anthracene | µg/kg | 451 | 241 | 19.0 | 6.22 | 63.4 | 113 | 135 | 260 | 230 OM | |
| | Dibenzofuran | µg/kg | 451 | 241 | | | | | | | 110 E | 2,000 |
| | Dimethylphenol, 2,4- | µg/kg | 451 | 241 | | | | | | | 18.0 N | |
| | Fluoranthene | µg/kg | 451 | 241 | 119 | 113 | 600 | 1,034 | 1,494 | 5,100 | 1,300 E | |
| | Fluorene | µg/kg | 451 | 241 | 19.0 | 21.2 | 19.0 | 114 | 144 | 540 | 120 E | 540 |
| | Hexachlorobenzene | µg/kg | 451 | 241 | | | | | | | 6.00 B | |
| | Methylnaphthalene, 2- | µg/kg | 451 | 241 | 21.0 | 20.2 | 70.0 | 128 | 201 | 670 | 64.0 E | |
| | Naphthalene | µg/kg | 228 | 122 | 30.0 | 34.6 | 160 | 217 | 391 | 2,100 | 230 E | 480 |
| | Nitrobenzene | µg/kg | 451 | 241 | | | | | | | 21.0 M | |
| | N-Nitrosodiphenylamine | µg/kg | 451 | 241 | | | | | | | 28.0 I | |
| | Pyrene | µg/kg | 451 | 241 | 125 | 153 | 665 | 932 | 1,398 | 2,600 | 2,400 E | |
| | Pyrene, Indeno (1,2,3-cd) | µg/kg | 451 | 241 | 68.0 | | | 488 | | | 600 M | |

### 2.7.2.2 Environmental Consequences

#### 2.7.2.2.1 Future without Project Conditions

Without the proposed MTG hurricane risk reduction project, the study area would still be affected by natural and man induced activities that would have beneficial and detrimental impacts to water quality. Some of these activities include: other Federal, state, local, and private restoration efforts such as CWPPRA, USACE ecosystem restoration projects, various NRCS programs (e.g., Coastal Wetlands Restoration Program), and LDNR projects; state and local water quality management programs; national level programs to address hypoxia in the northern Gulf of Mexico; the continued erosion/subsidence of the coast; oil and gas development; industrial, commercial, and residential development; and Federal, State, and municipal navigation and flood damage reduction projects.

### 2.7.2.2.2 Future with Project Conditions

#### 2.7.2.2.2.1 Direct Impacts

As the proposed project entails construction of approximately 93 miles of levee, the footprint for 78 miles of which includes existing hydraulic features within the study area, and the remaining 15 miles of which includes wetlands and open water, it would have significant direct impacts for area within the proposed footprint which currently consists of wetlands and open water. These areas would be converted into upland habitat, and would no longer provide for water quality. As coastal wetlands are known to benefit water quality, for example, as a source or sink for constituents, these benefits would no longer exist within the proposed levee footprint.

In addition, direct impacts as a result of construction activities are anticipated. The excavation and placement of borrow material for levee fill, as well as dredging and dredged material placement activities associated with flotation access channel construction, would result in localized increases in turbidity and suspended solids, at both the dredging and placement sites. Sediment chemistry for sample sites representative of adjacent borrow indicate the presence of low level contamination in some sediments proposed for use as levee fill. Because the method of excavation and placement (mechanical dredging) minimizes water column impacts from placement activities, and includes dewatering, it is not anticipated that the use of adjacent borrow for levee fill would have significant impacts on the receiving aquatic environment. In addition, because adjacent borrow material is expected to have characteristics similar to sediments present at the proposed placement sites, no significant changes in sediment quality at the placement sites are anticipated.

Construction of structures (i.e., floodgates, tidal exchange structures, and the locks) would result in localized increases in turbidity associated with runoff of construction materials. To minimize construction related impacts, it is anticipated that a Stormwater Pollution Prevention Plan (SWPPP) shall be implemented for construction activities. SWPPPs shall be prepared in accordance with good engineering practices emphasizing storm water Best Management Practices and complying with Best Available Technology Economically Achievable and Best Conventional Pollutant Control Technology. The SWPPP shall identify potential sources of pollution, which may reasonably be expected to affect storm water discharges associated with the construction activity. In addition, the SWPPP shall describe and ensure the implementation of practices which are to be used to reduce pollutants in storm water discharges associated with the construction activity and to assure compliance with the terms and conditions of this permit (USEPA 2012).

#### 2.7.2.2.2.2 **Indirect Impacts**

The proposed hurricane risk reduction project could have significant indirect impacts on study area water quality, the extent to which is largely unknown. Based on historical water quality information for the study area, it is clear that a majority of the water quality problems within the study area occur on the protected side of the proposed levee alignment. Although McAlpin et. al (2010) suggests that proper management of tidal exchange structures can minimize changes in flow and water level between the flood and protected side of the proposed levee alignment , it is a legitimate concern that the proposed alignment will cause significant alteration of hydrology and hydraulics in the study area, such that water exchange between the protected and flood sides of the proposed levee alignment is significantly inhibited, and that localized areas of stagnation behind the levee alignment may occur. If these conditions present themselves, the levee alignment would serve as a barrier between relatively free of contamination Gulf of Mexico waters and impaired waters, further exacerbating water quality conditions on the protected side of the alignment. Moreover, the potential expansion of developed areas as a result of the project could lead to additional point and nonpoint discharges within the hurricane risk reduction system, which would further degrade water quality on the protected side of the propose alignment. Also, as sea level rise increases water levels in the study area, the frequency with which tidal structures are closed would be expected to increase, causing further stagnation for waters on the protected side of the proposed levee alignment.

The proposed project could also prevent the introduction of mineral sediments from the flood side to the protected side. Mineral sediments are known to stimulate the growth of marsh vegetation, and input of mineral sediments associated with tropical activity can raise ground elevations, helping marshes to keep pace vertically with sea level rise. A lack of sediment input to the protected side of the proposed levee system could lead to the conversion of marsh substrate to predominantly organic substrate, creating a situation similar to that which occurs in areas subject to river water influx without mineral sediment input, such as portions of the Penchant Basin which receives Atchafalaya River water input and the marsh area beyond Big Mar which receives river water input via the Caernarvon Freshwater Diversion (Swarzenski et. al 2008). This could make marshes more vulnerable to erosional forces, leading to a further reduction in water quality on the protected side of the proposed levee alignment.

A major potential benefit of the project is that it would provide for the protection of marshes on the flood side of the proposed levee alignment, potentially extending the lifespan of these marshes. However, the marshes just outside of the hurricane risk reduction system are expected to be subjected to an increase in wave energy as a result of the proposed project, which could lead to the accelerated loss of unprotected marsh vegetation. This detracts from rationale for utilizing the topmost organic sediment layer of adjacent levee borrow areas for marsh construction on the flood side of the proposed levee alignment. All of these impacts to wetlands habitat would affect water quality, for reasons stated in section 2.7.1.1.3.

###### 2.7.2.2.2.3 Cumulative Impacts

The proposed project, combined with other coastal activities (such as those included in the discussion of future without project conditions) would cumulatively impact study area water quality. In addition, it is foreseeable that the proposed project may impact the attainment of state water quality standards in the study area, leading to changes in regulation of point and nonpoint source discharges within the area, particularly on the protected side of the proposed hurricane risk reduction alignment.

## 2.8 Other Studies – Eastern Tie-In Levee and C-North Levee Section

### 2.8.1 Background

Initially, it was proposed for levee Reach L of the authorized Morganza to the Gulf alignment to terminate at the connection to an existing levee of an adjacent study- the Larose to Golden Meadow Project. However, our most recent findings from the current MTG surge analysis results, which were completed after the 2002 report, indicates the existing levees in the LGM system will be flanked by surge, if the LGM levees are not raised to the same level of protection that will be provided by the construction of the MTG levees. Similar to MTG, the LGM project is currently completing a post authorization change report which is scheduled to be completed after the MTG report. At this time, the future levee elevations have not been finalized. The LGM project is not authorized to be raised to the same level of protection of the MTG study.
In order to resolve this issue, refinements have been made to the MTG alignment to prevent overtopping of the LGM levee and to also provide additional protection from storm surge from the Barataria Basin. Reach L of the MTG study has been extended northwest along the existing LGM study alignment (referred to as "Larose C-North Reach 1") and further north to Lockport (referred to as the "Lockport to Larose Reach"). The extended alignment is shown on Figure 96. The Lockport to Larose Reach follows an alignment formerly proposed under the Donaldsonville to the Gulf Feasibility Study which was determined to be economically feasible. The Lockport reach will protect the MTG study area from surges from the Barataria Basin but could be overtopped in future due to relative sea level rise. The following section details the design for the two levee reaches required to provide a continuous enclosed barrier to protect the MTG study

area from hurricane surge.

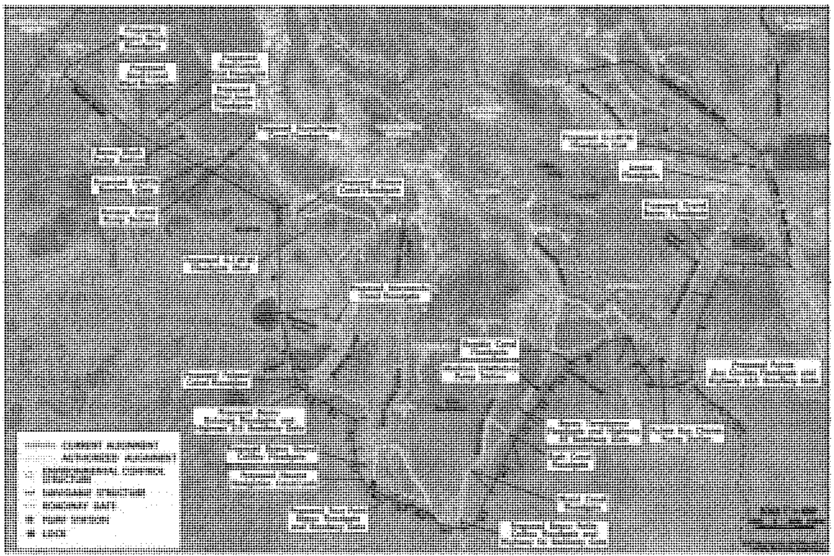

Figure 96 – Morganza to the Gulf Levee Reaches

### 2.8.2 Methodology

The Larose C-North reach was subdivided into two hydraulic reaches. The western portion of the reach remained Larose C-North and the northern portion of the reach was renamed the GIWW reach. The Larose to Lockport reach was subdivided in two hydraulic reaches as well. The new reaches were renamed to Lockport to Larose (a) and Lockport to Larose (b). The new reach designations are shown in Figure 97.

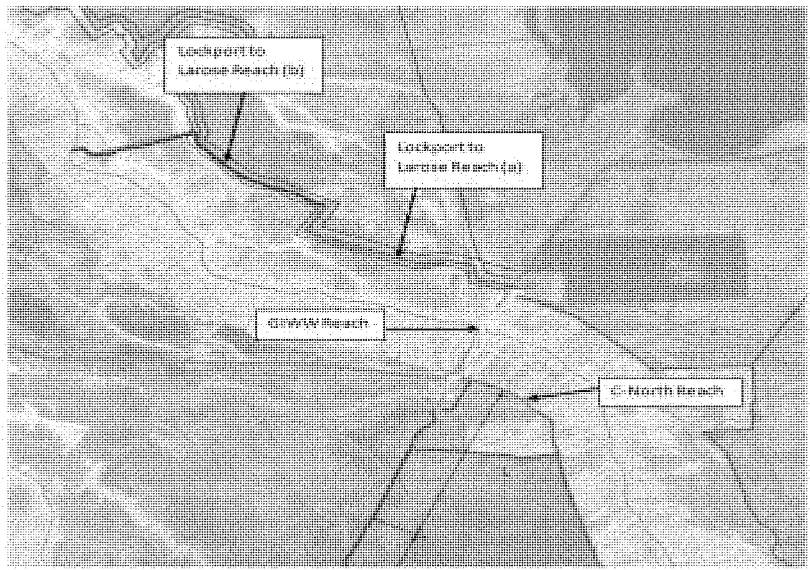


**Figure 97– Hydraulic Reaches**

Using the 2010 Morganza to the Gulf ADCIRC base hydraulic boundary conditions (for the Larose C-North reach) and the 2010 West Shore Lake Pontchartrain ADCIRC base hydraulic boundary conditions (for the GIWW, Lockport to Larose (a), and Lockport to Larose (b) reaches) along with the intermediate sea level rise rate of 0.03 ft/yr (eustatic + subsidence) previously used for the other Morganza to the Gulf levee reaches, the 2035 and 2085 hydraulic boundary conditions were then determined.

First, the 2010 base hydraulic boundary conditions results from the models were found.

### Table 90 - ADCIRC Base Still Water Levels from model results

| 2010 ADCIRC Base Model Results Mean Still Water Levels At Varying Return Periods | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Levee Reach | 2010 ADCIRC Point ID | 10% (10 Year) Mean Still Water Level (ft) | Std. Dev. | 2% (50 Year) Mean Still Water Level (ft) | Std. Dev. | 1% (100 Year) Mean Still Water Level (ft) | Std. Dev. | 0.2% (500 Year) Mean Still Water Level (ft) | Std. Dev. |
| GIWW | 3 | 4.2 | 0.1 | 7 | 0.35 | 8.4 | 0.5 | 10.9 | 0.9 |
| C-North | 171 | 6.4 | 0.4 | 9.5 | 1.2 | 13.2 | 1.5 | 18 | 2.3 |
| Lockport to Larose (a) | 1 | 4.3 | 0.1 | 6.6 | 0.35 | 7.9 | 0.5 | 9.8 | 0.9 |
| Lockport to Larose (b) | 2 | 4 | 0.1 | 5.7 | 0.35 | 6.7 | 0.5 | 8.2 | 0.9 |

### Table 91 – ADCIRC Base Wave Heights from model results

| 2010 ADCIRC Base Model Results Wave Heights At Varying Return Periods | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Levee Reach | 2010 ADCIRC Point ID | 10% (10 Year) Wave Height (ft) | Std. Dev. | 2% (50 Year) Wave Height (ft) | Std. Dev. | 1% (100 Year) Wave Height (ft) | Std. Dev. | 0.2% (500 Year) Wave Height (ft) | Std. Dev. |
| GIWW | 3 | 0.7 | 0.07 | 1 | 0.10 | 1.5 | 0.15 | 2.3 | 0.23 |
| C-North | 171 | 1 | 0.10 | 1.2 | 0.12 | 2.3 | 0.23 | 4.1 | 0.41 |
| Lockport to Larose (a) | 1 | 2.1 | 0.21 | 3 | 0.30 | 4 | 0.40 | 5.4 | 0.54 |
| Lockport to Larose (b) | 2 | 1.3 | 0.13 | 1.8 | 0.18 | 2.5 | 0.25 | 3.7 | 0.37 |

**Table 92 – ADCIRC Base Wave Periods from model results**

| 2010 ADCIRC Base Model Results Wave Periods At Varying Return Periods | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Levee Reach | 2010 ADCIRC Point ID | 10% (10 Year) Wave Period (s) | Std. Dev. | 2% (50 Year) Wave Period (s) | Std. Dev. | 1% (100 Year) Wave Period (s) | Std. Dev. | 0.2% (500 Year) Wave Period(s) | Std. Dev. |
| GIWW | 3 | 0.9 | 0.18 | 1.3 | 0.26 | 3 | 0.60 | 4.8 | 0.96 |
| C-North | 171 | 5.1 | 1.02 | 5.2 | 1.04 | 5.5 | 1.10 | 5.8 | 1.16 |
| Lockport to Larose (a) | 1 | 2.9 | 0.58 | 4.1 | 0.82 | 4.8 | 0.96 | 5.6 | 1.12 |
| Lockport to Larose (b) | 2 | 2.9 | 0.58 | 4.2 | 0.84 | 5 | 1.00 | 6.1 | 1.22 |

The base hydraulic boundary conditions were then plotted to find the base hydraulic boundary condition for the 35 year return period as shown in Figure 98,Figure 99 and Figure 100 with return periods in years on the x-axis.

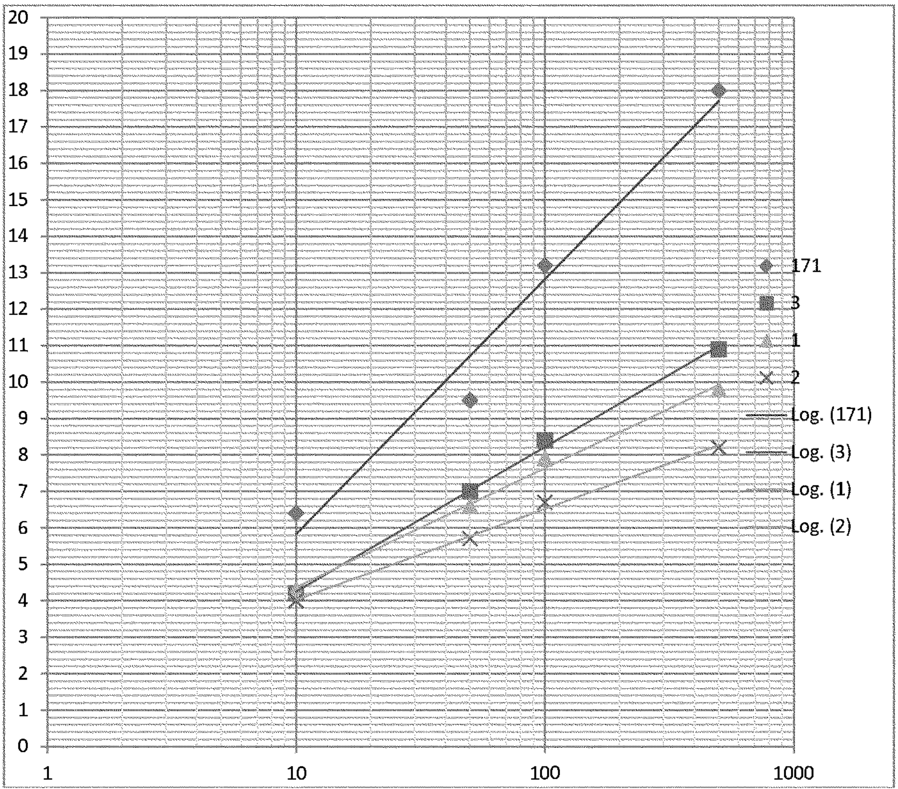


**Figure 98 – Return Period (years) vs. Still Water Elevation (ft)**

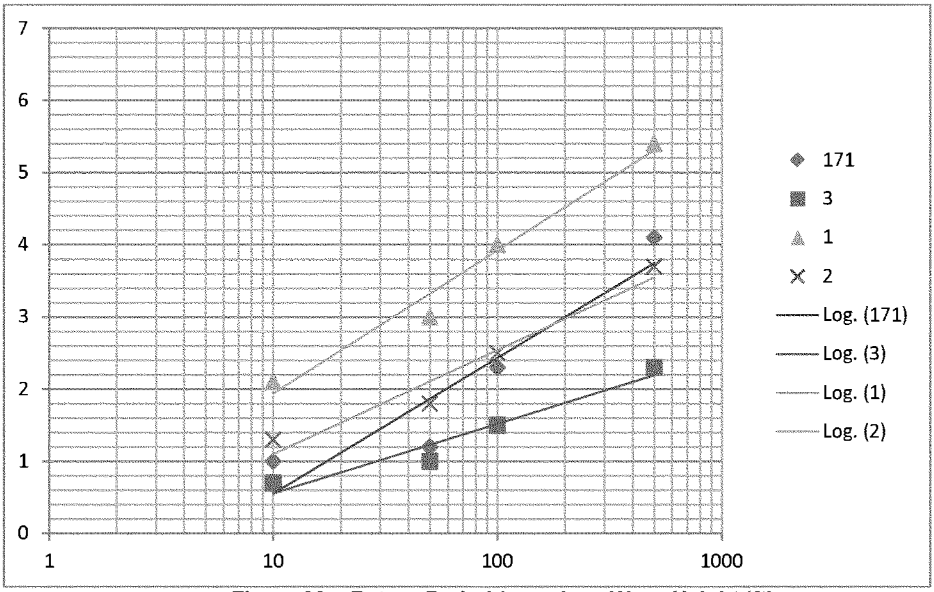


Figure 99 – Return Period (years) vs. Wave Height (ft)

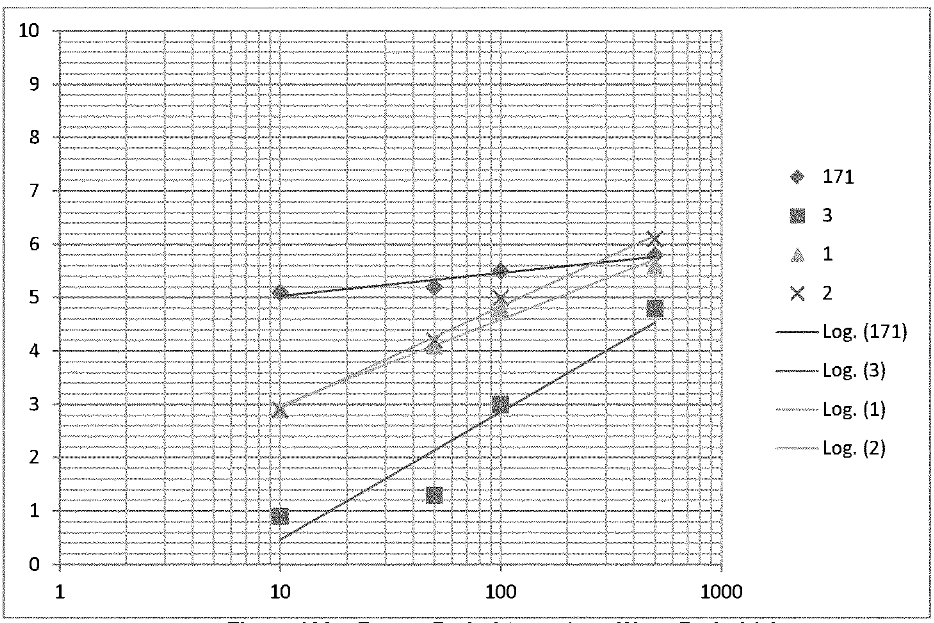


Figure 100 – Return Period (years) vs. Wave Period (s)

**Table 93 – Computed ADCIRC Base 35 Year Hydraulic Boundary Conditions**

| 2010 ADCIRC Base Model Results Computed From Graphs<br>Hydraulic Boundary Conditions At 3% (35 Year) Return Period | | | | |
|---|---|---|---|---|
| Levee Reach | 2010 ADCIRC Point ID | Mean Still Water Level (ft) | Wave Height (ft) | Wave Period (s) |
| GIWW | 3 | 6.4 | 1.1 | 1.8 |
| C-North | 171 | 9.6 | 1.6 | 5.3 |
| Lockport to Larose (a) | 1 | 6.2 | 3 | 3.9 |
| Lockport to Larose (b) | 2 | 5.4 | 1.9 | 4 |

Sea level rise was then applied and the hydraulic boundary conditions were converted to the appropriate years (2035 and 2085) as illustrated below.

**Table 94 – ADCIRC 2035 Converted Still Water Levels (ft)**

| 2035 ADCIRC Converted Model Results<br>Mean Still Water Levels At Varying Return Periods | | | |
|---|---|---|---|
| Levee Reach | 2010 ADCIRC Point ID | 3% (35 Year) Still Water Level (ft) | 1% (100 Year) Still Water Level (ft) |
| GIWW | 3 | 7.2 | 9.2 |
| C-North | 171 | 10.4 | 14.0 |
| Lockport to Larose (a) | 1 | 7.0 | 8.7 |
| Lockport to Larose (b) | 2 | 6.2 | 7.5 |

**Table 95 – ADCIRC 2035 Converted Wave Heights (ft)**

| 2035 ADCIRC Converted Model Results<br>Wave Heights At Varying Return Periods | | | |
|---|---|---|---|
| Levee Reach | 2010 ADCIRC Point ID | 3% (35 Year) Wave Height (ft) | 1% (100 Year) Wave Height (ft) |
| GIWW | 3 | 1.5 | 1.9 |
| C-North | 171 | 2.0 | 2.7 |
| Lockport to Larose (a) | 1 | 3.4 | 4.4 |
| Lockport to Larose (b) | 2 | 2.3 | 2.9 |

**Table 96 – ADCIRC 2035 Converted Wave Periods (s)**

| 2035 ADCIRC Converted Model Results<br>Wave Periods At Varying Return Periods | | | |
|---|---|---|---|
| Levee Reach | 2010 ADCIRC Point ID | 3% (35 Year) Wave Periods (s) | 1% (100 Year) Wave Periods (s) |
| GIWW | 3 | 2.1 | 3.4 |
| C-North | 171 | 5.9 | 5.9 |
| Lockport to Larose (a) | 1 | 4.1 | 5.0 |
| Lockport to Larose (b) | 2 | 4.4 | 5.4 |

**Table 97– ADCIRC 2085 Converted Still Water Levels (ft)**

| 2085 ADCIRC Converted Model Results<br>Mean Still Water Levels At Varying Return Periods | | | |
|---|---|---|---|
| Levee Reach | 2010 ADCIRC Point ID | 3% (35 Year) Still Water Level (ft) | 1% (100 Year) Still Water Level (ft) |
| GIWW | 3 | 8.7 | 10.7 |
| C-North | 171 | 11.9 | 15.5 |
| Lockport to Larose (a) | 1 | 8.5 | 10.2 |
| Lockport to Larose (b) | 2 | 7.7 | 9.0 |

**Table 98 – ADCIRC 2085 Converted Wave Heights (ft)**

| 2085 ADCIRC Converted Model Results<br>Wave Heights At Varying Return Periods | | | |
|---|---|---|---|
| Levee Reach | 2010 ADCIRC Point ID | 3% (35 Year) Wave Height (ft) | 1% (100 Year) Wave Height (ft) |
| GIWW | 3 | 2.2 | 2.6 |
| C-North | 171 | 2.7 | 3.4 |
| Lockport to Larose (a) | 1 | 4.1 | 5.1 |
| Lockport to Larose (b) | 2 | 3.0 | 3.6 |

**Table 99 – ADCIRC 2085 Converted Wave Periods (s)**

| 2085 ADCIRC Converted Model Results Wave Periods At Varying Return Periods | | | |
|---|---|---|---|
| Levee Reach | 2010 ADCIRC Point ID | 3% (35 Year) Wave Periods (s) | 1% (100 Year) Wave Periods (s) |
| GIWW | 3 | 2.6 | 4.0 |
| C-North | 171 | 6.9 | 6.7 |
| Lockport to Larose (a) | 1 | 4.6 | 5.4 |
| Lockport to Larose (b) | 2 | 5.0 | 6.0 |

These hydraulic boundary conditions were then used to determine the levee and structure elevations. For the surge elevation, wave height, and wave period determined for the authorized level of risk reduction, the maximum allowable average wave overtopping of 0.1 cfs/ft at 90% level of assurance and 0.01 cfs/ft at 50% level of assurance for grass-covered levees. For the surge elevation, wave height, and wave period determined for the post authorization level of risk reduction, the maximum allowable average wave overtopping of 0.1 cfs/ft at 90% level of assurance and 0.03 cfs/ft at 50% level of assurance for wall type structures with appropriate protection on the back side. A Monte Carlo analysis was then applied. In the Monte Carlo analysis the overtopping algorithm is repeated to compute the overtopping rate many times (in this case 10,000 iterations).To determine the overtopping rate in the Monte Carlo analysis, the probabilistic overtopping formulations from Van der Meer are applied for levees (see text box below) and the Franco & Franco formulation for floodwalls. Besides the geometric parameters (levee height and slope), hydraulic input parameters for determination of the overtopping rate in Equations 1 and 2 are the water elevation ($\zeta$), the significant wave height ($H_s$) and the peak wave period ($T_p$).

**Van der Meer overtopping formulations**

The overtopping formulation from Van der Meer reads (TAW, 2002)-

$$\frac{q}{\sqrt{gH_{m0}^3}} = \frac{0.067}{\sqrt{\tan\alpha}}\gamma_b\xi_0 \exp\left(-4.75\frac{R_c}{H_{m0}}\frac{1}{\xi_0\gamma_b\gamma_f\gamma_\beta\gamma_v}\right)$$

$$with \quad \max imum: \quad \frac{q}{\sqrt{gH_{m0}^3}} = 0.2\exp\left(-2.6\frac{R_c}{H_{m0}}\frac{1}{\gamma_f\gamma_\beta}\right) \tag{1}$$

With-

q - average overtopping rate [cfs/ft]
g - gravitational acceleration [ft/s$^2$]
$H_{m0}$ - wave height at toe of the structure [ft]
$\xi_0$- surf similarity parameter [-]
$\alpha$ - slope [-]
$R_c$ - freeboard [ft]
$\gamma$ - coefficient for presence of berm (b), friction (f), wave incidence ($\beta$), vertical wall (v)

The surf similarity parameter $\xi 0$ is defined herein as $\xi_0 = \tan\alpha / \sqrt{s_0}$ with $\alpha$ the angle of slope and $s_0$ the wave steepness. The wave steepness follows from $s0 = 2\,\pi\, H_{m0} /(g\, Tm_{-10}{}^2)$. The coefficients -4.75 and -2.6 in Equation 1 are the mean values. The standard deviations of these coefficients are equal to 0.5 and 0.35, respectively and these errors are normally distributed (TAW, 2002). The reader is referred to TAW (2002) for definitions of the various coefficients for presence of berm, friction, wave incidence, vertical wall.

Equation 1 is valid for $\xi_0 < 5$ and slopes steeper than 1-8. For values of $\xi_0 > 7$ the following equation is proposed for the overtopping rate-

$$\frac{q}{\sqrt{gH_{m0}^3}} = 10^{-0.92}\exp\left(-\frac{R_c}{\gamma_f\gamma_\beta H_{m0}(0.33+0.022\xi_0)}\right) \tag{2}$$

The overtopping rates for the range $5 < \xi_0 < 7$ are obtained by linear interpolation of Equation 1 and 2 using the logarithmic value of the overtopping rates. For slopes between 1-8 and 1-15, the solution should be found by iteration. If the slope is less than 1-15, it should be considered as a berm or a foreshore depending on the length of the section compared to the deep water wavelength. The coefficients -0.92 is the mean value. The standard deviation of this coefficient is equal to 0.24 and the error is normally distributed (TAW, 2002).

Figure 101 graphically shows the overtopping for a levee and floodwall situation including the most relevant parameters.

In the design process, we use the best estimate 1% values for these parameters from the JPM-OS method (Resio, 2007); uncertainty in these values exists. Resio (2007) has provided a method to derive the standard deviation in the 1% surge elevation. Standard deviation values of 10% of the average significant wave height and 20% of the peak period were used (Smith, 2006, pers. comm.). In absence of data, all uncertainties are assumed to be normally distributed. If additional data would show another distribution, that distribution has to be included in the methodology.

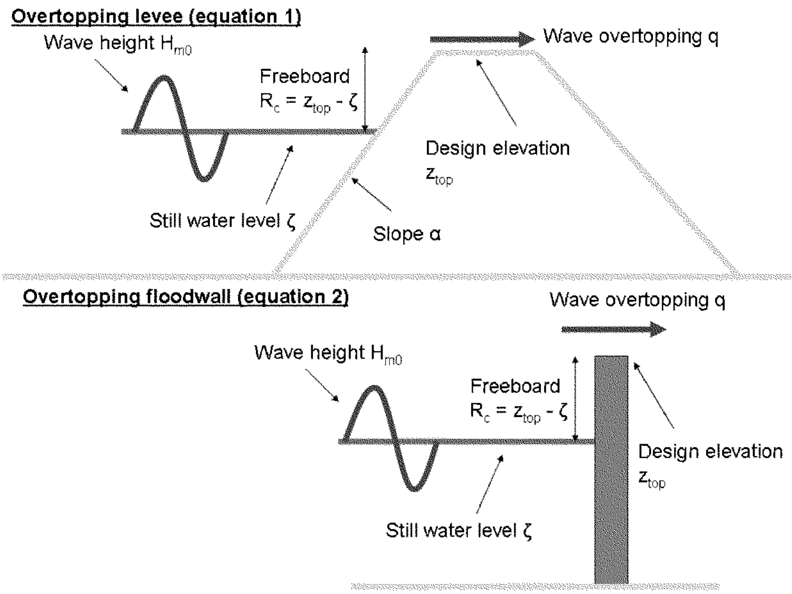


**Figure 101 – Definitions for Overtopping for Levee and Floodwall**

The Monte Carlo Analysis is executed as follows:

1. Draw a random number between 0 and 1 to set the exceedence probability (p).
2. Compute the water elevation from a normal distribution using the mean 1% surge elevation and standard deviation as parameters and with an exceedence probability (p).
3. Draw a random number between 0 and 1 to set the exceedence probability (p).
4. Compute the wave height and wave period from a normal distribution using the mean 1% wave height/wave period and the associated standard deviation and with an exceedence probability (p).
5. Repeat step 3 and 4 for the three overtopping coefficients independently.
6. Compute the overtopping rate for these hydraulic parameters and overtopping coefficients determined in step 2, 4 and 5 using the Van der Meer overtopping formulations for levees or the Franco & Franco equation for floodwalls (see Equations 1 and 2 in the textbox).
7. Repeat the Step 1 through 5 a large number of times. (N)
8. Compute the 50% and 90% confidence limit of the overtopping rate. (i.e. $q_{50}$ and $q_{90}$)

The procedure is implemented in the numerical software package MATLAB because it is a computationally intensive procedure. MATLAB is a high-level technical computing language and interactive environment for algorithm development, data visualization, data analysis, and numeric computation.

The computation of the overtopping rate in the present MATLAB routine is limited in the sense that it can only take into account an average slope for the entire cross-section. If a wave berm exists, this effect is included in a berm factor. The following procedure was carried out to determine this berm factor. First, the overtopping rate is computed with PC-Overslag with the best estimates of surge level and waves. Next, the berm factor is calibrated with the Van der Meer overtopping formulations to get exactly same result from PC-Overslag. Then, the berm factor is checked to see if it is in between the recommended range of 0.6 – 1.0. Finally, the calibrated berm factor is applied in the uncertainty analysis (and keep this factor constant) throughout the Monte Carlo analysis in MATLAB.

The 1% and 3% levee and structure elevations for the years 2035 and 2085 were then computed for the "with" and "without" wave berm (GIWW and Larose C-North reaches only) scenarios.

### 2.8.3 Results

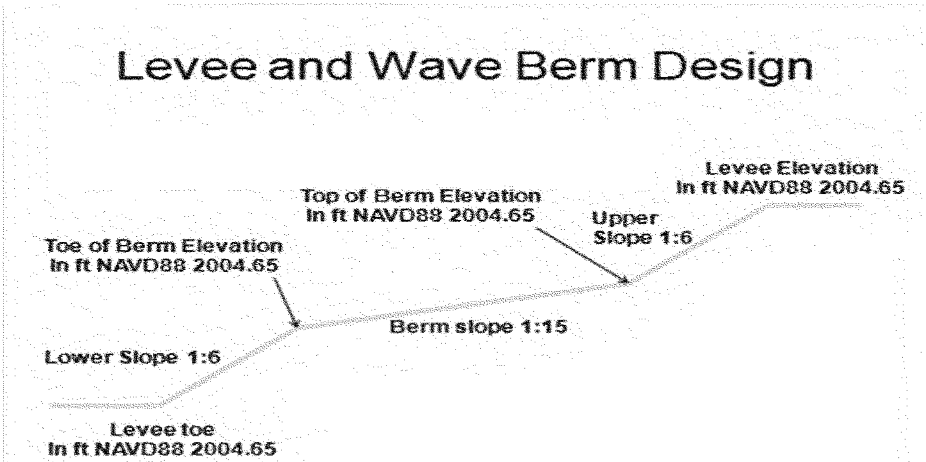


Figure 102 – Levee and Wave Berm Design

**Table 100 – 2035 and 2085 3% Elevations with wave berms**

2035 3% Elevations With Wave Berms

| Section | SWL ft | SWL Std. Dev. | Hs ft | Tp sec | Levee Elev ft | Upper Slope | Top of Berm El ft | Berm Slope | Toe of Berm El ft | Lower Slope |
|---|---|---|---|---|---|---|---|---|---|---|
| C-North | 10.4 | 1 | 2 | 5.9 | 13.5 | 1 on 6 | 10.4 | 1 on 15 | 8.4 | 1 on 6 |
| GIWW | 7.2 | 0.25 | 1.5 | 2.1 | 8.0 | 1 on 6 | 7.2 | 1 on 15 | 5.7 | 1 on 6 |
| Lockport to Larose (a) | 7 | 0.25 | 3.4 | 4.1 | 9.5 | 1 on 6 | 7.0 | 1 on 15 | 3.6 | 1 on 6 |
| Lockport to Larose (b) | 6.2 | 0.25 | 2.3 | 4.4 | 8.5 | 1 on 6 | 6.2 | 1 on 15 | 3.9 | 1 on 6 |

2085 3% Elevations With Wave Berms

| Section | SWL ft | SWL Std. Dev. | Hs ft | Tp sec | Levee Elev ft | Upper Slope | Top of Berm El ft | Berm Slope | Toe of Berm El ft | Lower Slope |
|---|---|---|---|---|---|---|---|---|---|---|
| C-North | 11.9 | 1 | 2.7 | 6.9 | 15.5 | 1 on 6 | 11.9 | 1 on 15 | 9.2 | 1 on 6 |
| GIWW | 8.7 | 0.25 | 2.2 | 2.6 | 9.5 | 1 on 6 | 8.7 | 1 on 15 | 6.5 | 1 on 6 |
| Lockport to Larose (a) | 8.5 | 0.25 | 4.1 | 4.6 | 12.0 | 1 on 6 | 8.5 | 1 on 15 | 4.4 | 1 on 6 |
| Lockport to Larose (b) | 7.7 | 0.25 | 3 | 5 | 11.0 | 1 on 6 | 7.7 | 1 on 15 | 4.7 | 1 on 6 |

**Table 101 – 2035 and 2085 1% Elevations with wave berms**

2035 1% Elevations With Wave Berms

| Section | SWL ft | SWL Std. Dev. | Hs ft | Tp sec | Levee Elev ft | Upper Slope | Top of Berm El ft | Berm Slope | Toe of Berm El ft | Lower Slope |
|---|---|---|---|---|---|---|---|---|---|---|
| C-North | 14 | 1.5 | 2.7 | 5.9 | 18.0 | 1 on 6 | 14.0 | 1 on 15 | 11.3 | 1 on 6 |
| GIWW | 9.2 | 0.5 | 1.9 | 3.4 | 11.0 | 1 on 6 | 9.2 | 1 on 15 | 7.3 | 1 on 6 |
| Lockport to Larose (a) | 8.7 | 0.5 | 4.4 | 5 | 12.5 | 1 on 6 | 8.7 | 1 on 15 | 4.3 | 1 on 6 |
| Lockport to Larose (b) | 7.5 | 0.5 | 2.9 | 5.4 | 10.5 | 1 on 6 | 7.5 | 1 on 15 | 4.6 | 1 on 6 |

2085 1% Elevations With Wave Berms

| Section | SWL ft | SWL Std. Dev. | Hs ft | Tp sec | Levee Elev ft | Upper Slope | Top of Berm El ft | Berm Slope | Toe of Berm El ft | Lower Slope |
|---|---|---|---|---|---|---|---|---|---|---|
| C-North | 15.5 | 1.5 | 3.4 | 6.7 | 20.5 | 1 on 6 | 15.5 | 1 on 15 | 12.1 | 1 on 6 |
| GIWW | 10.7 | 0.5 | 2.6 | 4 | 13.5 | 1 on 6 | 10.7 | 1 on 15 | 8.1 | 1 on 6 |
| Lockport to Larose (a) | 10.2 | 0.5 | 5.1 | 5.4 | 15.0 | 1 on 6 | 10.2 | 1 on 15 | 5.1 | 1 on 6 |
| Lockport to Larose (b) | 9 | 0.5 | 3.6 | 6 | 13.0 | 1 on 6 | 9.0 | 1 on 15 | 5.4 | 1 on 6 |

**Table 102 – 2035 and 2085 3% Elevations without wave berms**

2035 3% Elevations Without Wave Berms

| Section | SWL ft | SWL Std. Dev. | Hs ft | Tp sec | Levee Elev ft |
|---|---|---|---|---|---|
| C-North | 10.4 | 1 | 2 | 5.9 | 15.0 |
| GIWW | 7.2 | 0.25 | 1.5 | 2.1 | 9.0 |

2085 3% Elevations Without Wave Berms

| Section | SWL ft | SWL Std. Dev. | Hs ft | Tp sec | Levee Elev ft |
|---|---|---|---|---|---|
| C-North | 11.9 | 1 | 2.7 | 6.9 | 18.5 |
| GIWW | 8.7 | 0.25 | 2.2 | 2.6 | 11.0 |

1V to 4H levee slope

**Table 103 – 2035 and 2085 1% Elevations without wave berms**

| 2035 1% Elevations Without Wave Berms | | | | | |
|---|---|---|---|---|---|
| Section | SWL ft | SWL Std. Dev. | Hs ft | Tp sec | Levee Elev ft |
| C-North | 14 | 1.5 | 2.7 | 5.9 | 20.5 |
| GIWW | 9.2 | 0.5 | 1.9 | 3.4 | 12.5 |

| 2085 1% Elevationsout Without Wave Berms | | | | | |
|---|---|---|---|---|---|
| Section | SWL ft | SWL Std. Dev. | Hs ft | Tp sec | Levee Elev ft |
| C-North | 15.5 | 1.5 | 3.4 | 6.7 | 24.0 |
| GIWW | 10.7 | 0.5 | 2.6 | 4 | 15.0 |
| 1V to 4H levee slope | | | | | |

**Table 104 – 2085 3% and 1% Structure Elevations**

| 2085 3% Structure Elevations | | | |
|---|---|---|---|
| Section | 90% SWL ft | Wave Height ft | Struct. Elev. ft |
| C-North | 13.2 | 2.7 | 16.0/18.5* |
| GIWW | 9 | 2.2 | 12.0 |
| Lockport to Larose (a) | 8.8 | 4.1 | 13.0 |
| Lockport to Larose (b) | 8 | 3 | 11.5 |

| 2085 1% Structure Elevations | | | |
|---|---|---|---|
| Section | 90% SWL ft | Wave Height ft | Struct. Elev. ft |
| C-North | 17.4 | 3.4 | 21.0/24.0* |
| GIWW | 11.3 | 2.6 | 15.0 |
| Lockport to Larose (a) | 10.8 | 5.1 | 16.0 |
| Lockport to Larose (b) | 9.6 | 3.6 | 13.5 |

*Structure elevations should not be lower than the 2085 levee elevations for the same reach, per HSDRRS guidelines. If the without wave berm scenario is chosen, then the structure elevations should be raised to match the 2085 levee elevations for the corresponding without wave berm scenario.

## 2.9 REFERENCES

Alette, D. M., Washington, D. M., 2011, "Morganza to the Gulf of Mexico Reverse Head Load Cases for Hydraulic Structures- (Floodgates and Lock) Summary of Decision Making Process and Supporting Documentation".

Cialone, M., Wamsley T., Sleath, A., Thomas, L., Tubman, M., Smith, J., McAlpin, T., Resio, D.T., 2010. Morganza to the Gulf Summary Draft Report. U.S. Army Corps of Engineers, ERDC-CHL.

Couvillion, B.R., Barras J.A., Steyer G.D., Sleavin W., Fischer M., Beck H., Trahan N., Griffin B., and Heackman D. Land Area Change in Coastal Louisiana from 1932 to 2010. U.S. Geological Survey Scientific Investigations Map 3164. http-//pubs.usgs.gov/sim/3164/. Last accessed on February 26, 2012.

Johnson, C.B., 2004. *Capacity of freshwater marsh to process nutrients in diverted Mississippi River water.* MS thesis, Louisiana State University, Baton Rouge, Louisiana. http-//etd.lsu.edu/docs/available/etd-11112004-193110/. Last accessed on February 23, 2012.

Louisiana Department of Environmental Quality (LDEQ), 2011. *2010 Louisiana Water quality Inventory- Integrated Report.* http-//www.deq.state.la.us/portal/DIVISIONS/WaterPermits/WaterQualityStandardsAssessment/WaterQualityInventorySection305b/2010WaterQualityIntegratedReport.aspx. Last accessed on February 23, 2012.

Luettich, R.A., Westerink, J.J., and Scheffner, N.W., 1992. "ADCIRC- An advanced three-dimensional circulation model for shelves, coasts, and estuaries; Report 1. Theory and methodology of ADCIRC-2DD1 and ADCIRC-3DL." Technical Report DRP-92-6, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Luettich, R. A., and Westerink, J. J., 2004. "Formulation and Numerical Implementation of the 2D/3D ADCIRC Finite Element Model Version 44.XX," web publication, http-//adcirc.org/adcirc_theory_2004_12_08.pdf.

Maynord, Stephen T., 2000. "Interim Report for the Upper Mississippi River – Illinois Waterway System Navigation Study, Physical Forces near Commercial Tows" U.S. Army Engineer District, Rock Island, St. Louis, St. Paul, pp. 13-43.

McAlpin, T.O., Letter, J.V., and Carson, F.C. 2010. Comparison of Plan Alternatives for the Morganza to the Gulf of Mexico Levee System. In preparation.

Mitsch, W.J. and J.G. Gosselink, 2000. *Wetlands, 3rd Ed.* John Wiley & Sons, New

York. 920 pp.

National Oceanic and Atmospheric Administration (NOAA). 2012. *NOAA's 1981-2010 Climate Normals*. http-//www.ncdc.noaa.gov/oa/climate/normals/usnormals.html. Last accessed on February 23, 2012.

NOAA, 2008. *Screening Quick Reference Tables (SQuiRTs)*. http-//response.restoration.noaa.gov/book_shelf/122_NEW-SQuiRTs.pdf. Last accessed on February 24, 2012.

Reference 1- U.S. Army Corps of Engineers 1991 (December 23). Policy Guidance Letter No.26, *Benefit Determination Involving Existing Levees*.

Reference 2- U.S. Army Corps of Engineers. 1999 (May 28). "Risked-Based Analysis on Geotechnical Engineering for Support of Planning Studies," *ETL 1110-2-556*.

Reference 3- U.S. Army Corps of Engineers, 2007. "Feasibility Study and Environmental Assessment, Fargo, North Dakota, Appendix D, Geotechnical Design and Geology." St. Paul District.

Reference 4- U.S. Army Corps of Engineers. 1994 (June 30). "Hydraulic Design of Flood Control Channels." *EM 1110-2-1601*

Resio, D.T., 2007. White Paper on Estimating Hurricane Inundation. U.S. Army Corps of Engineers, ERDC-CHL.

Steyer, G.D., Sasser, C., Evers, E., Swenson, E., Suir, G., and Sapkota, S., 2008. *Influence of the Houma Navigation Canal on salinity patterns and landscape configuration in coastal Louisiana*. U.S. Geological Survey Open-File Report 2008-1127. http-//pubs.usgs.gov/of/2008/1127/. Last accessed on February 26, 2012.

Swarzenski, C.M., Doyle T.W., Fry B., and Hargis,T.G., 2008. *Biogeochemical response of organic-rich freshwater marshes in the Louisiana delta plain to chronic river water influx*. Biogeochemistry 90-49-63. TAW, Wave Run-Up and Overtopping at Dikes, Technical Report. Technical Advisory Committee on Flood Defence, The Netherlands. Delft, 2002.

USEPA, 1998. *Evaluation of Dredged Material Proposed for Discharge in Waters of the U.S. - Testing Manual*. Washington (DC)- U.S. Environmental Protection Agency (USEPA). Guidance Manual No. EPA-823-B-98-004. http-//www.epa.gov/waterscience/itm/itmpdf.html. Last accessed on February 26, 2012.

USACE, 2001. Coastal Engineering Manual. Engineer Manual 1110-2-1100, U.S.

Army Corps of Engineers, Washington, D.C. (in 6 volumes).

USACE, 2002. Mississippi River and Tributaries Morganza, Louisiana to the Gulf of Mexico Hurricane Protection. Final Feasibility Report Volume II – Appendix A-E, U.S. Army Corps of Engineers, Washington, D.C. (reference for sentence in Appendix 1)

USACE, 2003. *Evaluation of Dredged Material Proposed for Placement in Island, Nearshore, or Upland Confined Disposal Facilities – Testing Manual.* ERDC/EL TR-03-1. http-//el.erdc.usace.army.mil/dots/pdfs/trel03-1.pdf. Last accessed on February 26, 2012.

USACE, 2007. Elevations for Design of Hurricane Protection Levees and Structures, New Orleans District.

USACE, 2010. Hurricane and Storm Damage Risk Reduction System – Design Elevation Report. Draft Report (Version 4.0), U.S. Army Corps of Engineers, Washington, D.C. (Whitney's design report)

USEPA, 2009a. *National Recommended Water Quality Criteria.* http-//water.epa.gov/scitech/swguidance/standards/current/index.cfm. Last accessed on September 20, 2011.

USEPA, 2009b. *Section 404(b)(1) Guidelines for Specification of Disposal Sites for Dredged or Fill Material.* http-//www.epa.gov/owow/wetlands/pdf/40cfrPart230.pdf. Last accessed on August 28, 2009.

USEPA, 2011. *Impaired Waters and Total Maximum Daily Loads.* http-//water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/index.cfm. Last accessed on September 15, 2011.

USEPA, 2012. *Stormwater Pollution Prevention Plans for Construction Activities.* http-//cfpub.epa.gov/npdes/stormwater/swppp.cfm. Last accessed on February 26, 2012.

USGS, 2003. *Surface-Water Hydrology of the Gulf Intracoastal Waterway in South-Central Louisiana, 1996-1999.* U.S. Geological Survey (USGS) Professional Paper 1672. http-//pubs.usgs.gov/pp/pp1672/. Last accessed on February 26, 2012.

Westerink, J.J., C.A. Blain, R.A. Luettich, Jr., and Scheffner, N.W., 1993. "ADCIRC- An advanced three-dimensional circulation model for shelves coasts and estuaries, Report 2- Users manual for ADCIRC-2DDI," Dredging Research Program Technical Report DRP-92-6, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS., 156 p.

# 3 GEOTECHNICAL

## 3.1 Geology

### 3.1.1 Geology/Geomorphology

The project area is located within the south-central portion of the Mississippi River deltaic plain. Dominant physiographic features in the project area include abandoned courses of the Mississippi River (Bayous Black and Lafourche) and their associated natural levees, numerous abandoned distributary channels and associated natural levees, the GIWW, the HNC, swamp, marsh, lakes, ponds, and bays. Elevations are highest on the crests of the natural levees bordering Bayous Black and Lafourche and the numerous abandoned distributaries.

The project area has received sediments from two Mississippi River deltas within approximately the last 4,500 years. The Teche-Mississippi River Delta was actively building land in the western and central portions of the project area from approximately 4,500 to 3,500 years ago. Bayou Black, the trunk stream of the Teche-Mississippi, and major distributaries such as Bayous Penchant, Cocodrie, Piquant, Little Horn, and Carencro all trend southeast indicative of the direction of delta growth. The branching pattern of distributaries indicates that the Teche Delta prograded into shallow open water in this portion of the project area. Approximately 3,500 years ago, the Teche-Mississippi shifted eastward and started building the St. Bernard Delta. Subsidence and erosion of the Teche Delta became the dominant processes acting in the project area. Much of the original land area was submerged beneath Gulf waters or reworked by waves to become part of the transgressive shoreline which was located just north of Lake Penchant. The initial deposition from the Lafourche-Mississippi River Delta in the central and eastern portions of the project area began approximately 2000 years ago. Bayou Lafourche was the trunk stream of the Lafourche Delta. Major distributaries of the Lafourche Delta in the project area include Bayous Mauvais Bois, Dularge, Grand Caillou, Petit Caillou, Terrebonne, St. Jean Charles, and Pointe au Chenes. Like the Teche Delta, the Lafourche Delta prograded mainly into shallow open water in this portion of the project area. Approximately 1,000 years ago, the main flow of the Mississippi River shifted eastward, away from the project area. The Bayou Lafourche course was abandoned approximately 300 years ago.

The entire project area is in the transgressive phase of the "delta cycle". During this phase, delta abandonment takes place and the processes of subsidence, erosion, and marine transgression dominate the landscape. The result is land loss, submergence, habitat change (driven mainly by elevation decrease and salinity increase), and an increase in water area.

The surface and shallow subsurface of the project area is generally composed of natural levee, swamp, and marsh deposits. Natural levee deposits are at the surface and underlie marsh and swamp deposits and occur adjacent to abandoned courses and distributaries. Natural levee deposits generally consist of soft to stiff, clays interbedded with layers and lenses of silt and silty sand. Natural levee deposits vary in thickness but generally range from 5 to 20 feet in thickness. Swamp and marsh deposits are located adjacent to natural levee deposits and comprise most of the land area in the project area. They consist mainly of very soft to medium, organic clays, with lenses of soft to medium lean clay, peat, silt, and silty sand. Swamp deposits contain wood. These deposits generally range from 5 to 20 feet thick. Interdistributary deposits underlie marsh, swamp, and natural levee deposits and consist of soft to medium clay interbedded with layers and lenses of very soft to medium lean clay, silt, and silty sand and occasional lenses of shell. Interdistributary deposits generally range from 80 to 120 feet thick. Swamp deposits are also frequently interbedded with interdistributary deposits. Intradelta deposits underlie marsh, swamp, and natural levee deposits and are interbedded with interdistributary deposits. Intradelta deposits are associated with delta progradation and are found adjacent to abandoned courses and major distributaries. Intradelta deposits consist of silt, silty sand and sand with occasional layers and lenses of soft to medium, fat and lean clays. Intradelta deposits vary in thickness but average 10 feet thick.

Cancienne-Gramercy and Commerce soils occur adjacent to the major distributaries and courses on the high to intermediate elevations of the natural levees. They are level, somewhat poorly drained soils that are loamy throughout. Schriever and Sharkey soils occur adjacent to the Cancienne-Gramercy and Commerce soils. These soils are on the low and intermediate elevations of the natural levees. They consist of level, poorly drained soils that have a loamy or clayey surface layer and a clayey subsoil. Allemands, Kenner, and Larose soils occur in the northern third of the project area. These soils are adjacent to the levees in freshwater marshes. They are level, very poorly drained soils that have a semifluid, mucky surface layer and semifluid, mucky and semifluid clayey underlying material. Lafitte and Clovelly soils occur in the middle third of the project area. These soils are level, very poorly drained soils that have a semifluid, mucky surface layer and semifluid, clayey underlying material in brackish marshes. Timbalier and Scatlake soils occur in the southern third of the project area. These soils are level, very poorly drained soils in saline marshes.

### 3.1.2 Groundwater

Groundwater is at or near the surface throughout much of the project area except near the crests of natural levees and where artificially lowered within forced drainage areas. Intradelta deposits may be hydraulically connected to the adjacent water bodies.

## 3.2 General

In the study area beyond the narrow strips of land, natural ridges, that were formed by the bayous, generally flowing in a north to south direction, the area consists of marsh with a large percentage of open water. Sediments that comprise the natural ridges are stronger than the sediments in the lower surrounding areas, especially sediments that are in open water environments. Levee construction on top of the marsh sediments will be challenging from a stability and settlement viewpoint, especially for levee heights exceeding 15 feet. Smaller levees can initially be constructed and used to preload and strengthen the foundation and construction of subsequent lifts over time will help achieve the desired crown elevations.

Generally, the approach for levee construction consist of an initial preload lift to an elevation between +12 to +14 N.A.V.D.88 to provide a good base and working surface for construction of a geosynthetic fabric reinforced levee substantially higher than the initial preload lift. This study provides data and analyses to build a 3% AEP Level of Risk Reduction (LORR) base year (2035) and future year (2085) levee to the desired grade utilizing multiple lift construction as well as a 1% AEP LORR base and future year levee. Geotextile reinforcement, berms, and flat berm slopes were used to achieve stable levees. This report assumes a base year of 2035 when the 1% AEP project loop will provide protection to the design heights for the LORR and a base year of 2026 for the 3% AEP. Construction sequencing will be discussed later in the report. Much effort was spent on levee stability analyses and structure analysis. Settlement analyses are an important part of the study due to the added construction cost associated with settlement during and after construction.

### 3.3 Levee Alignments

Levees were placed as close as practical to the natural ridges along existing or former bayous to take advantage of the stronger foundation conditions and reduce the probability of failure during and after construction.

### 3.4 Levee Heights

The study presents two levee alternatives, namely the 3% AEP and 1% AEP LORR levees of various heights. Two time conditions were used for the investigation, the base year and future conditions. Under each condition, there are two alternative levels of protection, the 3% AEP protection levels and 1% AEP protection levels, as shown in Table 105.

**Table 105 - Levee Alternatives**

| Base Year Condition (2035) | Future Condition (2085) |
|---|---|
| 3% AEP level | 3% AEP level |
| 1% AEP level | 1% AEP level |

### 3.5 Geotechnical Exploration

Borings were obtained along the most likely alignments to provide design data for stability analyses, settlement calculations and time rate of settlement. Towards the end of this study, there were adjusted alignments for Reach G and the Barrier Alignment. Reach G has enough boring data scattered in the vicinity to provide a good basis for expected soil conditions along the newly selected alignment. The Barrier Alignment was bored for North Terrebonne Parish Drainage and Conservation District in year 2000.

Undisturbed borings were obtained for this study. Boring locations and detailed logs can be furnished upon request. Due to funding issues, borings were mostly obtained in two phases. A small portion of borings were obtained during a previous general investigation of the project area prior to year 2000. Boring investigation for Reaches F, G, H, and I were obtained in 2002 and 2003, including borings for levees and anticipated structure sites. In 2009 to 2010, Boring and CPT data was obtained for project Reaches A, B, E, K, and L. To analyze final designs if this project is authorized, additional deep undisturbed borings (approx. 400), shallow general type borrow borings (approx. 400), and Cone Penetrometers (CPTs) (approx. 600) will be necessary. Details on this will be furnished upon request.

### 3.6 Laboratory Tests

For the undisturbed borings, visual classifications were made on all samples obtained from soil borings. Moisture content determinations were made on all cohesive soil samples. Shear strength tests included Unconfined Compression (UCT) tests and Unconsolidated Undrained (Q) tests. Liquid and plastic limits were determined on selected samples. Organic Matter Content tests were also performed on selected undisturbed samples for the 2009/10 boring samples. Consolidation testing was completed on selected undisturbed samples for all borings taken by the Corps or our A-E contractors.

### 3.7 Shear Strength

Design strengths for clay layers were selected based on the available testing from somewhat limited borings and CPTs. The soil borings were taken along the alignment corridor. Some structure borings near bayous were taken from the adjacent road shoulder, but where accessible by barge, many were obtained in the waterway. Generally, the project area contains large amounts of open water and many bayous, which results in heterogeneous soil foundations. Data from each boring has to be extrapolated over a large area, which can result in inexact assumptions. Efforts were made to provide a realistic design.

Shear strength data from undisturbed borings, general type borings and CPTs were grouped together for soil reaches of similar deposits. For structures, shear strengths were based on borings in close vicinity of the structure sites. For structures with no site specific boring data, other borings in the vicinity were used to approximate soil properties. Presently, about one-third of the subsurface exploration required for construction of the project has been completed. It is anticipated that the selected shear strength lines for this Feasibility study may be conservative when future boring data and CPTs are used to supplement the shear information.

### 3.8 Survey Data

Some survey data was provided by the local sponsor's A-E firm. Collection and interpretation of survey data required much more effort than had been anticipated for the services. Ground surface elevations were approximated for reaches with limited survey data. Data provided prior to 2009 was presented in North American Vertical Datum (NGVD) and the 2009/2010 survey data and LIDAR are plotted in NAVD elevations.

### 3.9 Levee Stability Analyses

The study alignment was divided into stability reaches, based on the height of levee that is required to satisfy hydraulic conditions, types of soils in the foundation, strength of the foundation, and ground surface elevation. A graphical representation of the current proposed alignment will be furnished upon request. The project was divided into 10 stability reaches. Reaches G, H, I, and J were split into subreaches due to differences in levee heights, subsurface conditions, or surface conditions (natural ground elevations, water, miscellaneous). Reaches include the Barrier Alignment, Reaches A, B, E, F, G, H, I, J, K&L. Levee and berm slopes, on the flood (gulf) side, for the levees were controlled or mostly controlled by the hydraulic wave berm requirements. On the protected side, the slopes and berms were designed to meet stability requirements. Geotextile reinforcement was used to increase the stability factor of safety as the levees are enlarged to higher heights. Protection heights for levees analyzed for this study are substantially higher than typical hurricane protection levees in Southeast Louisiana. Generally, the levee footprint is designed to preload the footprint for the second lift to be buttressed by geosynthetic (geotextile fabric) reinforcement to decrease fill requirements as compared to an all earthen fill section. Many shallow bodies of water will be crossed to provide protection to the area. Analyses of sporadic low areas (intermittent) are beyond the scope of this study, especially with the data that is available. Such area that may require crossings or closures will be investigated with site specific data, or generalized data for typical crossings. For current designs, crossings and other anomalies were not specifically addressed. It was assumed that the cost to cross the bodies of water will not change the overall cost of each reach.

### 3.9.1 Stability Criteria

The preloading initial lifts were designed for a safety factor of 1.3 with flood water to the top of levee or Still Water Level (SWL), whichever is greater. Borrow pit locations were based on a levee failure into the pit for a minimum safety factor of 1.5 for the 3% AEP LORR protection levels for a base year (2035) section (with an estimated overbuild). It is anticipated that after years of settlement and subsurface strengthening, some shallow borings and some CPTs can be obtained to verify foundations shear strength assumptions for the next lift. The preload area are to be partially degraded to about elevation 4 (assumed), a reinforcement fabric laid down and compacted fill construction to provide for a substantially higher levee.

### 3.9.2 Initial Lift (Preload) Construction

When possible, the initial lift for levees will be constructed using adjacent cast soils to provide a base for future lifts. Due to the presence of near surface sands and silts in many of the soil foundations, dewatering or unwatering of borrow pits are not recommended due to uplift issues, stability issues, and potential seepage issues. It is anticipated that adjacent borrow will be excavated in wet conditions (no pump down of water) and will be side cast and stockpiled to dry the clay soils to a reasonable condition (water content) to be placed within section. In many areas of shallow water marsh, the first few feet of fill should be cast or bulldozed into place along the alignment, progressively pushing the borrow outwards away from the centerline of the levee, thus pushing a mud wave of softer, marsh surface soils. The mud wave should be periodically removed and discarded (possible use for marsh creation) so that the soft, weaker soils are not trapped into the levee section foundation. The initial lift will typically be constructed between elevation 12 to 14 with a berm footprint that will help consolidate and strengthen the foundation for future lifts. The Initial levee sections can be utilized for both the 3% AEP and 1% AEP LORR levees.

### 3.9.3 Stability Analyses for the 3% AEP LORR Base Condition

#### 3.9.3.1 General Levee Conditions

Analyses were performed for the levee heights listed in Figures behind the "Hydraulics Requirements" tab. Levee heights vary from elev. 9 to elev. 18. Survey data ranges from adequate to limited for this scope of analysis. A typical ground surface elevation was estimated for use in the stability analyses. A minimum distance of 40 feet is required between the levee toe and the intersection of the top of the borrow cut and the ground surface. A crown width of 10 feet was used and required wave berms were used on the floodside.

#### 3.9.3.2 Stability Analyses

Results of the stability analyses will be furnished upon request.

For the 3% AEP LORR levees, Table 106 shows the stability criteria used for the study design sections.

**Table 106 - Factor-of-Safety Criteria For 3% AEP Levees**

| Stability Method | Stability Case | Water Level | Req'd F.S. |
|---|---|---|---|
| SLOPE/W (Spencer) | Prot. Side Levee into Borrow Pit | SWL | 1.5 |
| SLOPE/W (Spencer) | Prot. Side Levee | SWL | 1.5 |
| SLOPE/W (Spencer) | Floodside Levee into Borrow Pit | LWL | 1.5 |
| SLOPE/W (Spencer) | Floodside Levee | LWL | 1.4 |

where

- SWL = Still Water Level (Elev. 9 to 18)
- LWL = Low Water Level (Elev. -1)

The levee stability was analyzed with an industry accepted computer program SLOPE/W (ver. 7.15), part of the Geo-Studio 2007 Suite. The levees were analyzed using Spencer Analysis for the SWL with Circular Failure options of the SLOPE/W program. Failure surfaces were optimized and tension cracks were added, both of which provide for a more conservative, lower factor-of-safety. For this study, a block analysis was not performed and could result in a lower possible safety factor. However, in most cases, the difference is minimal and in all cases will not result in a significant cost differential. If this study is approved and funded, future analysis will meet all current construction design criteria.

For analysis, the 3% AEP LORR Base Year (2035) levels and wave berm requirements were used with an estimated overbuild (OB). Conservative assumptions were made for subsurface strengthening due to the initial (preload) lift for the Base Year LORR analyses. In most cases, the overbuild is 1.5 to 2 feet for the crown with some overbuild for the levee berms. As an added bonus, the overbuild section analyses show that predicted future levels are attainable with established safety factors.

### 3.9.4 Stability Analyses for the 1% AEP LORR Base Condition

#### 3.9.4.1 General Levee Conditions

Analyses were performed for the levee heights determined through hydraulic analysis. Levee heights vary from elev. 14 to elev. 24. Survey data ranges from adequate to limited for this scope of analysis. A typical ground surface elevation was estimated for use in the stability analyses. A minimum distance of 40 feet is required between the levee toe and the intersection of the top of the borrow cut and the ground surface. A crown width of 10 feet was used and required wave berms were used on the floodside.

#### 3.9.4.2 Stability Analyses

Results of the stability analyses will be furnished upon request.

For the 1% AEP LORR levees, Table 107 shows the stability criteria used for the study design sections.

**Table 107- Factor-of-Safety Criteria for 1% AEP Levees**

| Stability Method | Stability Case | Water Level | Req'd F.S. |
|---|---|---|---|
| SLOPE/W (Spencer) | Prot. Side Levee into Borrow Pit | SWL | 1.5 |
| SLOPE/W (Spencer) | Prot. Side Levee | SWL | 1.5 |
| SLOPE/W (Spencer) | Floodside Levee into Borrow Pit | LWL | 1.5 |
| SLOPE/W (Spencer) | Floodside Levee | LWL | 1.4 |

where

- SWL = Still Water Level (Elev. 13 to 23)
- LWL = Low Water Level (Elev. -1)

The levee stability was analyzed with an industry accepted computer program SLOPE/W (ver. 7.15), part of the Geo-Studio 2007 Suite. The levees were analyzed using Spencer Analysis for the SWL with Circular Failure options of the SLOPE/W program. Failure surfaces were optimized and tension cracks were added, both of which provide for a more conservation, lower factor-of-safety. For this study, a block analysis was not performed and could result in a lower possible safety factor. However, in most cases, the difference is minimal and in all cases will not result in a significant cost differential. As a check, a few sections were evaluated with a block analysis. Generally, the results were similar for most runs, with the exception of a few shallow failure surfaces that ran along a soft clay layer. For these exceptions, the difference in levee fill volume was not significant (less than 2%).If this study is approved and funded, future analysis will meet all current construction design criteria.

For analysis, the 1% AEP LORR Base Year (2035) levels and wave berm requirements were used with an estimated overbuild (OB). Conservative assumptions were made for subsurface strengthening due to the initial (preload) lift for the Base Year LORR analyses. In most cases, the overbuild is 3 to 5 feet for the crown with some overbuild for the levee berms. As an added bonus, the overbuild section analyses show that predicted future levels are attainable within established safety factors.

### 3.10 Borrow Material

Borrow sources may include adjacent borrow pits and hauled in fill, whenever it is an acceptable source. Information used to determine the adequacy of borrow material along the various alignments included borrow borings where available, borings and CPTs along the baseline, and information supplied by the local sponsor. The undisturbed borings are generally in the foot print of the levee, but in many areas where those borings were obtained at natural ground elevations (below +3), assumptions can be made about the suitability of side cast borrow.

Some of the borings from the local sponsor are not along the alignment, resulting in more extrapolation. There are not enough borings, including vibracores, to accurately cover the area and determine the suitability of borrow with great certainty. A more extensive investigation would have been too time consuming and costly during this phase of the investigation. It is generally anticipated that the first section will primarily serve to preload the foundation of the levees. The fill generally will come from side cast borrow that will need some drying prior to construction of the levee section in horizontal layers not to exceed 3 feet in thickness for the first layer (or until 1 foot above the water) and not to exceed 2 feet in thickness for subsequent layers. To help reduce the water content, the clay material from adjacent borrow areas should be placed within or adjacent to the levee footprint and allowed to dry to a moisture content that shall not be lower than 40 and no higher than 20 prior to incorporating the fill into the levee layers. The levee section layers will require a minimum effort of compaction (i.e., three passes of a dozer) to achieve a minimum cohesive strength of 300 psf.

Where adjacent material is used, the top five feet may be unsuitable due to the presence of highly organic soils. In some areas, material will be hauled from offsite borrow areas. A much more in-depth borrow investigation will have to be performed at the next level of study.

### 3.11 Foundation Settlement

Consolidation tests are expensive and time consuming. Some undisturbed boring samples were tested for this phase of the investigation. Settlement predictions are based on limited consolidation data and are not intended to be precise. Predicted settlement curves and associated analysis will be furnished upon request. Settlement predictions were analyzed for the 3% AEP and 1% AEP LORR levees. The area consists mainly of marshland.

Bayous, which pass through the area in a north to south direction and fan out into the gulf, deposit the coarsest soil along their banks. When the bayous meander and change coarse, areas of coarser and less prone to settlement materials are left in erratic configurations. The opposite occurs at areas away from the bayous where fine clay and organic materials accumulate. Settlement in the areas comprised of clay and organic matter is much greater than in the areas that contain the coarser soils. Another important feature of the area is the large number of canals and channels. Settlement calculations for the canal areas are beyond the scope of this study.

These areas will experience more settlement due to the greater heights of fill and the soft canal bottoms. The emphasis of the study was to arrive at settlement values that are in the average range, realizing that the actual value can be more than the calculated values.

### 3.12 Time Rate of Consolidation

The time required for the foundation to settle is difficult to determine because it depends on many variables, such as past overburden, the amount of organic soils, thickness of clay layers, size of clay platelets, amount of silt or sand in the foundation, the layering of silts and sands, number of foundation drainage layers, and other factors. Time rate of consolidation was used to predict lift schedules for the economic analysis. The coefficient of consolidation $C_v$ value was extrapolated from available testing data.

### 3.13 Levee Seepage

This project consists of multiple levee reaches due to foundation soil differences. Design reaches require design elevations that vary from 13.0 to 23.0 NAVD88 (for 1% AEP LORR, Base Yr). A seepage analysis was analyzed for the foundation of Reach F and Reach I. Reach F is believed to be the most vulnerable to seepage due to the presence of near surface sands and will represent a worst case seepage condition for the western portion of the project. Reach I is typical of many of the eastern reaches in regards to seepage. Details on the seepage analyses can be furnished upon request.

### 3.14 Recommendations

Based on the information that is available, some of the 3% AEP and most of the 1% AEP should not be erected by one lift construction. The amount of soil that is required to provide the required crown elevations for these reaches may exceed the resistance that is available in the foundation and increases the probability for stability failures to unacceptable levels. Construction sequencing is recommended to promote foundation soil strengthening to withstand the loading of future levee enlargements.

### 3.15 General Structural Design

#### 3.15.1 Geotechnical Analysis of Structures

The project has numerous gated flood control structures across bayous, canals, and roads as well as many water control culverts to allow tidal flow that will be closed during hurricane conditions. Feasibility geotechnical design of sector gates, floodgates (roads), culvert structures, and T-Walls are presented below.

<u>ALL FLOODWALLS</u>: HSDRRS criteria for Floodwalls/T-Wall design as compared to the below referenced Ems, etc. consist of additional checks, list specific methods for analysis, and has a more stringent or equal criteria for various safety factors.

The HSDRRS criteria for T-Wall design list the following USACE Publications for General Design Guidance:

- EM 1110-2-2502, Retaining and Flood Walls, Sept. 89
- EM 1110-2-2906, Design of Pile Foundations, Jan. 91
- EM 1110-2-2504, Design of Sheet Pile Walls, Mar. 94
- EM 1110-2-1913, Design and Construction of Levees, Apr. 00
- EM 1110-2-1901, Seepage Analysis and Control for Dams, Apr 93
- EM 1110-2-2100, Stability Analysis of Concrete Hydraulic Structures, Dec 05
- DIVR 1110-1-400, Soil Mechanic Data, Dec. 98
- ETL 1110-2-569, Design Guidance for Levee Underseepage, May 05

### 3.15.2 Bayou Dularge Gate Structure Stability Analyses

The proposed sector gate structure was studied using previously obtained strength lines in this area. Both the sector gate and the T-wall were deemed geologically similar enough to use the same strength line for both. Elevations of the top of the structures were supplied by ED-T personnel. No detailed surveys were available at this stage, so ground surface elevations were assumed at EL -7 for the sector gate structure. Low ground water elevations of EL -1 were used. For the purposes of this study, the structures were analyzed with water to the top of the structures. Analyses of sporadic low areas (intermittent) are beyond the scope of this study, especially with the data that is currently available. For current designs, crossings and other anomalies were not specifically addressed.

Due to similarities in the soil parameters, loading, and dimensions, the analysis results for the Bayou Dularge sector gate structure are generally applicable to the Bayou Grand Caillou Sector Gate, Shell Canal E, Bayou Black, Shell Canal West, NAFTA Gates, Minors Canal Gate, and Falgout Canal Sector Gate.

#### 3.15.2.1 Stability Criteria

The sector gates were analyzed for a safety factor of 1.4 with flood water to the top of structure. The HSDRRS guidelines were utilized on this study as applicable. Spencer's stability method was used for analysis of global stability. For further detailed design and development for plans, both Spencer's stability and verification by use of another stability method (program) is recommended and required.

#### 3.15.2.2 Stability Analyses

The functionality of the sector gate precludes the use of stability berms. The structure stability was analyzed with an industry accepted computer program SLOPE/W (ver. 7.15), part of the Geo-Studio 2007 Suite. The structures were analyzed using Spencer Analysis for the High Water Level (HWL) with Block Failure options of the SLOPE/W program. Failure surfaces were optimized to obtain the highest unbalanced load.

#### 3.15.2.3 Stability Results

The sector gate structure was analyzed using a base slab elevation of -12.0, ground surface elevation of -7.0, flood side (FS) water to the top of the structure (elevation 25.5), and protected side (PS) water elevation of -1.0. Stability analysis determined there are no unbalanced loads for the sector gate. Results of the stability will be furnished upon request. A summary of these results are listed in Table 108 below.

**Table 108 Stability Results for Bayou Dularge - Sector Gate**

| FS Water Elevation | Type of Search | Critical Failure Elevation | Required Factor of Safety | Factor of Safety Obtained |
|---|---|---|---|---|
| EL. 25.5 | Block Search | EL. -51.0 | 1.40 | 1.40 |
| EL 25.5 | Fully Specified (Optimized) | EL -51.0 | 1.40 | 1.52 |

#### 3.15.2.4 Temporary Retaining Structure

A Temporary Retaining Structure (TRS) was designed for the sector gate structure for cost estimating purposes. Design of the actual TRS is normally required of the contractor. Results of the TRS design will be furnished upon request. A summary of these results are listed in Table 109. The TRS was designed using a combination of CWALSHT and VWALSHT. CWALSHT is a Case program developed by the USACE for the use in designing and analyzing sheetpile structures. VWALSHT is an excel spreadsheet developed by Richard Varuso, PH.D, P.E. for the use in designing a TRS. Due to the similarities in soil parameters, loading, and dimensions, The Bayou Dularge TRS design calculations are applicable for Bayou Grand Caillou Sector Gate, Shell Canal E, Bayou Black, Minors Canal Gate, Falgout Canal Sector Gate, Bayou

Terrebonne, Grand Bayou Sector Gate, Humble Canal Sector Gate, Placid Canal Sector Gate, and Bayou Petite Caillou Sector Gate.

**Table 109 Results of Bayou Dularge-Sector Gate TRS Design**

| Tip Elevation | Bending Moment (Ft-Kips) | Anchor Force 1 (Kips) | Anchor Force 2 (Kips) | Anchor Force 3 (Kips) |
|---|---|---|---|---|
| EL. -66.3 | 96.9 | 7.7 @ EL. -2.0 | 8.1 @ EL. -7.0 | 24.8 @ EL. -13.0 |

### 3.15.3 Bayou Dularge T-wall Stability Analyses

The Bayou Dularge T-wall was studied using previously obtained strength lines in this area. Both the sector gate and the T-wall were deemed geologically similar enough to apply the same strength line to both. Elevations of the top of the structures were supplied by ED-T personnel. No detailed surveys were available at this design stage, so realistic ground surface elevations were assumed at -1 for the T-wall. Low ground water elevations were also assumed at -1. For the purposes of this study, the structures were analyzed with water to the top of the structures. Analyses of sporadic low areas (intermittent) are beyond the scope of this study, especially with the data that is currently available. For current designs, crossings and other anomalies were not specifically addressed. Due to similarities in the soil parameters, loading, and dimensions, the T-wall analysis results for the Bayou Dularge structure are applicable to the Bayou Grand Caillou Sector Gate, Shell Canal West, NAFTA Gates, Minors Canal Gate, and Falgout Canal Sector Gate.

#### 3.15.3.1 Stability Criteria

The T-wall was designed for a safety factor of 1.4 with flood water to the top of structure. The HSDRRS guidelines were utilized on this study as applicable. Only Spencer's stability method was required for this study. For further detailed design and development for plans, both Spencer's stability and verification by use of another stability method will be required.

#### 3.15.3.2 Stability Analyses

No stability berms were designed for the T-wall. The structure stability was analyzed with an industry accepted computer program SLOPE/W (ver. 7.15), part of the Geo-

Studio 2007 Suite. The structures were analyzed using Spencer Analysis for the HWL with Block Failure options of the SLOPE/W program. Failure surfaces were optimized to obtain the highest unbalanced load.

#### 3.15.3.3 Stability Results

The T-wall was analyzed using a base elevation of -7.0, ground surface elevation of -1.0, flood side (FS) water to the top of the structure (elev. 25.5), and protected side (PS) water elevation of -1.0. Stability analysis determined that an unbalanced load was required for the T-wall. Results of the stability analyses will be furnished upon request. These results are summarized in Table 110 below.

**Table 110 Stability Results for Bayou Dularge T-Wall**

| FS Water Elevation | Type of Search | Critical Failure Elevation | Max. UBL (lbs) | Elevation of UBL | Required Factor of Safety | Factor of Safety Obtained |
|---|---|---|---|---|---|---|
| EL. 25.5 | Fully Specified (Optimized) | EL. -51.0 | N/A | N/A | 1.40 | 1.11 |
| EL. 25.5 | Fully Specified (Optimized) | EL. -51.0 | 16,500 lbs | EL. -29.0 | 1.40 | 1.40 |

### 3.15.4 Bayou Terrebonne Sector Gate

The proposed sector gate structure was studied using previously obtained strength lines in this area. Elevations of the top of the structures were supplied. No detailed surveys were available at this stage so realistic ground surface and ground water elevations were assumed. Only water to the top of the structure was analyzed to provide a reasonable cost estimate. Analyses of sporadic low areas (intermittent) are beyond the scope of this study, especially with the data that is currently available. For current designs, crossings and other anomalies were not specifically addressed. Due to similarities in the soil parameters, loading, and dimensions, the analysis results for the Bayou Terrebonne structure are applicable to the Grand Bayou Sector Gate, Humble Canal Sector Gate, Placid Canal Sector Gate, and Bayou Petite Caillou Sector Gate.

#### 3.15.4.1 Stability Criteria

The sector gate was designed for a safety factor of 1.40 with flood water to the top of structure. The HSDRRS guidelines were utilized on this study as applicable. Only Spencer's method was required for this study. For further detailed design and development for plans, both Spencer's stability and verification by use of another stability method (program) is recommended and required.

#### 3.15.4.2 Stability Analyses

The sector gate was analyzed with an industry accepted computer program, SLOPE/W (ver. 7.15), part of the Geo-Studio 2007 Suite. The structure was analyzed using Spencer Analysis for the HWL with Block Failure and Fully Specified options of the SLOPE/W program. No stability berms were designed since functionality of the sector gate precludes their use. Failure surfaces were optimized to obtain the most critical factor of safety.

#### 3.15.4.3 Stability Results

The sector gate structure was analyzed using a base elevation of -15.0, ground surface elevation of -9.0, flood side (FS) water to the top of the structure (elev. 33.0), and protected side (PS) water elevation of -1.0. Stability analysis (see Table 111 below) determined that an unbalanced load was required for the sector gate.

**Table 111 Stability Results for Bayou Terrebonne Sector Gate**

| Structure Sector Gate Analysis | | | | | |
|---|---|---|---|---|---|
| **Structure** | **Sill EL.** | **Base EL.** | **Structural Analysis Factor of Safety** | **Unbalanced Load Needed** | **Factor of Safety without Unbalanced Load** |
| Bayou Terrebonne SG | -9 | -15 | 1.4 | 21000 lbs @ EL. -25 | 0.87 |

#### 3.15.4.4 Temporary Retaining Structure

A Temporary Retaining Structure (TRS) was not designed for the Bayou Terrebonne sector gate structure. Instead, due to similarities in the soil parameters, loading, and dimensions, the analysis results for the Bayou Dularge Sector Gate (TRS) are applicable to the Bayou Terrebonne Sector Gate. Design of the actual TRS is normally done by the contractor. Results of the TRS design (for cost estimating) are included in Table 112. The TRS was designed using a combination of CWALSHT and VWALSHT. CWALSHT is a Case program developed by the USACE for the use in designing and analyzing sheetpile structures. VWALSHT is an excel spreadsheet developed by Richard Varuso, PH.D, P.E. for the use in designing a TRS.

**Table 112 Results of Bayou Terrebonne TRS Design (Via Bayou Dularge)**

| TRS Analysis | | | | |
|---|---|---|---|---|
| **Tip Elevation** | **Bending Moment (Ft-Kips)** | **Anchor Force 1 (Kips)** | **Anchor Force 2 (Kips)** | **Anchor Force 3 (Kips)** |
| EL. -66.3 | 96.9 | 7.7 @ EL. -2.0 | 8.1 @ EL. -7.0 | 24.8 @ EL. -13.0 |

### 3.15.5 Bayou Terrebonne T-Wall

The proposed T-Wall was studied using previously obtained strength lines in this area. Elevations of the top of the structures were supplied by ED-T personnel. No detailed surveys were available at this stage so realistic ground surface and ground water elevations were applied. For the purposes of this study, the structures were analyzed with water to the top of the structures. Analyses of sporadic low areas (intermittent) are beyond the scope of this study, especially with the data that is currently available. For current designs, crossings and other anomalies were not specifically addressed. Due to similarities in the soil parameters, loading, and dimensions, the analysis results for the Bayou Terrebonne structure are applicable to the Grand Bayou Sector Gate, Humble Canal Sector Gate, Placid Canal Sector Gate, and Bayou Petite Caillou Sector Gate.

#### 3.15.5.1 Stability Criteria

The T-Wall was designed for a safety factor of 1.40 with flood water to the top of structure. The HSDRRS guidelines were utilized on this study as applicable. Spencer's stability method was used for analysis of global stability. For further detailed design and development for plans, both Spencer's stability and verification by use of another stability method is recommended and required.

#### 3.15.5.2 Stability Analyses

The T-Wall was analyzed with an industry accepted computer program, SLOPE/W (ver. 7.15), part of the Geo-Studio 2007 Suite. The T-Wall was analyzed using Spencer Analysis for the HWL with Block Failure and Fully Specified options of the SLOPE/W program. No stability berms were designed at this time. Failure surfaces were optimized to obtain the most critical factor of safety and the highest unbalanced load (UBL).

#### 3.15.5.3 Stability Results

The T-Wall was analyzed using a base elevation of -9.0, ground surface elevation of -3.0, flood side (FS) water to the top of the structure (elev 33.0), and protected side (PS) water elevation of -1.0. Stability analysis determined that an unbalanced load was required for the T-Wall. Results of this analysis are summarized in Table 113.

**Table 113 Stability Results for Bayou Terrebonne T-Wall**

| FS Water Elevation | Type of Search | Critical Failure Elevation | Max. UBL (lbs) | Elevation of UBL | Required Factor of Safety | Factor of Safety Obtained |
|---|---|---|---|---|---|---|
| EL. 33.0 | Fully Specified (Optimized) | EL. -35.0 | N/A | N/A | 1.40 | 0.69 |
| EL. 33.0 | Fully Specified (Optimized) | EL. -35.0 | 33000 lbs | EL. -22.0 | 1.40 | 1.41 |

### 3.15.6 Bush Canal Sector Gate

The proposed sector gate structure was studied using previously obtained strength lines in this area. Elevations of the top of the structures were supplied. No detailed surveys were available at this stage so realistic ground surface and ground water elevations were assumed. For the purposes of this study, the structures were analyzed with water to the top of the structures. Analyses of sporadic low areas (intermittent) are beyond the scope of this study, especially with the data that is currently available. For current designs, crossings and other anomalies were not specifically addressed.

#### 3.15.6.1 Stability Criteria

The sector gate was designed for a safety factor of 1.40 with flood water to the top of structure. The HSDRRS guidelines were utilized on this study as applicable. Spencer's stability method was required for this study. For further detailed design and development for plans, both Spencer's stability and verification by use of another stability method (program) is recommended and required.

#### 3.15.6.2 Stability Analyses

The sector gate was analyzed with an industry accepted computer program, SLOPE/W (ver. 7.15), part of the Geo-Studio 2007 Suite. No stability berms were designed since functionality of the sector gate precludes their use. The structures were analyzed using Spencer Analysis for the High Water Level (HWL) with Block Failure options of the SLOPE/W program. Failure surfaces were optimized to obtain the highest unbalanced load.

#### 3.15.6.3 Stability Results

The sector gate structure was analyzed using a base elevation of -18.0, ground surface elevation of -12.0, flood side (FS) water to the top of the structure (elev. 33.0), and protected side (PS) water elevation of -1.0. Stability analysis determined that an unbalanced load was not required for the sector gate. The results of the analysis on the GIWW-West sector gate are listed in Table 114 .

**Table 114 Stability Results for GIWW-West Sector Gate**

| FS Water Elevation | Type of Search | Critical Failure Elevation | Required Factor of Safety | Factor of Safety Obtained |
|---|---|---|---|---|
| EL. 33.0 | Fully Specified (Optimized) | EL. -50.0 | 1.40 | 2.00 |

#### 3.15.6.4 Temporary Retaining Structure

A Temporary Retaining Structure (TRS) was designed for the sector gate structure to provide a high level cost estimate. Design of the actual TRS is normally done by the contractor. Results of the TRS design are listed in Table 115. The TRS was designed using a combination of CWALSHT and VWALSHT. CWALSHT is a Case program developed by the USACE for the use in designing and analyzing sheetpile structures. VWALSHT is an excel spreadsheet developed by Richard Varuso, PH.D, P.E. for the use in designing a TRS.

**Table 115 Results of GIWW-West TRS Design**

| Tip Elevation | Bending Moment (Ft-Kips) | Anchor Force 1 (Kips) | Anchor Force 2 (Kips) | Anchor Force 3 (Kips) |
|---|---|---|---|---|
| EL. -51.4 | 62.4 | 15.5 @ EL. -5.0 | 12.5 @ EL. -12.0 | 17.2 @ EL. -19.0 |

### 3.15.7 Bush Canal T-Wall

The proposed T-Wall was studied using previously obtained strength lines in this area. Elevations of the top of the structures were supplied by ED-T personnel. No detailed surveys were available at this stage so realistic ground surface and ground water elevations were assumed. For the purposes of this study, the T-Walls were analyzed with water to the top of the walls. Analyses of sporadic low areas (intermittent) are beyond the scope of this study, especially with the data that is currently available. For current designs, crossings and other anomalies were not specifically addressed.

#### 3.15.7.1 Stability Criteria

The T-Wall was designed for a safety factor of 1.40 with flood water to the top of structure. The HSDRRS guidelines were utilized on this study as applicable. For further detailed design and development for plans, both Spencer's stability and verification by use of another stability method (program) is recommended and required.

#### 3.15.7.2 Stability Analyses

The T-Wall was analyzed with an industry accepted computer program, SLOPE/W (ver. 7.15), part of the Geo-Studio 2007 Suite. The T-Wall was analyzed using Spencer

Analysis for the HWL with Block Failure options of the SLOPE/W program. No stability berms were designed at this time. Failure surfaces were optimized to obtain the most critical factor of safety and the highest unbalanced load (UBL).

#### 3.15.7.3 Stability Results

The T-Wall was analyzed using a base elevation of -12.0, ground surface elevation of -6.0, flood side (FS) water to the top of the structure (elev. 33.0), and protected side (PS) water elevation of -1.0. Stability analysis determined that an unbalanced load was required for the T-Wall. The results of the analysis on the GIWW-West T-Wall are presented in Table 116.

**Table 116 Stability Results for GIWW-West T-Wall**

| FS Water Elevation | Type of Search | Critical Failure Elevation | Max. UBL (lbs) | Elevation of UBL | Required Factor of Safety | Factor of Safety Obtained |
|---|---|---|---|---|---|---|
| EL. 33.0 | Fully Specified (Optimized) | EL. -30.0 | N/A | N/A | 1.40 | 1.39 |
| EL. 33.0 | Fully Specified (Optimized) | EL. -30.0 | 800 lbs | EL. -18.0 | 1.40 | 1.40 |

### 3.16 Larose (GIWW) Floodwall (T-Wall)

The proposed T-Wall was studied using previously obtained strength lines in this area. Elevations of the top of the structures were supplied by ED-T personnel. No detailed surveys were available at this stage so realistic ground surface and ground water elevations were applied. For the purposes of this study, the structures were analyzed with water to the top of the structures.

The proposed Larose Floodwall will serve a dual purpose. It will serve to protect the Larose area from high waters in the Gulf Intracoastal Waterway (GIWW). For the Larose to Golden Meadow loop protection, the GIWW is the “floodside” of the protection. If the Morganza to the Gulf protection is authorized, funded and constructed, the GIWW side of the new Larose floodwall will be inside the GIWW East Floodgate and thus will be part of the “protected” side of the MTG loop protection.

#### 3.16.1.1 Stability Criteria

The T-Wall was designed for a safety factor of 1.40 with flood water to the top of wall (TOW). The HSDRRS guidelines were utilized on this study as applicable. Spencer's stability method was used for analysis of global stability. For further detailed design and development for plans, both Spencer's stability and verification by use of another stability method is recommended and required.

#### 3.16.1.2 Stability Analyses

The T-Wall was analyzed with an industry accepted computer program, SLOPE/W (ver. 7.19), part of the Geo-Studio 2007 Suite. The T-Wall was analyzed using Spencer Analysis for the HWL (or TOW) with "NonCircular Failure" analysis and "Fully Specified" failure analysis options of the SLOPE/W program. No stability berms were designed at this time. Failure surfaces were optimized to obtain the most critical factor of safety and the highest unbalanced load (UBL).

#### 3.16.1.3 Stability Results

The T-Wall was analyzed using a base elevation of -0.5, ground surface elevation of +2.5, flood side (FS) water to the top of the wall (elev 15.0), and protected side (PS) water elevation of -1.0. Stability analysis determined that an unbalanced load was required for the T-Wall. The results of the analysis on the Larose Floodwall (T-Wall) are shown in Table 117 .

**Table 117 - Stability Results for Larose Floodwall (T-Wall)**

| FS Water Elevation | Type of Search | Critical Failure Elevation | Max. UBL (lbs) | Elevatiou of UBL | Required Factor of Safety | Factor of Safety Obtained |
|---|---|---|---|---|---|---|
| EL. 15.0 | Fully Specified (Optimized) | EL. -40.0 | N/A | N/A | 1.40 | 1.28 |
| EL. 15.0 | Fully Specified (Optimized) | EL. -40.0 | 55000 lbs | EL. -18.7 | 1.40 | 1.40 |

### 3.16.2 Pointe Aux Chenes Stability Analyses

The proposed sector gate structure was studied using previously obtained strength lines in this area. The elevation of the top of the structure was supplied. No detailed surveys were available at this stage so realistic ground surface elevations (el. -6.0) were assumed at the sector gate structure. Normal ground water elevation (el. -1.0) was also assumed. Only water to the top of the structure was analyzed to provide a reasonable cost estimate. Analyses of sporadic low areas (intermittent) are beyond the scope of this study, especially with the data that is currently available. For current designs, crossings and other anomalies were not specifically addressed.

#### 3.16.2.1 Stability Criteria

The sector gates were designed for a safety factor of 1.4 with flood water to the top of structure as shown in Table 118. The HSDRRS guidelines were utilized on this study as applicable. Spencer's method was required for this study. For further detailed design and development for plans, both Spencer's stability and verification by use of another stability method (program) is recommended and required.

**Table 118 - Pointe Aux Chenes Stability Criteria**

| Stability Method | Stability Case | Water Level | Req'd F.S. |
|---|---|---|---|
| SLOPE/W (Spencer) | TOS FAILING TO PS | HWL | 1.4 |

where

- HWL = High Water Level (Elev. 33.0)
- PS = Protected Side
- TOS = Top of Structure

#### 3.16.2.2 Stability Analyses

The sector gate was analyzed and had unbalanced loads (see Table 119 below). Results of the stability analyses will be furnished upon request. The functionality of the sector gate precludes the use of stability berms. The structure stability was analyzed with an industry accepted computer program SLOPE/W (ver. 7.15), part of the Geo-Studio 2007 Suite. The structure was analyzed using Spencer Analysis for the HWL with Block Failure options of the SLOPE/W program. Failure surfaces were optimized to obtain the highest unbalanced load.

**Table 119 - Pointe Aux Chenes Analysis**

| Structure | Sill EL. | Base EL. | TRS Dredge Elevation | Structural Analysis Factor of Safety | Unbalanced Load Needed | FOS w/o Unbalanced Load |
|---|---|---|---|---|---|---|
| Pointe Au Chenes | -6 | -12 | -14 | 1.4 | 7440 lbs @ EL. -12.5 | 0.87 |

#### 3.16.2.3 Temporary Retaining Structure

A Temporary Retaining Structure (TRS) was designed for the sector gate structure to provide a high level cost estimate (see Table 120 below). Design of the actual TRS is normally done by the contractor. Results of the TRS design will be furnished upon request. The TRS was designed using a combination of CWALSHT and VWALSHT. CWALSHT is a Case program developed by the USACE for the use in designing and analyzing sheetpile structures. VWALSHT is an excel spreadsheet developed by Richard Varuso, Ph.D., P.E. for the use in designing a TRS.

**Table 120 - Pointe Aux Chenes TRS Analysis**

| TRS Analysis | Tip EL. * | Bending Moment (Ft-Kips) | Anchor Force 1 (Kips) | Anchor Force 2 (Kips) |
|---|---|---|---|---|
| Pointe Au Chenes | -45 | 56.2 | 12.8 @ EL. -5 | 6.6 @ EL. -13 |
| All values are to be used for design (bending moments and Tip FS=1.3 and Anchor Force FS=1.0) | | | | |
| * Sheets for Pointe Au Chenes should be tipped at Elevation -45 to cut off the sand layers above that elevation. | | | | |
| ** Lowest Anchor Force will be Tremie Slab | | | | |

### 3.16.3 Pointe Aux Chenes Stability Analyses

The proposed T-wall was studied using previously obtained strength lines in this area. The elevation of the top of the T-wall was supplied by ED-T personnel. No detailed surveys were available at this stage so realistic ground surface elevations (el. 0.0) were assumed at the T-wall. Normal ground water elevation (el. -1.0) was also assumed.

Only water to the top of the T-wall was analyzed to provide a reasonable cost estimate. Analyses of sporadic low areas (intermittent) are beyond the scope of this study, especially with the data that is currently available. For current designs, crossings and other anomalies were not specifically addressed.

#### 3.16.3.1 Stability Criteria

The T-wall was designed for a safety factor of 1.4 with flood water to the top of wall as shown in Table 121. The HSDRRS guidelines were utilized on this study as applicable. Spencer analysis method was required for this study. For further detailed design and development for plans, both Spencer's stability and verification by use of another stability method (program) is recommended and required during PED.

**Table 121 - Pointe aux Chenes T-Wall Stability Criteria**

| Stability Method | Stability Case | Water Level | Req'd F.S. |
|---|---|---|---|
| SLOPE/W (Spencer) | TOW FAILING TO PS | HWL | 1.4 |

where

- HWL = High Water Level (Elev. 33.0)
- PS = Protected Side
- TOW = Top of Wall

#### 3.16.3.2 Stability Analyses

The T-wall was analyzed and had unbalanced loads (see Table 122). Results of the stability analyses will be furnished upon request. No stability berms were designed for the T-wall. The T-wall stability was analyzed with an industry accepted computer program SLOPE/W (ver. 7.15), part of the Geo-Studio 2007 Suite. The T-wall was analyzed using Spencer Analysis for the HWL with Block Failure options of the SLOPE/W program. Failure surfaces were optimized to obtain the highest unbalanced load.

**Table 122 - Pointe Aux Chenes T-Wall Analysis**

| FS Water Elevation | Type of Search | Critical Failure Elevation | Max. UBL (lbs) | Elevation of UBL | Required Factor of Safety | Factor of Safety Obtained |
|---|---|---|---|---|---|---|
| EL. 33.0 | Fully Specified (Optimized) | EL. -11.0 | N/A | N/A | 1.40 | 0.99 |
| EL. 33.0 | Fully Specified (Optimized) | EL. -11.0 | 6600 lbs | EL. -8.5 | 1.40 | 1.40 |

### 3.16.4 GIWW-West Sector Gate

The proposed sector gate structure was studied using previously obtained strength lines in this area. Elevations of the top of the structures were supplied. No detailed surveys were available at this stage so realistic ground surface and ground water elevations were assumed. Only water to the top of the structure was analyzed to provide a reasonable cost estimate. Analyses of sporadic low areas (intermittent) are beyond the scope of this study, especially with the data that is currently available. For current designs, crossings and other anomalies were not specifically addressed. Due to similarities in the soil parameters, loading, and dimensions, the analysis results for the GIWW-West structure are applicable to the GIWW-East structure.

#### 3.16.4.1 Stability Criteria

The sector gate was designed for a safety factor of 1.40 with flood water to the top of structure. The HSDRRS guidelines were utilized on this study as applicable. Only Spencer's method was required for this study. Both Spencer's and another method will be required during PED.

#### 3.16.4.2 Stability Analyses

The sector gate was analyzed with an industry accepted computer program, SLOPE/W (ver. 7.15), part of the Geo-Studio 2007 Suite. The structure was analyzed using Spencer Analysis for the HWL with Block Failure options of the SLOPE/W program. No stability berms were designed since functionality of the sector gate precludes their use. Failure surfaces were optimized to obtain the most critical factor of safety.

#### 3.16.4.3 Stability Results

The sector gate structure was analyzed using a base elevation of -26.0, ground surface elevation of -16.0, flood side (FS) water to the top of the structure, or elevation 23.0, and protected side (PS) water elevation of -1.0. Stability analysis determined that an unbalanced load was not required for the sector gate. The results of the analysis on the GIWW-West sector gate are presented in Table 123.

**Table 123 - Stability Results for GIWW-West Sector Gate**

| FS Water Elevation | Type of Search | Critical Failure Elevation | Required Factor of Safety | Factor of Safety Obtained |
|---|---|---|---|---|
| EL. 23.0 | Fully Specified (Optimized) | EL. -49.0 | 1.40 | 2.40 |

#### 3.16.4.4 Temporary Retaining Structure

A Temporary Retaining Structure (TRS) was designed for the sector gate structure to provide a high level cost estimate. Design of the actual TRS is normally done by the contractor. Results of the TRS design are included in Table 124 and Table 125 below. The braced excavation TRS was designed using a combination of CWALSHT and VWALSHT. CWALSHT is a Case program developed by the USACE for the use in designing and analyzing sheetpile structures. VWALSHT is an excel spreadsheet developed by Richard Varuso, PH.D, P.E. for the use in designing a TRS.

**Table 124 - Results of GIWW-West TRS Design (Braced Excavation)**

| Tip Elevation | Bending Moment (Ft-Kips) | Anchor Force 1 (Kips) | Anchor Force 2 (Kips) | Anchor Force 3 (Kips) | Anchor Force 4 (Kips) | Anchor Force 5 (Kips) |
|---|---|---|---|---|---|---|
| EL. -116.6 | 631.5 | 10.4 @ EL. -3.0 | 13.6 @ EL. -9.0 | 23.0 @ EL. -14.0 | 31.1 @ EL. -19.0 | 40.2 @ EL. -27.0 |

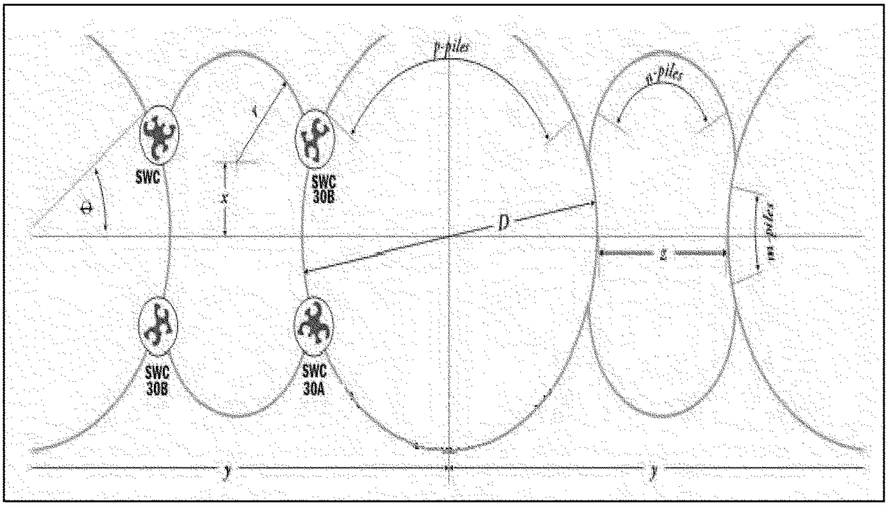


**Table 125 - Results of GIWW-West TRS Design (Cellular Cofferdam)**

| Tip Elevation | # pile s | D | z | y | r | X | □ | Number of Piles | | | Area | | Average Width |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ft | / Cell | ft | ft | ft | ft | ft | deg | m | n | p | within circle sq ft | between circles sq ft | ft |
| -76 | 132 | 67.28 | 19.56 | 86.83 | 14.33 | 16.93 | 31 | 22 | 27 | 42 | 3555 | 1406 | 57.1 |

Notes-

1. See Figure below for explanation of terms.
2. Deep Soil Mixing in center of cell to provide an increase in shear strength to El -82 (5 feet below the tip elevation.

### 3.16.5 GIWW-West T-Wall

The proposed T-Wall was studied using previously obtained strength lines in this area. Elevations of the top of the structures were supplied. No detailed surveys were available at this stage so realistic ground surface and ground water elevations were assumed. Only water to the top of the T-Wall was analyzed to provide a reasonable cost estimate. Analyses of sporadic low areas (intermittent) are beyond the scope of this study, especially with the data that is currently available. For current designs, crossings and other anomalies were not specifically addressed. Due to similarities in the soil parameters, loading, and dimensions, the analysis results for the GIWW-West T-Wall are applicable to the GIWW-East T-Wall.

#### 3.16.5.1 Stability Criteria

The T-Wall was designed for a safety factor of 1.40 with flood water to the top of structure. The HSDRRS guidelines were utilized on this study as applicable. Only Spencer's method was required for this study. Both Spencer's and another method will be required during PED.

#### 3.16.5.2 Stability Analyses

The T-Wall was analyzed with an industry accepted computer program, SLOPE/W (ver. 7.15), part of the Geo-Studio 2007 Suite. The T-Wall was analyzed using Spencer Analysis for the HWL with Block Failure options of the SLOPE/W program. No stability berms were designed at this time. Failure surfaces were optimized to obtain the most critical factor of safety and the highest unbalanced load (UBL).

#### 3.16.5.3 Stability Results

The T-Wall was analyzed using a base elevation of -16.0, ground surface elevation of -10.0, flood side (FS) water to the top of the structure, or elevation 23.0, and protected side (PS) water elevation of -1.0. Stability analysis determined that an unbalanced load was required for the T-Wall. The results of the analysis on the GIWW-West T-Wall are show in Table 126.

**Table 126 - Stability Results for GIWW-West T-Wall**

| FS Water Elevation | Type of Search | Critical Failure Elevation | Max. UBL (lbs) | Elevation of UBL | Required Factor of Safety | Factor of Safety Obtained |
|---|---|---|---|---|---|---|
| EL. 23.0 | Fully Specified (Optimized) | EL. -30.0 | N/A | N/A | 1.40 | 0.96 |
| EL. 23.0 | Fully Specified (Optimized) | EL. -30.0 | 9600 lbs | EL. -20.0 | 1.40 | 1.40 |

### 3.16.6 Dewatering and Sheet Pile Cutoff Design

It was determined, that a geotechnical analysis of the uplift pressures during dewatering needed to be performed for several structures in the Morganza to the Gulf Feasibility Study. Additionally, it was determined that design needed to be performed for the sheet pile seepage cutoff beneath the T-wall and structures. Included herein are the results of those analyses and the assumptions that were made.

#### 3.16.6.1 Uplift Design

Uplift pressures were assumed to develop in the underlying sand strata beneath the 17 structures that were analyzed. Top elevations for temporary retaining structures (TRS), and dredge line elevations where provided, for each of the excavations analyzed. 1% AEP still water elevations (SWE) were provided. Water elevations were assumed to be at the top of the TRS at elevation +6 feet. The total uplift driving head assumed was the difference in elevation from the top of the TRS to the dredge elevation of the excavation.

The USACE standardized method of calculating the FOS for uplift pressures was performed by dividing the resisting force (the weight of the overlying soil strata) by the driving force (pore water pressure in the critical sand strata). More details on this design will be furnished upon request.

#### 3.16.6.2 Seepage Cutoff Design

The 21 structures were designed by Lanes Creep Method for sheet pile seepage cutoff for the levee to structure transitions beneath the T-wall. Top of wall (TOW) structure elevations and sill elevations were provided for each of the structures analyzed. 1%

AEP still water elevations (SWE) were provided. The water head assumed was the difference in elevation from the TOW to the protected side water elevation of -1 feet.

Seepage cutoff design was performed for each of the provided reaches. Each of the provided reaches had a varying number of benches and elevations in the transition cross sections. The varying number of benches and elevations in the different transition cross sections affected the sheet pile design by reach, because of the soil stratification that the sheet piling was tipped. A numerical system of labeling the benches from below the structure elevation to the next highest bench towards the levee and so forth was used for sheet pile tip elevation design.

For sheet piling design it was assumed that the soil beneath the pile founded T-wall will settle and leave a gap between the base and the soil for a flow path. Thus the only seepage cutoff path taken into consideration in the Lanes Weighted Creep Ratio analysis was that of the sheet piling beneath the T-wall foundation. Sand and silt layers that the sheet piling penetrated were transformed by their corresponding creep ratios to that of a CH layer thickness with an equivalent creep ratio. More details of this analysis will be furnished upon request.

### 3.16.7 Pile Capacity For Structures

#### 3.16.7.1 Design Methods and Assumptions

Computations were made to determine the estimated allowable single pile load capacities for various sizes of precast concrete piles and steel H-Piles. Capacities were computed for piles driven from ground surfaces or from the excavated base elevations for various structures. The pile capacities were computed for Q-case and S-case soil parameters in accordance with EM 1110-2-2906 and the HSDRRS design guidelines (Jun 08 revised version).

The allowable load capacities for piles will be furnished upon request. Some provided curves are used for the multiple structures in the area with similar foundation conditions. The S-case analyses do not govern design. The pile capacities provided should be reduced by 33 percent (67 percent of indicated capacities) if a pile load test is not performed.

Q and S-case computations are plotted as ultimate capacity. Without a site specific pile test, a Factor-of-Safety of 3.0 and 1.5 is required for the Q-Case and S-Case, respectively, against failure of a single pile.

Where unbalanced loads exist at the T-wall structures, the axial capacity of the supporting piles above the identified critical depth should be ignored for support of the structure.

#### 3.16.7.2 Pile Group Capacity and Spacing

Piles will derive a majority of their supporting capacity from skin friction. Therefore, it will be necessary to consider the effect of group action.

#### 3.16.7.3 Estimated Settlement

Long-term settlement of individual pile foundations are typically not significant and usually in the range of ½ to ¾ inch. This estimate assumes piles will be driven in rows and does not include the elastic deformation of the piles. Elastic deformation can better be defined during the pile load test.

#### 3.16.7.4 Pile Driving

Close field supervision should be maintained by experienced personnel to ensure proper procedures are followed and accurate records are kept during pile driving operations. The driving record should include the pile type, overall length, tip and butt diameters, embedment below finished grade, and number of blows per foot of penetration. An accurate driving record is especially important to verify piles are installed to the required tip embedment and to give an indication of any unusual driving characteristics that may indicate pile breakage. Square precast concrete piles and steel H-Piles should be driven with a single acting air hammer with the hammer manufacturer's recommended rated energy (ft-lbs) per blow for each type (and length) of pile.

#### 3.16.7.5 Dynamic Pile Tests

If needed, a precast concrete test piles can be evaluated by a Dynamic Pile Test (DPT) using a Pile Driving Analyzer® (PDA) during the pile's installation. The PDA will monitor driving stresses during installation and evaluate pile integrity during installation. The PDA will also evaluate installation efficiency by monitoring the energy transferred to the pile by the hammer.

##### 3.16.7.6 Test Piles

Test piles should be installed along the project site. The number and location of the test piles will depend on the type and location of the project features. The test pile program will be developed once the project features are finalized.

##### 3.16.7.7 Static Load Tests

A series of load tests will be performed on piles considered for the project. The number of load tests will depend on the project features and will be provided during preparation of the plans and specifications. In general, load tests should be performed in accordance with ASTM D 1143. Project specifications will require load tests to failure or 300 percent of design load, whichever is achieved first. Static load tests will be performed no earlier than 21 days after initial pile installation.

##### 3.16.7.8 Monitoring Considerations

Installation of piles may affect nearby structures. When structures are nearby, vibrations should be monitored during the test pile program, installation of job piles, installation and removal of sheetpiles, and any demolition or other construction activities. The monitoring should be performed with a seismograph to evaluate peak particle velocities and frequency at critical structures during pile driving. The record of peak particle velocities should provide information in assessing potential damage and the need for changes in driving operations.

# 4 CIVIL DESIGN

## 4.1 Design Hurricane

The design hurricane for feasibility purposes are the 1% AEP hurricane and the 3% AEP hurricane. These storms represent a 1% AEP chance of occurring and 3% AEP chance of occurring in any given year respectively. See Section 2 of this report for specifics on storm modeling.

## 4.2 Levee Elevations

Levee elevations were determined by ensuring that the levee elevation equaled or exceeded the required hydraulic design elevation at any given point in time. To achieve this, each reach requires 2 or 3 lifts between 2019 and 2070 due to subsidence, consolidation, and other factors detailed in Section 2 and Section 3 of this report. Settlement curves and lift schedules with specific settlement and elevation data will be furnished upon request. Each reach was analyzed independently.

The initial construction resulting from this authorization will be considered and termed the Pre-Load (Initial Levee). With the exception of reach LGM (overlap) all reaches will require Pre-Load (Initial Levee) construction. Reach LGM (overlap) existing levee is within the proposed levee envelope and substantial enough to warrant accounting. All other reaches will ignore existing levees due to mis-alignment of centerline and insubstantial quantities. Enlargements to the Pre-Load (Initial Levee) will be termed lifts.

The Pre-Load (Initial Levee) design elevation will vary between elevation 10.0' and 14.0' NAVD88 depending on the reach and serves primarily as preload for future lifts. The Pre-Load (Initial Levee) design sections for all reaches, except for reach L2L B, will be the same for 1% AEP and 3% AEP level of risk reduction (LORR). Final lift elevations for the 3% AEP LORR will vary between elevations 13.0' and 20.0' NAVD88 depending on reach. Final lift elevations for the 1% AEP LORR will vary between elevations 22.0' and 28.0' NAVD88 depending on reach.

### 4.3 Levee Alignment

See Section 1.1 for location and description of project area. The Levee alignment includes 14 levee reaches including reaches BA, A, B, E, F, G, H, I, J, K, L, LGM (Overlap), L2L A, and L2L B and is broken down further into sub reaches as shown in Table 127.

**Table 127 – Levee Sub Reaches**

| Reach Data | | | | |
|---|---|---|---|---|
| Reach | Start Station | End Station | Length (ft.) | Lenth (mi.) |
| BA | 1000+00 | 1828+22 | 82,822 | 15.7 |
| A | 1828+22 | 2259+26 | 43,104 | 8.2 |
| B | 2259+26 | 2526+34 | 26,708 | 5.1 |
| E | 2526+34 | 2758+84 | 23,250 | 4.4 |
| F | 2758+84 | 2987+35 | 22,851 | 4.3 |
| G | 2987+35 | 3224+12 | 23,677 | 4.5 |
| H | 3224+12 | 3640+67 | 41,655 | 7.9 |
| I | 3640+67 | 3941+76 | 30,109 | 5.7 |
| J | 3941+76 | 4438+85 | 49,709 | 9.4 |

| Reach Data | | | | |
|---|---|---|---|---|
| Reach | Start Station | End Station | Length (ft.) | Lenth (mi.) |
| K | 4438+85 | 4706+99 | 26,814 | 5.1 |
| L | 4706+99 | 5021+78 | 31,479 | 6.0 |
| | | Sub Total | 402,178 | 76.2 |
| LGM (Overlap) | 2953+00 | 3193+50 | 24,050 | 4.6 |
| L2L A | 2481+08 | 2810+00 | 32,892 | 6.2 |
| L2L B | 2160+69 | 2481+08 | 32,039 | 6.1 |
| | | Sub Total | 88,981 | 16.9 |
| | | Total | 491,159 | 93 |
| | | | | |
| Sub Reach Data | | | | |
| Sub-Reach | Start Station | End Station | Length (ft.) | Lenth (mi.) |
| BA | 1000+00 | 1828+22 | 82,822 | 15.7 |
| A | 1828+22 | 2259+26 | 43,104 | 8.2 |
| B | 2259+26 | 2526+34 | 26,708 | 5.1 |
| E2 | 2526+34 | 2646+34 | 12,000 | 2.3 |
| E1 | 2646+34 | 2758+84 | 11,250 | 2.1 |
| F2 | 2758+84 | 2860+35 | 10,152 | 1.9 |
| F1 | 2860+35 | 2987+35 | 12,700 | 2.4 |
| G1 | 2987+35 | 3098+96 | 11,161 | 2.1 |
| G2 | 3098+96 | 3191+53 | 9,257 | 1.8 |
| G3 | 3191+53 | 3224+12 | 3,259 | 0.6 |
| H1 | 3224+12 | 3319+12 | 9,500 | 1.8 |
| H2 | 3319+12 | 3460+81 | 14,168 | 2.7 |
| H3 | 3460+81 | 3640+67 | 17,986 | 3.4 |
| I1 | 3640+67 | 3733+30 | 9,263 | 1.8 |
| I2 | 3733+30 | 3832+26 | 9,896 | 1.9 |
| I3 | 3832+26 | 3941+76 | 10,950 | 2.1 |
| J2 | 3941+76 | 4202+33 | 26,058 | 4.9 |
| J1 | 4202+33 | 4367+74 | 16,541 | 3.1 |
| J3 | 4367+74 | 4438+85 | 7,111 | 1.3 |
| K | 4438+85 | 4706+99 | 26,814 | 5.1 |
| L | 4706+99 | 5021+78 | 31,479 | 6.0 |
| | | Total | 402,178 | 76.2 |

| Reach Data | | | | |
|---|---|---|---|---|
| Reach | Start Station | End Station | Length (ft.) | Lenth (mi.) |
| LGM (Overlap) | 2953+00 | 3193+50 | 24,050 | 4.6 |
| L2L A | 2481+08 | 2810+00 | 32,892 | 6.2 |
| L2L B | 2160+69 | 2481+08 | 32,039 | 6.1 |
| | | Sub Total | 88,981 | 16.9 |
| | | Total | 491,159 | 93 |

### 4.4 Construction

For each reach (11-total), the Pre-Load (Initial Levee), will be constructed to the design dimensions and elevations. All design information and data is available upon request. All reaches except AB (3% only) and A (3% only) are designed with reinforcement geotextile. During first lift construction, the pre-load (initial levee) will be degraded for installation of reinforcing geotextile to approximate elevation +4.0' NAVD88 except reach L2L A and L2L B where degrading existing levee and placement of geotextile will placed during pre-load (initial levee) . Prior to the embankment construction, clearing and grubbing of the levee footprint will be required. For reach AB to L, the Pre-Load (Initial Levee) material will be excavated from the adjacent government furnished borrow area(s) land and/or flood side of levee within new rights of way. For reach LGM (overlap) to L2L B material will be hauled in. In adjacent borrow cases, the distance between the levee toe and top of borrow pit will vary from 50 feet to 125 feet. Borrow pits adjacent to and flood side of levee will require plugs or natural crossings every 500-feet to prevent erosive channeling of the pits. Borrow pits were sized assuming in place borrow to in place levee embankment ratio of 2-1 applied after stripping the top 3'-5' of unsuitable material for levee construction. The unsuitable levee material will be used for wetland mitigation. Borrow pit geometry will be 1V to 4H side and end slopes excavated to bottom elevation -20.0' NAVD, varying bottom widths, and discrete varying lengths adjacent and parallel to the centerline alignment on either the flood side or protected side. Levee grade material will be temporarily stockpiled then processed and placed within the authorized rights-of-way. Levee grade material will be placed and compacted in lifts and strictly tested in accordance with the QA/QC guidelines described in Hurricane and Storm Damage Risk Reduction System Design Guidelines (HSDRRS).

### 4.5 Embankment Material (Levee Grade Material)

Material used for embankment will be levee grade material meeting the HSDRRS guidelines. Levee grade material is currently defined and specified as follows-
Earth materials naturally occurring or Contractor blended materials that are classified in accordance with ASTM D2487 as CL or CH with less than 35% sand content are suitable for use as embankment fill (Materials classified as ML are suitable if blended to produce a material that classifies as CH or CL according to ASTM D 2487). Materials shall be free from masses of organic matter, sticks, branches, roots, and other debris including hazardous and regulated solid wastes. Isolated pieces of wood will not be considered objectionable in the embankment provided their length does not exceed 1 foot, their cross-sectional area is less than 4 square inches, and they are distributed throughout the fill. Not more than 1 percent (by volume) of objectionable material shall be contained in the earth material placed in each cubic yard of the levee section. Pockets and/or zones of wood shall not be placed in the embankment. Materials placed in the section must be at or above the Plasticity Index of 10. Materials placed in the section must be at or below organic content of 9 percent by weight, as determined by ASTM D 2974, Method C.

All levee grade material will be moisture controlled and compacted. Levee grade material will be compacted to at least 90% maximum dry density as determined by ASTM D 698 (Standard Proctor Compaction Test) at a moisture content within the limits of plus 5 to minimum 3 percentage points of optimum moisture content determined from ASTM D 698. Compactive techniques and effort vary but are typically some combination of mechanical rollers, scrapers, dozers and dump trucks to achieve the required compaction.

#### 4.5.1 Future Levee Enlargements

The levee will be constructed in lifts as described in section 4.2 Levee Elevations. Stability/wave berms are a key component of future levee design, providing additional stability and wave protection. Prior to first lift construction, the existing levee is projected to settle to approximate elevation+10.0' NAVD88. Settlement curves and lift schedules for reach specific settlement and elevation data will be furnished upon request. The first levee enlargement (lift one) will begin in years 2019 thru 2045. Reinforecment geotextile will be placed as described above. The material excavated as a result of the degrade operation will be temporarily stockpiled then re-used as compacted fill within the new levee section. Final lifts will occur in Years 2045 to 2070 completing the authorized levee. Borrow for construction of future lifts embankment will be obtained offsite at Government furnished borrow sources and truck hauled to the levee site. The average haul distance between the borrow source and construction site was assumed to be 25 miles for the 1% AEP alternative and 20 miles for the 3% AEPalternative. Borrow pit locations are not identified at this time. The material excavated for construction of embankment will be temporarily stockpiled and processed at the borrow pit site within Government rights-of-way prior to vehicular transport to the levee construction site. The embankment operation will also include borrow pit development, clearing and grubbing of the levee footprint, placing and compacting levee grade material, and fertilizing and seeding all disturbed areas.

### 4.6 Quantity

Pre-Load (Initial Levee) volume quantities were calculated by average end area method between the proposed Pre-Load (Initial Levee) section and existing grades. Existing grades were roughly estimated from low resolution Contractor furnished surveys and typically simplified as a plane at elevations varying between -2.0' and 0.0' NAVD88 depending on reach. See typical sections for reach specific existing grades. Lift volume quantities were calculated by average end area method between the lift and the Pre-Load (Initial Levee) and/or the existing grade where the lift extends beyond the Pre-Load (Initial Levee). The Pre-Load (Initial Levee)section was vertically adjusted to account for settlement shown in the settlement curves prior to area calculations for future lifts. Levee crowns were adjusted by the full amount shown on the settlement curves and levee berms were adjusted by an average of 1.0'. Finally a shrinkage factor of 12% was applied to all volume quantities. The volume of the existing levee is not included in volume calculations.

## 5 STRUCTURE DESIGN

### 5.1 Structural Project Features

This section summarizes the feasibility design work that was performed to develop sufficient quantities for the structural features that are part of the Morganza to the Gulf Alignment for both the 3% AEP and the 1% AEP level of protections. A limited design approach was followed due to the volume of structures within the alignment as well as the limited geotechnical and civil site data at some locations. For most structural features, designs were prepared for a limited number of structures and the remainder of the structures were pro-rated. Some structural features were not designed at all, rather quantified based on similar features from historical structures constructed with MVN, such as timber guidewalls and pile clusters. More critical, costly components such as the pile foundations for the structures were designed and quantified for each structure where adequate geotechnical site data was available.

## 5.2 General Structural Design Criteria

### 5.2.1 References

All design is in accordance with the Hurricane and Storm Damage Risk Reduction System Design Guidelines, New Orleans District Engineering Division, dated 23 October 2007 with Addenda dated 12 June 2008 along with other applicable Corps engineering guidance and applicable industry standards. Where there are discrepancies between the Hurricane and Storm Damage Risk Reduction System Design Guidelines and other references, the requirements of the Hurricane and Storm Damage Risk Reduction System Design Guidelines superseded the other references.

#### 5.2.1.1 Technical Publications

- American Concrete Institute, Building Code Requirements for Structural Concrete and Commentary (ACI 318-08).
- American Institute of Steel Construction (AISC), Manual of Steel Construction, Allowable Stress Design, 9th Edition.

#### 5.2.1.2 Corps of Engineers Publications

- Hurricane and Storm Damage Reduction System Design Guidelines, New Orleans District, 12 June 2008.
- EM 1110-2-2000 Standard Practice for Concrete for Civil Works Structures Change 2 (Mar 01).
- EM 1110-2-2104 Strength Design Criteria for Reinforced Concrete Hydraulic Structures (Jun 92, Aug 03).
- EM 1110-2-2105 Design of Hydraulic Steel Structures Change 1 (May 94).
- EM 1110-2-2502 Retaining and Floodwalls (Sep 89).
- EM 1110-2-2503 Design of Sheet Pile Cellular Structures Cofferdams & Retaining Structures (Sep 89).
- EM 1110-2-2703 Lock gates and Operating Equipment (Jun 94).
- EM 1110-2-2906 Design of Pile Foundations (Jan 91).
- ER 1110-2-8152 Planning and Design of Temporary Cofferdams and Braced Excavation (Aug 94).

#### 5.2.1.3 Computer Programs

- Structural Analysis and Design Software, “STAAD.Pro 2006”, release 23W, Research Engineers
- CE Pile Group Analysis Program, “CPGA”, CASE Program No. X0080
- “Mathcad”, Version 14.0.2.5, Parametric Technology Corporation

- "Microsoft Excel", 2007, Microsoft Corporation

### 5.2.2 General Design Criteria

Table 128 below provides the general load cases that were examined for all flood protection elements. The allowable overstress values taken are based on the 12 June 2008 revision of the HSDRRS criteria. For hydraulic steel structure (HSS) design, the allowable stress was multiplied by 0.83 times that allowed by AISC in accordance with EM 1110-2-2105.

**Table 128 - General Load Cases**

| LOAD CASE | % ALLOWABLE OVERSTRESS | |
|---|---|---|
| | WALL | FOUNDATION |
| CONSTRUCTION | 16 2/3 | 16 2/3 |
| CONSTRUCTION + WIND | 33 1/3 | 33 1/3 |
| SWL | 0 | 0 |
| | | |
| SWL + WIND | 33 1/3 | 33 1/3 |
| SWL + WAVE | 33 1/3 | 33 1/3 |
| SWL + WIND + BOAT IMPACT (BI) | 50 | 33 1/3 |
| REVERSE HEAD | 0 | 0 |
| REVERSE HEAD + WIND | 33 1/3 | 33 1/3 |
| REVERSE HEAD + WIND + BI | 33 1/3 | 33 1/3 |
| TOW | 33 1/3 | 33 1/3 |
| TOW + UNBALANCED LOAD | 50 | 50 |
| MAINTENANCE DEWATERING | 16 2/3 | 16 2/3 |
| MAINTENANCE DEWATERING + WIND | 33 1/3 | 33 1/3 |
| MAINTENANCE DEWATERING + BI | 50 | 50 |

#### 5.2.2.1 Unit Weights

Unit weights utilized for structural design are summarized in Table 129.

**Table 129 - Unit Weights**

| Item | LBS/CF* |
|---|---|
| Water | 62.4 |
| Steel | 490 |
| Granular Fill(saturated) | 120 |
| Stone | 132 |
| Stabilization Slab Concrete | 135 |
| Normal Weight Concrete | 150 |

*Unit weights taken from HSDRRS guidelines.

### 5.2.2.2 Loadings

#### 5.2.2.2.1 Water Elevations

The water elevations used for design are shown in Table 130.

**Table 130 - Water Elevations**

| Structure | SWL F/S 3% AEP | SWL F/S 1% AEP | SWL P/S | TOW F/S 3% AEP | TOW F/S 1% AEP | TOW P/S | Reverse F/S | Reverse P/S | Maint. Dewat. |
|---|---|---|---|---|---|---|---|---|---|
| Bayou Black 56' SG | 10.6 | 14.71 | -1 | 15 | 22 | -1 | -0.87 | 4.58 | 5 |
| Shell Canal East 56' SG | 10.93 | 15.24 | -1 | 16 | 23.5 | -1 | -1.35 | 2.87 | 5 |
| Minors Canal 56'SG | 11.32 | 15.6 | -1 | 16 | 23 | -1 | -1.25 | 2.54 | 5 |
| Falgout Canal 56' SG | 11.85 | 15.61 | -1 | 16.5 | 23 | -1 | -0.74 | 3.06 | 5 |
| Bayou DuLarge 56' SG | 13.77 | 18.21 | -1 | 18 | 25.5 | -1 | -0.74 | 3.06 | 5 |
| Bayou Grand Caillou 56' SG | 13.77 | 18.21 | -1 | 18 | 25.5 | -1 | -0.74 | 3.11 | 5 |
| Bayou Petite Caillou 56' SG | 13.71 | 17.7 | -1 | 22.5 | 30.5 | -1 | -2.76 | 3.49 | 5 |
| Placid Canal 56' SG | 14.74 | 18.64 | -1 | 24 | 31.5 | -1 | -2.76 | 3.49 | 5 |
| Bush Canal 56' SG | 15.48 | 19.63 | -1 | 25 | 33 | -1 | -1.14 | 2.99 | 5 |
| Bayou Terrebonne 56' SG | 15.48 | 19.63 | -1 | 25 | 33 | -1 | -1.64 | 3.10 | 5 |
| Humble Canal 56' SG | 15.48 | 19.63 | -1 | 25 | 33 | -1 | -1.64 | 1.19 | 5 |
| Pointe Aux Chenes 56' SG | 15.48 | 19.63 | -1 | 25 | 33 | -1 | -1.64 | 3.00 | 5 |
| Grand Bayou 56' SG | 14.69 | 19.75 | -1 | 21 | 29.5 | -1 | -2.76 | 3.49 | 5 |
| GIWW West 125' SG | 11.32 | 15.6 | -1 | 16 | 23 | -1 | -1.25 | 3.04 | 5 |
| GIWW East 125'SG | 12.06 | 18.2 | -1 | 17 | 25 | -1 | -1.64 | 3.96 | 5 |
| Elliot Jones 20' Stoplog Gate | 10.93 | 15.24 | -1 | 16 | 23.5 | -1 | -1.35 | 3.28 | 5 |
| Humphreys Canal 20' Stoplog Gate | 11.31 | 15.75 | -1 | 16 | 23.5 | -1 | -1.35 | 3.28 | 5 |
| Shell Canal West 30' Stoplog | 10.93 | 15.24 | -1 | 16 | 23.5 | -1 | -1.35 | 2.87 | 5 |

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**DRAFT ENGINEERING APPENDIX**

| Structure | SWL F/S 3% AEP | SWL F/S 1% AEP | SWL P/S | TOW F/S 3% AEP | TOW F/S 1% AEP | TOW P/S | Reverse F/S | Reverse P/S | Maint. Dewat. |
|---|---|---|---|---|---|---|---|---|---|
| Gate | | | | | | | | | |
| Marmande Canal 30' Stoplog Gate | 11.85 | 15.61 | -1 | 16.5 | 23.0 | -1 | -2.76 | 3.30 | 5 |
| Four Point Bayou 30' Stoplog Gate | 13.71 | 17.7 | -1 | 22.5 | 30.0 | -1 | -2.76 | 3.30 | 5 |
| Barrier 1 ECS | 11.31 | 15.75 | -1 | 16.0 | 23.5 | -1 | N/A | N/A | 5.0 |
| Barrier 2 ECS | 11.31 | 15.75 | -1 | 16.0 | 23.5 | -1 | N/A | N/A | 5.0 |
| Barrier 3 ECS | 11.31 | 15.75 | -1 | 16.0 | 23.5 | -1 | N/A | N/A | 5.0 |
| Barrier 4 ECS | 11.31 | 15.75 | -1 | 16.0 | 23.5 | -1 | N/A | N/A | 5.0 |
| Barrier 5 ECS | 11.31 | 15.75 | -1 | 16.0 | 23.5 | -1 | N/A | N/A | 5.0 |
| Barrier 6 ECS | 11.31 | 15.75 | -1 | 16.0 | 23.5 | -1 | N/A | N/A | 5.0 |
| Barrier 7 ECS | 11.31 | 15.75 | -1 | 16.0 | 23.5 | -1 | N/A | N/A | 5.0 |
| Reach A ECS | 11.32 | 13.71 | -1 | 16.0 | 22.5 | -1 | N/A | N/A | 5.0 |
| Reach E-1 ECS | 13.77 | 18.21 | -1 | 18.0 | 25.5 | -1 | N/A | N/A | 5.0 |
| Reach E-2 ECS | 13.77 | 18.21 | -1 | 18.0 | 25.5 | -1 | N/A | N/A | 5.0 |
| Reach G-2 – 1 ECS | 13.71 | 17.70 | -1 | 22.5 | 30.5 | -1 | N/A | N/A | 5.0 |
| Reach G-2 – 2 ECS | 13.71 | 17.70 | -1 | 22.5 | 30.5 | -1 | N/A | N/A | 5.0 |
| Reach G-2 – 3 ECS | 13.71 | 17.70 | -1 | 22.5 | 30.5 | -1 | N/A | N/A | 5.0 |
| Reach H-1 – 1 ECS | 13.71 | 17.70 | -1 | 22.5 | 30.5 | -1 | N/A | N/A | 5.0 |
| Reach H-1 – 2 ECS | 13.71 | 17.70 | -1 | 22.5 | 30.5 | -1 | N/A | N/A | 5.0 |
| Reach J2 – 1 ECS | 15.48 | 19.63 | -1 | 25.0 | 33.0 | -1 | N/A | N/A | 5.0 |
| Reach J2 – 2 ECS | 15.48 | 19.63 | -1 | 25.0 | 33.0 | -1 | N/A | N/A | 5.0 |
| Reach J2 – 3 ECS | 15.48 | 19.63 | -1 | 25.0 | 33.0 | -1 | N/A | N/A | 5.0 |
| Reach K – 1 ECS | 14.69 | 19.75 | -1 | 21.0 | 29.5 | -1 | N/A | N/A | 5.0 |
| Reach K – 2 ECS | 14.69 | 19.75 | -1 | 21.0 | 29.5 | -1 | N/A | N/A | 5.0 |
| Reach L ECS | 14.69 | 19.75 | -1 | 21.0 | 29.5 | -1 | N/A | N/A | 5.0 |
| Madison PS Fronting Protection | 15.48 | 19.63 | N/A | 25.0 | 33.0 | N/A | N/A | N/A | N/A |
| Pointe Aux Chenes PS Fronting Protection | 15.48 | 19.63 | N/A | 25.0 | 33.0 | N/A | N/A | N/A | N/A |
| Bayou Black PS Fronting Protection | 11.31 | 15.75 | N/A | 16.0 | 23.5 | N/A | N/A | N/A | N/A |
| Hanson Canal PS Fronting Protection | 11.31 | 15.75 | N/A | 16.0 | 23.5 | N/A | N/A | N/A | N/A |
| Hwy 315 Swing Gate | 13.77 | 18.21 | N/A | 18.0 | 25.5 | N/A | N/A | N/A | N/A |
| Hwy 55 Swing Gate | 13.71 | 17.7 | N/A | 25.0 | 33.0 | N/A | N/A | N/A | N/A |
| Hwy 56 Swing Gate | 13.71 | 17.7 | N/A | 22.5 | 30.0 | N/A | N/A | N/A | N/A |

| Structure | SWL F/S 3% AEP | SWL F/S 1% AEP | SWL P/S | TOW F/S 3% AEP | TOW F/S 1% AEP | TOW P/S | Reverse F/S | Reverse P/S | Maint. Dewat. |
|---|---|---|---|---|---|---|---|---|---|
| Hwy 665 Swing Gate | 15.48 | 19.63 | N/A | 25.0 | 33.0 | N/A | N/A | N/A | N/A |
| Four Point Road Swing Gate | 15.48 | 19.63 | N/A | 22.5 | 30.0 | N/A | N/A | N/A | N/A |
| NAFTA Swing Gate | 11.31 | 15.75 | -1 | 16 | 23.5 | -1 | -1.35 | 3.28 | 5 |
| C North Gulf South Pipeline | 13.2 | 17.4 | -1 | 18 | 23 | -1 | N/A | N/A | N/A |
| C North American Midstream Pipeline | 13.2 | 17.4 | -1 | 18 | 23 | -1 | N/A | N/A | N/A |
| C North Williams Discovery Pipeline | 13.2 | 17.4 | -1 | 18 | 23 | -1 | N/A | N/A | N/A |
| ECS Lockport to Larose 1 | 8.8 | 10.8 | -1 | 15 | 18 | -1 | -0.74 | 3.11 | 5 |
| ECS Lockport to Larose 2 | 8.8 | 10.8 | -1 | 15 | 18 | -1 | -0.74 | 3.11 | 5 |
| Union Pacific Railroad 36' Swing Gate | 8.8 | 10.8 | -1 | 15 | 18 | -1 | N/A | N/A | N/A |
| Larose FG 56' SG | 9 | 11.3 | -1 | 14 | 17 | -1 | -0.74 | 3.11 | 5 |
| GIWW Floodwall and Hwy 24 and Hwy 3235 36' Swing Gates | 9 | 11.3 | -1 | 14 | 17 | -1 | N/A | N/A | N/A |

#### 5.2.2.2.2 Lateral Pressure

Use Unit Weight and K at rest values
Ko = 0.8 for clay
Ko = 0.5 for granular materials
Ko = 0.5 for rip rap

The above at rest pressure coefficients are per the HSDRRS guidelines.

#### 5.2.2.2.3 Wind Pressures

The wind force utilized for design was 50 psf for hurricane conditions and 20 psf for maintenance conditions.

#### 5.2.2.2.4 Wave Loadings

Wave loadings utilized for design were provided by ED-H. The ED-H analysis will be furnished upon request. Wave loadings were not investigated for the Larose to Lockport Reach due to the short duration of the feasibility design effort for that reach. Wave load conditions typically did not govern for the remainder of the Morganza to the

Gulf alignment structures.

#### 5.2.2.2.5 Boat Impact

##### 5.2.2.2.5.1 Concrete Structures

Although the HSDRRS design guidelines do not specifically provide impact maps for Morganza to the Gulf, judgment was used to apply a 50 kip pleasure craft load to all 56' sector gate crossings and stop log gate crossings based on the fishing vessels and pleasure craft that will use these structures. The 125' sector gate crossings were designed for the unusual impact force of 200 kips in accordance with the HSDRRS design guidelines. A .5 kip/ft debris impact force was applied to all environmental control structures and fronting protection T-Walls based on the structures not being located on navigable waterways. The T-Walls along the GIWW and the tie-in walls for the Larose FG were designed for the unusual impact force of 200 kips in accordance with the HSDRRS design guidelines for a protected side impact from the GIWW and designed for the 50 kip pleasure craft load on the flood side.

##### 5.2.2.2.5.2 Sector Gate Channel Truss in Open Position and Sector Gate in Closed Position

The sector gate leaves were designed for a 125 kip impact force applied at each joint along the channel truss/skin plate in accordance with the requirements of EM 1110-2-2703, "Lock gates and Operating Equipment".

##### 5.2.2.2.5.3 Steel Roadway Swing Gates

Although the HSDRRS design guidelines do not specifically provide impact maps for Morganza to the Gulf, judgment was used to apply a 50 kip pleasure craft load to the roadway swing gates based on the fact that they are adjacent to navigation structures that fishing vessels and pleasure craft use.

#### 5.2.2.2.6 Uplift Conditions

Uplift conditions utilized for design were in accordance with Chapter 5 of the HSDRRS design guidelines.

Impervious - Sheet pile cutoff is assumed 100% effective
Pervious - Linearly varying between the F/S and P/S elevations

### 5.2.3 Concrete Design General Requirements

#### 5.2.3.1 Reinforced Concrete Strength

All reinforced concrete will have a design compressive strength of 4000 psi.

#### 5.2.3.2 Load Factors

Reinforced concrete hydraulic structures were designed in accordance with EM 1110-2-2104. EM 1110-2-2104 procedures are referenced to the load factors and strength reduction factors found in ACI 318-08, Appendix C.

A single load factor of 1.7 was used for dead and live loads in addition to a hydraulic factor of 1.3.

Strength reduction factor for bending = 0.9

Strength reduction factor for shear = 0.85

### 5.2.4 HNC Lock

Houma Navigation Lock was not designed as part of this study. The 50% Design Documentation Report (DDR) dated July 2008 by URS Group, Inc. was used to develop costs for this particular feature. Because the 50% DDR was based off a different level of protection (El 24.5) and sill elevation (El -23.0); the quantities were pro-rated based on the elevation/ hydrostatic pressure differences. The quantities contained within this study are based on a sill elevation of El -18.0 in conjunction with a 3% AEP level of protection of El 22.5 and a 1% AEP level of protection of El 30.5.

### 5.2.5 56' Sector Gates

This section contains a summary of work for the 13, 56' sector gate structures, which are part of the Morganza to the Gulf Alignment for both the 3% AEP and the 1% AEP level of protections. Table 131 lists the structures examined.

Table 131 - Structures

| Structure | Sill Elevation | Top Elevation (3% AEP) | Top Elevation (1% AEP) | Top of Guidewalls |
|---|---|---|---|---|
| Bayou Black | -12 | 15 | 22 | 10 |
| Shell Canal East | -12 | 16 | 23.5 | 10 |
| Minors Canal | -9 | 16 | 23 | 10 |
| Falgout Canal | -9 | 16.5 | 23 | 10 |
| Bayou DuLarge | -7 | 18 | 25.5 | 10 |
| Bayou Grand Caillou | -12 | 18 | 25.5 | 10 |
| Bayou Petite Caillou | -8 | 22.5 | 30.5 | 10 |
| Placid Canal | -8 | 24 | 31.5 | 10 |
| Bush Canal | -12 | 25 | 33 | 10 |
| Bayou Terrebonne | -9 | 25 | 33 | 10 |
| Humble Canal | -9 | 25 | 33 | 10 |
| Pointe Aux Chenes | -6 | 25 | 33 | 10 |
| Grand Bayou | -9 | 21 | 29.5 | 10 |
| Larose | -12.3 | 14 | 17 | 10 |

#### 5.2.5.1 Physical Features

The physical features associated with the construction of the 56 ft sector gate structures are as follows:

- Temporary Bypass Channels
- Phase 1 and 2 Interior Braced Cofferdams
- Sector Gate Concrete Monolith
- Sector Gate Pile Foundation
- Steel Sector Gate
- Needle Girder, Needles and Supports
- Needle Girder Storage Platform
- Guidewalls and Pile Clusters
- Sluice Gate Concrete Monolith*
- Sluice Gate Pile Foundation*
- Sluice Gates*
- Sluice Gate Bulkheads*
- Tie-in T-Walls
- Electrical Controls and Circuitry
- Mechanical Equipment

*(Bayou Grand Caillou, Bush Canal, Falgout Canal, Grand Bayou, Placid Canal and Bayou Petite Caillou only)

#### 5.2.5.2 Construction Sequencing

All sector gates will be constructed approximately in the center of the existing channels. A minimum 60' temporary bypass channel will be constructed as the first order of construction, allowing navigation passage during construction. Once navigation is routed through the temporary bypass channel, a cofferdam will be constructed, permitting the construction of the 56' sector gate monolith and the sluice gate monoliths, if applicable. Reduced power will be required for vessels passing through the construction area to reduce the risk of impact to the cofferdam. A timber guidewall and pile clusters will be provided along the bypass channel to prevent vessel impact on the cofferdam. Once construction of the 56' sector gate monolith and sluice gate monoliths is completed, navigation will be re-routed through the permanent sector gate structure. A phase 2 cofferdam will be required for the T-Walls adjacent to the sector gate/sluice gate structures. Once navigation is re-routed, the phase 2 cofferdam, needle girder storage platform, permanent guidewalls and pile clusters, tie-in t-walls and final civil site work can be completed.

#### 5.2.5.3 Structural Design

##### 5.2.5.3.1 Cofferdams

A Phase 1 cofferdam will be constructed to permit the in the dry construction of the sector gate concrete monolith and the sluice gate concrete monolith (if applicable). The cofferdam is an internally braced cofferdam with wide-flange walers and pipe braces supporting PZ sheet piling. Anchor forces, bending moment in the sheet piling, and required sheet piling tip elevation were computed for for Bush Canal, Bayou Dularge and Point Aux Chenes. Bayou Dularge cofferdam design was conservatively used for all remaining structures where no design was performed. Details of the Phase 1 cofferdam can be found on Plate S-024.

A phase 2 cofferdam will be constructed to permit the construction of the adjacent T-Walls to the sector gate/sluice gate structures that will be in the water. The same anchor forces, moments, and tips used for the Phase 1 cofferdams will be conservatively used for the Phase 2 cofferdams. Details of the Phase 2 cofferdam can be found on Plate S-100.

ER 1110-2-8152 will be followed throughout the project design process, requiring that all cofferdams will be designed by the Government.

#### 5.2.5.3.2 Sector Gate Monolith Concrete

Details of the concrete monolith are shown on Plates S-002 to S-004 (3% AEP LORR) and S-002A to S-004A (1% AEP LORR).

##### 5.2.5.3.2.1 Sector Gate Wall

Sector gate walls were designed as a cantilever beam extending from the base slab. A constant wall thickness was assumed the full height of the wall. A typical wall was designed for each sector gate. No pro-rating of wall thickness was performed. The resulting calculated wall thicknesses are summarized in Table 132.

**Table 132 - Wall Thickness**

| Structure | Wall Thickness (ft) (3% AEP) | Wall Thickness (ft) (1% AEP) |
|---|---|---|
| Bayou Black | 3.25 | 4.50 |
| Shell Canal East | 3.25 | 4.50 |
| Minors Canal | 3.00 | 4.50 |
| Falgout Canal | 3.00 | 4.50 |
| Bayou DuLarge | 3.00 | 4.50 |
| Bayou Grand Caillou | 3.50 | 5.00 |
| Bayou Petite Caillou | 3.50 | 6.00 |
| Placid Canal | 4.00 | 6.00 |
| Bush Canal | 4.75 | 7.00 |
| Bayou Terrebonne | 4.25 | 6.50 |
| Humble Canal | 4.25 | 6.50 |
| Pointe Aux Chenes | 4.00 | 6.00 |
| Grand Bayou | 3.50 | 6.00 |
| Larose | 3.00 | 3.50 |

##### 5.2.5.3.2.2 Sector Gate Thrust Block and Machinery Block

Sector gate thrust and machinery blocks were not designed because of their relatively small quantity compared to that of the remainder of the walls. Historical data from previously constructed sector gates was utilized to size the thrust and machinery blocks.

#### 5.2.5.3.2.3 Sector Gate Base Slab

The 56' sector gate base slab will be 134 ft long by 78 ft wide. The sector gate base slab thickness was determined utilizing 2D transverse and longitudinal strips. The transverse strip was taken beneath the thrust block while the longitudinal strip was taken beneath the machine and thrust blocks. The strips were designed as solid beams, given the property of the width of the slab that was examined. All loads acting along the width of the beams were input into STAAD (Structural Analysis and Design) and resolved along the centroid of the beam. Piles were modeled as pinned supports. The 2D strips were analyzed for the Falgout Canal and Bush Canal sector gates only. The remaining structures' base slab thickness was pro-rated based on the analysis performed for Falgout Canal and Bush Canal. The base slab thicknesses are summarized in Table 133.

**Table 133 - Base Slab Thickness**

| Structure | Slab Thickness (ft) (3% AEP) | Slab Thickness (ft) (1% AEP) |
|---|---|---|
| Bayou Black | 6.50 | 8.50 |
| Shell Canal East | 6.50 | 9.00 |
| Minors Canal | 6.00 | 8.00 |
| Falgout Canal | 6.00 | 8.00 |
| Bayou DuLarge | 6.00 | 8.00 |
| Bayou Grand Caillou | 7.00 | 9.50 |
| Bayou Petite Caillou | 7.00 | 10.00 |
| Placid Canal | 7.50 | 10.50 |
| Bush Canal | 8.50 | 12.00 |
| Bayou Terrebonne | 8.00 | 11.00 |
| Humble Canal | 8.00 | 12.00 |
| Pointe Aux Chenes | 7.50 | 10.00 |
| Grand Bayou | 7.00 | 10.00 |
| Larose | 6.50 | 7.50 |

### 5.2.5.3.3 Sector Gate Pile Foundation

#### 5.2.5.3.3.1 General

The pile foundation for the 3% AEP LORR sector gates will include 138 HP 14X73 piles battered on 3 vertical to 1 horizontal slope while the pile foundation for the 1% AEP LORR sector gates will include 193 HP 14X73 piles on a similar batter. The design Factors of Safety utilized for the design comply with EM 1110-2-2906 and the latest requirements in the HSDRRS design guidelines. All pile capacities used assumed compression pile testing, but no tension pile testing. Tension hooks are provided on all piles on the flood side of the sheet pile cutoff- wall to handle the maximum tensile load. CPGA analysis was performed for each sector gate. No pro-rating was performed. Details for the pile foundation are shown on Plate S-005 (3% AEP LORR) and S-005A (1% AEP LORR). Alternative pile types and arrangements will be investigated during detailed design for each structure to optimize the pile foundation.

5.2.5.3.3.2 **CPGA Analysis**

CPGA was utilized to develop the pile layouts for the gate structures and determine the required tip elevation. The piles were modeled as pinned connections with the piles providing all of the lateral resistance. The horizontal subgrade modulus was based on the soil in the top ten pile diameters. The horizontal subgrade modulus was reduced for group effects in accordance with EM 1110-2-2906.

5.2.5.3.3.3 **Pile Curves and Horizontal Subgrade Modulus**

Pile curves and horizontal subgrade modulus were calculated for a limited number of structures. Existing pile curves were utilized for those structures where no pile curve was calculated. A summary of the pile curve used for each structure is summarized below-

| 56' Gate Structure | | Pile Curve Utilized |
|---|---|---|
| *Bayou Grand Caillou* | → | *Bayou Grand Caillou* |
| *Bush Canal* | → | *Bush Canal* |
| *Bayou Terrebonne* | → | *Bayou Terrebonne* |
| *Humble Canal* | → | *Humble Canal* |
| *Bayou Pointe Aux Chenes* | → | *Bayou Pointe Aux Chenes* |
| *Grand Bayou* | → | *Grand Bayou* |
| *Bayou Black* | → | *Box Culverts for Barrier Alignment* |
| *Shell Canal East* | → | *Box Culverts for Barrier Alignment* |
| *Minors Canal* | → | *GIWW 175' Sector Gate West* |
| *Falgout Canal* | → | *Bayou Grand Caillou* |
| *Bayou Dularge* | → | *Bayou Grand Caillou* |
| *Bayou Petite Caillou* | → | *Lapeyrouse Canal* |
| *Placid Canal* | → | *Bayou Terrebonne* |
| *Larose FG* | → | *Larose to Golden Meadow Feasibility Study* |

The resulting pile tips are summarized in Table 134.

**Table 134 - Pile Tips**

| Structure | Pile Tip (ft) (3% AEP) | Pile Tip (ft) (1% AEP) |
|---|---|---|
| Bayou Black | -145.5 | -111.0 |
| Shell Canal East | -145.5 | -111.0 |
| Minors Canal | -141.0 | -124.0 |
| Falgout Canal | -126.5 | -116.0 |
| Bayou DuLarge | -124.5 | -116.0 |
| Bayou Grand Caillou | -135.5 | -128.5 |
| Bayou Petite Caillou | -157.0 | -157.0 |
| Placid Canal | -160.0 | -160.0 |
| Bush Canal | -158.0 | -124.0 |
| Bayou Terrebonne | -167.0 | -167.0 |
| Humble Canal | -125.5 | -129.5 |
| Pointe Aux Chenes | -137.0 | -137.0 |
| Grand Bayou | -151.0 | -151.0 |
| Larose | -145.5 | -126.0 |

#### 5.2.5.3.3.4 **Cut-off Wall**

A cut-off sheetpile wall will be provided to reduce possible seepage, scouring and uplift. A PZC-13 sheetpile meeting the requirements of ASTM A572, Grade 50 was assumed for the cutoff wall. Tip elevations were provided by New Orleans District Engineering

Division Geotechnical Branch utilizing Lane's Weighted Creep Ratio for each structure. Details and tips for the cut-off wall are shown on Plate S-005 (3% AEP LORR) and S-005A (1% AEP LORR).

#### 5.2.5.3.4 Steel Sector Gate

##### 5.2.5.3.4.1 General

The structural design of the sector gates was performed in accordance with Corps engineering guidance and applicable industry standards. The Corps criteria are specified in EM1110-2-2105 and EM 1110-2-2703. The sector gates will consist of structural wide-flange sections supporting the vertical ribs and skin plate with a central angle of 60 degrees. All connections will be welded connections. Gates were designed for Falgout Canal and Bush Canal sector gates for the 3% AEP LORR and for Bayou Grand Caillou and Bush Canal for the 1% AEP LORR. The remaining gates were pro-rated based on the gates designed. A rack and pinion gear system will operate the gate. All steel members on the gate will be painted with a coal tar epoxy paint system. Details of the steel sector gate are shown on Plates S-006 to S-016 (3% AEP LORR) and S-006A to S-016A (1% AEP LORR).

##### 5.2.5.3.4.2 Skin Plate

The skin plate was designed conservatively as a simply supported member by vertical angles, spaced 2' on center. An allowable stress of 0.50 times the yield stress was permitted for basic loading conditions with a permissible increase of one-third for abnormal loading conditions. EM 1110-2-2703 requires that the skin plate be designed with a 1/16" reduction in thickness.

##### 5.2.5.3.4.3 Vertical Ribs

The skin plate will be attached to the vertical ribs by continuous welds. The ribs were designed as simply supported members between the horizontal wide flanges. The skin plate was considered as an effective part of the vertical ribs, with the effective width of skin plate determined according to the AISC specifications for a non-compact flange. A minimum depth of ribs is required to be 8 in. to facilitate painting and maintenance. The ribs will be constructed from material conforming to ASTM A-588 Grade 50 steel.

##### 5.2.5.3.4.4 Horizontal Beams

The gate leaf consists of horizontal beams supporting the vertical ribs and skin plate. The beam was designed as a continuous member supported by the horizontal struts and braces at midpoint between the struts. The curve of the beam was neglected, with the length used for design equal to the arc length along the center line of the beam. The beams will be constructed from material conforming to ASTM A572 Grade 50 steel. The dead weight applied to the girders included, where applicable, the walkway weight, the weight of the intercostals and ribs, and the self-weight of the girder.

##### 5.2.5.3.4.5 **3D Modeling of Gate**

The trusses and frames were analyzed as a three-dimensional space frame in STAAD Pro 2006. The chords of the trusses were analyzed as fixed members while the minor members of the trusses along with the members of the frames were analyzed as pinned connections.

The hinge was modeled to resist forces in the horizontal plane ($F_x$, $F_y$) while the pintle was modeled as a pinned connection to resist forces in both the horizontal and vertical planes ($F_x$, $F_y$, $F_z$). For gate open cases with boat impact, a roller support was added at the location of the gate stop to stabilize the structure during boat impacts while in the gate closed cases with boat impact, a roller support was added to the machinery to resist boat impacts and stabilize the structure. The vertical dead load was carried only by the pintle.

##### 5.2.5.3.4.6 **Hinge and Pintle**

The gate frames will be supported at the top by a hinge and at the bottom by a pintle. In order to assure good pintle and hinge alignment, a spherical pin will be provided in the hinge to compliment the spherical pintle. All vertical loads will be transferred to the concrete base through the pintle. Horizontal reactions will be transferred to the thrust block through bronze bushings. Bearing pressures on the bushings were limited to 2500 psi for operating conditions and 5000psi for maintenance conditions. The hinge and pintle were designed for the Bush Canal sector gate for the 3% AEP LORR and 1% AEP LORR. The hinge and pintle for the remaining gates were pro-rated based on the Bush Canal sector gate design.

##### 5.2.5.3.4.7 **Fender**

A fendering system was provided on the channel side truss of the sector gate to protect the truss from a barge impact of 125 kips. This load corresponds to the load recommended in EM 1110-2-2703 "Lock Gates and Operating Equipment" for sector gates. The entire fendering system will be removable to permit maintenance and painting of the gate as needed.

The impact load was assumed to be distributed evenly between two 8 in x 12 in composite marine timbers, supported on 5 ft centers by vertical W 10 x 77 sections. The composite marine timbers were designed as continuous members supported by the vertical members. The vertical members were designed as simply supported members between the horizontal members. Two large horizontal W24X104 sections, which are bolted on at panel points on the channel side truss of the gate, transfer the impact load back to the channel side truss and were designed as continuous members.

###### 5.2.5.3.4.8 Walkway

The walkway will extend around the trusses of the gate leaf as well as along the skin plate. A 4 ft walkway width will be provided, designed for an imposed live load of 200 psf. Aluminum grating with 1-1/4 in by 3/16 in bearing bars was selected to span the 4 ft required width of walkway. Aluminum handrails will be provided along the entire walkway to resist a force of 200 lb applied at the top rail in accordance with EM 385-1-1.

#### 5.2.5.3.5 Needle Girders, Needles and Supports

The needle girder system arrangement was designed to dewater the entire gatebay to permit maintenance of the sector gates. The needle girder system was designed for a sill elevation of -12.0 with a water elevation of +5.0. Twelve steel needles will be provided (6 on each side of the structure), measuring 9'-3" in width, used to dewater the concrete gatebay monoliths. The steel needles consist of vertical WT 8X33.5 members with a 3/8" skin plate. The needles are supported by the sill of the concrete gatebay and the needle girder at El 5.0. The needle girder was designed as a simply supported, built-up girder, spanning across the 56' gate opening. The girder will be supported along its weak axis by 2 support towers. The girder at mid-span will have a depth of 4'-6" with 5/8" web and 1"x15" flanges. The girder will taper down to a depth of 3'-2" at the ends. The support towers will consist of welded HSS connections, supporting the dead and vertical live loads of the needle girder. Details of the needle girder, needles and support are shown on Plates S-018 to S-019. Only Grand Bayou, Bush and Bayou Grand Caillou will have a needle girder system built as part of those gates' construction. The remainder of the gates will utilize those needle girder systems for their dewaterings.

#### 5.2.5.3.6 Needle Girder Storage Platform

The needle girder storage platform will be a reinforced concrete structure measuring 20 ft wide by 171 ft long. It is assumed that each 56' gate structure will have a needle girder storage platform. The 120' long longitudinal beams, measuring 2 ft wide by 1'-9" deep, were designed as continuous beams with the dead load of the needle girder system, a 100psf live load and the self-weight of the beam. The 9 transverse beams, measuring 1'-4" wide by 1'-9" deep, were analyzed as compression members bracing the longitudinal beams. 10% of the vertical load applied to the longitudinal beams was applied axially to the transverse beams. The storage platform will be supported by 18, 14" square precast pre-stressed concrete (PPC) piles, 80' long. Details of the needle girder storage platform are shown on Plate S-020.

#### 5.2.5.3.7 Guidewalls and Pile Clusters

Guidewalls and pile clusters will be provided as aids to navigation and to protect the main flood gate structure from impact. Details were taken from historical 56' sector gate structures constructed in New Orleans District rather than performing actual design on this component. The wall lengths and details on the walls and pile clusters are shown on Plates S-021 to S-023.

#### 5.2.5.3.8 Control Houses

A precast 14'x14' concrete control house will be provided for each gate leaf to shelter the gate control systems and machinery and provide space for a gate operator as required. The buildings are considered small and were not designed, so historical dimensions were used for cost estimation purposes. It is assumed that these buildings will be pre-fabricated during construction.

#### 5.2.5.3.9 Sluice Gate Monolith Concrete

Details of the concrete monolith are shown on Plates S-054 to S-057 (3% AEP) and S-054A to S-057A (1% AEP).

##### 5.2.5.3.9.1 Sluice Gate Walls

The breast walls were designed for the hydrostatic pressure differential above the sluice gates, fixed between the pier walls. A portion of the load from the hydraulic cylinder and walkway were also placed on the breast wall, but were not examined because the breast wall functions as a very deep beam with a large capacity in the plane that the hydraulic cylinder load is applied. A 3' thick breast wall was used for all sluice gate structures.

The operating platform beams were designed for the dead and live loads imparted by the sluice gate and its machinery as well the dead and live loads from the operating platform. The beam was designed as fixed between the pier wall supports. A 2' wide by 2'-6" deep operating platform beam was used for all sluice gate structures.
The pier walls were designed as a wall with the combined axial load and moment imparted by the breast walls, operating platform beam, and lateral load from a dewatered condition. The pier wall design section was set equal to the thickness of the

pier wall with loads extended through the depth of the wall at a 45 degree angle. An interaction diagram was setup to verify that the ultimate moment and compression were within the allowable limits. The pier wall was assumed as a cantilever to determine the moments associated with the dewatering loads. The live and dead load moments from the breast walls and operating platform beam were taken assuming those beams are fixed at the pier walls. A 3' thick pier wall was used for all sluice gate structures

#### 5.2.5.3.9.2 **Sluice Gate Base Slab**

The sluice gate base slab thickness was determined utilizing a 2D strip with a width equal to the width of one sluice gate bay. The strips were designed as solid beams, given the property of the width of the slab that was examined. All loads acting along the width of the beams were input into STAAD (Structural Analysis and Design) and resolved along the centroid of the beam. Piles were modeled as pinned supports. The 2D strips were analyzed for the Bayou Grand Caillou and Bush Canal sluice gates only. The remaining structures' base slab thicknesses were selected based on similar head differentials as the sluice gate structures that were analyzed. The base slab thicknesses are summarized in Table 135.

**Table 135 - Sluice Gate Base Slab Thickness**

| Structure | Slab Thickness (ft) (3% AEP) | Slab Thickness (ft) (1% AEP) |
|---|---|---|
| Bayou Grand Caillou | 5 | 8 |
| Bayou Petite Caillou | 7 | 10 |
| Placid Canal | 7 | 10 |
| Bush Canal | 7 | 10 |
| Falgout Canal | 5 | 8 |
| Grand Bayou | 7 | 10 |

### 5.2.5.3.10 Sluice Gate Pile Foundation

#### 5.2.5.3.10.1 **General**

The pile foundation for the sluice gates will include HP 14X73 piles battered on 3 vertical to 1 horizontal. The design Factors of Safety utilized for the design comply with EM 1110-2-2906 and the latest requirements Hurricane and Storm Damage Risk Reduction System Design Guidelines. All pile capacities used assumed compression pile testing, but no tension pile testing. Tension hooks will be provided on all piles on the flood side of the sheet pile cutoff- wall to handle the maximum tensile load. CPGA analysis was performed for each sluice gate. No pro-rating was performed. Details for the pile foundation are shown on Plate S-058 (3% AEP LORR) and S-058A (1% AEP LORR). Alternative pile types and arrangements will be investigated during detailed design for each structure to optimize the pile foundation.

#### 5.2.5.3.10.2 **CPGA Analysis**

CPGA was utilized to develop the pile layouts for the sluice gate structures and determine the required tip elevation. The piles were modeled as pinned connections with the piles providing all of the lateral resistance. The horizontal subgrade modulus was based on the soil in the top ten pile diameters. The horizontal subgrade modulus was reduced for group effects in accordance with EM 1110-2-2906.

#### 5.2.5.3.10.3 **Pile Curves and Horizontal Subgrade Modulus**

Pile curves and horizontal subgrade modulus were calculated for a limited number of structures. Existing pile curves were utilized for those structures where no pile curve was calculated. A summary of the pile curve used for each structure is summarized below:

| Sluice Gate Structure | | Pile Curve Utilized |
|---|---|---|
| *Bayou Grand Caillou* | → | *Bayou Grand Caillou* |
| *Bush Canal* | → | *Bush Canal* |
| *Bayou Terrebonne* | → | *Bayou Terrebonne* |
| *Grand Bayou* | → | *Grand Bayou* |
| *Bayou Petite Caillou* | → | *Lapeyrouse Canal* |
| *Placid Canal* | → | *Bayou Terrebonne* |

The resulting pile tips are summarized in Table 136.

**Table 136 - Sluice Gate Pile Tips**

| Structure | Pile Tip (ft) (3% AEP) | Pile Tip (ft) (1% AEP) |
|---|---|---|
| Bayou Grand Caillou | -124.5 | -124.5 |
| Bayou Petite Caillou | -157.0 | -157.0 |
| Placid Canal | -155.0 | -155.0 |
| Bush Canal | -130.0 | -130.0 |
| Falgout Canal | -113.0 | -113.0 |
| Grand Bayou | -140.0 | -140.0 |

#### 5.2.5.3.10.4 Cut-off Wall

A cut-off sheetpile wall will be provided to reduce possible seepage, scouring and uplift. A PZC-13 sheetpile meeting the requirements of ASTM A572, Grade 50 was assumed for the cutoff wall. Tip elevations were calculated utilizing Lane's Weighted Creep Ratio for each structure. Details and tips for the cut-off wall are shown on Plate S-058 (3% AEP LORR) and S-058A (1% AEP LORR).

### 5.2.5.3.11 Sluice Gates

The sluice gates will be manufactured 16'x16' or 16'x12' cast iron gates.

### 5.2.5.3.12 Sluice Gate Bulkheads

The sluice gate bulkheads are designed to dewater the entire gatebay to permit maintenance of the sluice gates and concrete gatebay. The bulkheads were designed for a sill elevation of -12.0 with a water elevation of +5.0. Each sluice gate structure will be provided with 4 bulkheads, permitting the dewatering of 2 sluice gate bays at a time.

The steel bulkheads consist of horizontal L8X4X1/2 members with a 3/8" skin plate. The skin plate was designed conservatively as a simply supported member between the horizontal angles. The horizontal angles were designed as simply supported members between the sluice gates walls. The skin plate was considered as an effective part of the horizontal angles, with the effective width of skin plate determined according to the AISC specifications for a non-compact flange. All steel will be constructed from material conforming to ASTM A-572 Grade 50. Details of the sluice gate bulkheads are shown on Plate S-059.

### 5.2.5.3.13 Tie-in T-Walls

Tie-in T-Walls extend from the sector gate/sluice gate structures to the full levee section. The distance from the gate structure to the full levee section was calculated. T-Walls were designed in accordance with the latest requirements of the HSDRRS design guidelines. A 30' sheetpile cutoff will be embedded into the levee at the transition between the tie-in T-Walls and the levee section. Nine inches of reinforced concrete scour protection will be provided at the transition area. A pre-load 2'-0" above the final grade along the T-Walls will be provided to eliminate settlement induced bending effects.

T-Walls were broken into different types according to hydraulic reach and base elevation and typical designs were performed. The required pile tip was determined individually for each structure based on the pile capacity demand from the typical designs. All pile capacities used assumed compression pile testing, but no tension pile testing. Tension hooks are provided on all piles on the flood side of the sheet pile cutoff-wall to handle the maximum tensile load. Details of the tie-in T-Walls can be found on Plates S-092 to S-099 (3% AEP LORR) and S-092A to S-099A (1% AEP LORR).

### 5.2.5.4 Electrical Design

#### 5.2.5.4.1 Electrical Service

The Electrical service to the structure will be 480/277 volt, 3 phase, 4 wire grounded secondary service from the local utility company. The service will be sized to support the structure loads including power for Gate machinery, lighting, controls, and any other miscellaneous loads.

#### 5.2.5.4.2 Emergency Generator

A diesel generator will be provided for back-up power in the case of loss of utility power. The fuel supply for the generator will be provided from a fuel tank to a skid mounted UL-Listed double-walled day tank. Alarms will be locally annunciated on the generator.

#### 5.2.5.4.3 Grounding System

The structure grounding system will be in accordance with the NFPA 70 - National Electrical Code. The grounding system will consist of copper ground rods interconnected with copper conductors. All jumpers and grounding electrode conductor connections will be done by exothermic weld. All electrical equipment, machinery, and exposed metal will be bonded to the grounding electrode system.

#### 5.2.5.4.4 Lighting System

All exterior lighting fixtures will be provided with vandal-proof shields. The fixtures will be HPS and shall be controlled by photocells. Fluorescent light fixtures will be provided in the control houses.

#### 5.2.5.4.5 Conduit and Boxes

All wiring will be installed in rigid metal conduit except that motors and other electrical equipment subject to vibration will be connected with liquid-tight flexible metal conduit. All pull boxes and junction boxes will be of cast metal of sufficient thickness or provided with bosses to accommodate the required threads for the conduit connections of size specified. All outlet boxes for receptacles, switches, and lighting fixtures will be of cast metal with bosses drilled and tapped or with threaded hubs of sizes specified. The edges will be designed to take a heavy cover gasket with four or more screws for attaching covers or fixtures.

#### 5.2.5.4.6 Controls

A hard wired control system will be installed to operate the Gates. The control consoles will be installed in the control houses. Additionally, local controls will be provided at each sluice gate.

#### 5.2.5.4.7 Lightning Protection System

A lightning protection system will be designed to protect the structure from lightning strikes. The system will be designed in accordance with NFPA 780-Installation of Lightning Protection Systems. Surge suppression devices on all incoming power and communication lines will be provided.

### 5.2.5.5 Mechanical Design

#### 5.2.5.5.1 Gate Operation

Gate operation will be two speeds with a time dependent 1 to 4 second speed ramp at start, stop and speed changes. The dual speed and speed ramp will be accomplished electronically by way of a hydraulic proportional valve. A slow gate speed of 3.5 degrees per minute will be used near the end of gate travel, (1 to 3 feet from fully close or fully open, measured at the skin plate). A higher speed of 30 degrees per minute will be used in between the ends of travel.

#### 5.2.5.5.2 Gate Operating Loads

The gate operating loads consist of friction from hinge, pintle and seal and hydrodynamic loads. The hydrodynamic loads were based on differential hydrostatic head applied over the gate end beams. Three load cases were considered; a balanced head case, a direct head case and a reverse head case.

#### 5.2.5.5.3 Gate Operating Machinery

The gate operating machinery will be a rack and pinion gear drive. The rack will be attached to the gate along the outside radius of the gate's skin plate. A pinion drive gear will be attached to a low speed high torque hydraulic (LSHT) motor mounted on the wall. A Hagglunds Viking Series 64 LSHT hydraulic motor operating at 2000 psi was used for design purposes. Each gate will be equipped with its own hydraulic power unit (HPU). The HPU will include a variable delivery pressure compensated pump driven by an electric motor. The electric motor will be 10 horsepower. Additional HPU items will include valves, manifold, gauges, filters, clean vent, and storage tank. The gate operating machinery is shown on Plate M-001.

#### 5.2.5.5.4 Hinge and Pintle Bushing Material

Hinge and pintle bushings will be split in the vertical plane. Hinge and pintle bushings will be a greaseless/self-lubricating system with an approved composite. The material will have a dynamic coefficient of friction that is less than or equal to 0.08 dry and 0.10 water-lubricated for a bearing pressure load of 2 ksi at surface speed 90 fpm. The ultimate compressive strength of the material will be a minimum of 50 ksi and its water absorption will be less than 0.10 percent by weight. Bushing material and dowels will meet the requirements of ASTM B 148, Alloy C95500, ASTM B 271, Alloy C95500, or ASTM A705, Type 630, minimum hardness 40 Rc.

#### 5.2.5.5.5 Sluice Gate Operation

Sluice gate operation will be to raise, lower, or hold in intermediate positions to allow, prevent, or meter drainage water flow and to prevent backflow during storm conditions. Operating time was designed to operate in less than fifteen minutes to totally raise or lower the sluice gate.

#### 5.2.5.5.6 Sluice Gate Operating Loads

The sluice gate operating loads consist of friction from the stem, sluice gate weight, stem weight, hydrodynamic loads. The hydrodynamic loads were developed from differential hydrostatic head applied over the sluice gate.

#### 5.2.5.5.7 Sluice Gate Operating Machinery

The sluice gate operating machinery will be an operating stem, bevel gearbox, and electric actuator. The operating stem will be attached to the top of the sluice gate within the stem pocket. The operating stem will be machine threaded AISI 316 stainless steel. The aluminum bronze ASTM B505 lift nut within the bevel gearbox will be machine threaded to mate with the AISI 316 stainless steel operating stem. The electric actuator will mount onto the bevel gearbox used to rotate the operating stem to raise or lower the sluice gate. The bevel gearbox used for design purposes for the 16'x16' sluice gates was a Diamond Gear 105BG7. The bevel gearbox used for design purposes for the 16'x12' sluice gates was a Diamond Gear 57BG6. The electric actuator considered for the 16'x16' sluice gates was a 30 horsepower Biffi Icon 2000 050/1440-173. The electric actuator considered for the 16'x12' sluice gates was a 10 horsepower Biffi Icon 2000 040/720-173. The sluice gate operating machinery is shown on Plate S-055.

### 5.2.6 125' Sector Gate

This section contains a summary of work for the two, 125' sector gate structures, which are part of the Morganza to the Gulf Alignment for both the 3% AEP and the 1% AEP level of protections. Table 137 lists the structures examined-

**Table 137 - 125' Sector Gate Structures**

| Structure | Sill Elevation | Top Elevation (3% AEP) | Top Elevation (1% AEP) | Top of Guidewalls |
|---|---|---|---|---|
| GIWW West | -16 | 16 | 23 | 10 |
| GIWW East | -16 | 17 | 25 | 10 |

#### 5.2.6.1 Physical Features

The physical features associated with the construction of the 125 ft sector gate structures are-

- Temporary Bypass Channels
- Phase 1 Cellular Cofferdam
- Phase 2 Interior Braced Cofferdams
- Sector Gate Concrete Monolith
- Sector Gate Pile Foundation
- Steel Sector Gate
- Needle Girder, Needles and Supports
- Needle Girder Storage Platform
- Guidewalls
- End Cell Dolphins
- Sluice Gate Concrete Monolith
- Sluice Gate Pile Foundation
- Sluice Gates
- Sluice Gate Bulkheads
- Tie-in T-Walls
- Electrical Controls and Circuitry
- Mechanical Equipment

#### 5.2.6.2 Construction Sequencing

Both 125' sector gates will be constructed in the approximate center of the existing channels. A minimum 125' temporary bypass channel will be constructed as the first order of construction, to allow navigation passage during construction. Once navigation is routed through the temporary bypass channel, a cellular cofferdam will be constructed, permitting the construction of the 125' sector gate monolith and the sluice gate monoliths. Reduced power will be required for vessels passing through the construction area to reduce the risk of impact to the cofferdam. A timber guidewall and pile clusters will be provided along the bypass channel to minimize potential vessel impact on the cofferdam. Once construction of the 125' sector gate monolith and sluice gate monoliths is completed, navigation will be re-routed through the permanent sector gate structure. A phase 2 cofferdam will be required for the T-Walls adjacent to the sector gate/sluice gate structures. Once navigation is re-routed, the phase 2 cofferdam, needle girder storage platform, permanent guidewalls, end cell dolphins, tie-in T-Walls and final civil site work can be completed.

#### 5.2.6.3 Structural Design

##### 5.2.6.3.1 Phase 1 Cellular Cofferdam

A Phase 1 cellular cofferdam will be constructed to permit the in the dry construction of the sector gate concrete monolith and the sluice gate concrete monolith. The cofferdam will be a sheet pile cellular cofferdam in-filled with sand. Deep soil mixing will be necessary in the interior of the cellular structure to provide adequate geotechnical safety factors. Details of the Phase 1 cellular cofferdam can be found on Plate S-050.

ER 1110-2-8152 will be followed throughout the project design process, requiring that all cofferdams will be designed by the Government.

##### 5.2.6.3.2 Phase 2 Interior Braced Cofferdams

A phase 2 cofferdam will be constructed to permit the construction of the adjacent T-Walls to the sector gate/sluice gate structures that will be in the water. The anchor forces, moments, and tips used for the Phase 1 Bayou Dularge sector gate phase 1 cofferdams will be conservatively used for the Phase 2 cofferdams. Details of the Phase 2 cofferdam can be found on Plate S-100.

ER 1110-2-8152 will be followed throughout the project design process, requiring that all cofferdams will be designed by the Government.

##### 5.2.6.3.3 Sector Gate Monolith Concrete

Details of the concrete monolith are shown on Plates S-026 to S-027 (3% AEP LORR) and S-026A to S-027A (1% AEP LORR).

#### 5.2.6.3.3.1 Sector Gate Wall

Sector gate walls were designed as a cantilever beam extending from the base slab. A constant wall thickness was assumed the full height of the wall. A typical wall was designed for each sector gate. No pro-rating of wall thickness was performed. The resulting calculated wall thicknesses are shown in Table 138.

**Table 138 - 125' Sector Gate Wall Thickness**

| Structure | Wall Thickness (ft) (3% AEP) | Wall Thickness (ft) (1% AEP) |
|---|---|---|
| GIWW West | 4 | 4.75 |
| GIWW East | 4 | 4.75 |

#### 5.2.6.3.3.2 Sector Gate Thrust Block and Machinery Block

Sector gate thrust and machinery blocks were not designed because of their relatively small quantity compared to that of the remainder of the walls. Historical data from previously constructed sector gates was utilized to size the thrust and machinery blocks.

#### 5.2.6.3.3.3 Sector Gate Base Slab

The 125' sector gate base slab will measure 310'-6" long by 117'-8" wide. The sector gate base slab thickness was determined utilizing 2D transverse and longitudinal strips. The transverse strip was taken beneath the thrust block while the longitudinal strip was taken beneath the machine and thrust blocks. The strips were designed as solid beams, given the property of the width of the slab that was examined. All loads acting along the width of the beams were input into STAAD (Structural Analysis and Design) and resolved along the centroid of the beam. Piles were modeled as pinned supports. The 2D strips were analyzed for the GIWW West sector gate only. It was assumed that GIWW East would have the same slab thickness. The base slab thicknesses are summarized in Table 139.

**Table 139 - 125' Sector Gate Base Slab Thickness**

| Structure | Slab Thickness (ft) (3% AEP) | Slab Thickness (ft) (1% AEP) |
|---|---|---|
| GIWW West | 10 | 12 |
| GIWW East | 10 | 12 |

### 5.2.6.3.4 Sector Gate Pile Foundation

#### 5.2.6.3.4.1 General

The pile foundation for the 3% AEP LORR sector gates will include 246 twenty-four inch pipe piles with ½" thick wall thickness battered on 4 vertical to 1 horizontal slope while the pile foundation for the 1% AEP LORR sector gates will include 300 twenty-four inch pipe piles with ½" thick wall thickness on a similar batter. The design Factors of Safety utilized for the design comply with EM 1110-2-2906 and the latest requirements Hurricane and Storm Damage Risk Reduction System Design Guidelines. All pile capacities used assumed compression pile testing, but no tension pile testing. Tension hooks are provided on all piles. CPGA analysis was performed for each sector gate. No pro-rating was performed. Details for the pile foundation are shown on Plate S-029 (3% AEP LORR) and S-029A (1% AEP LORR). Alternative pile types and arrangements will be investigated during detailed design for each structure to optimize the pile foundation.

#### 5.2.6.3.4.2 CPGA Analysis

CPGA was utilized to develop the pile layouts for the gate structures and determine the required tip elevation. The piles were modeled as pinned connections with the piles providing all of the lateral resistance. The horizontal subgrade modulus was based on the soil in the top ten pile diameters. The horizontal subgrade modulus was reduced for group effects in accordance with EM 1110-2-2906.

#### 5.2.6.3.4.3 Pile Curves and Horizontal Subgrade Modulus

Pile curves and horizontal subgrade modulus were calculated for the two sector gates. The resulting pile tips are summarized in Table 140.

**Table 140 - 125' Sector Gate Pile Tips**

| Structure | Pile Tip (ft) (3% AEP) | Pile Tip (ft) (1% AEP) |
|---|---|---|
| GIWW West | -160.0 | -160.0 |
| GIWW East | -161.50 | -161.50 |

#### 5.2.6.3.4.4 Cut-off Wall

A cut-off sheetpile wall will be provided to reduce possible seepage, scouring and uplift. A PZC-13 sheetpile meeting the requirements of ASTM A572, Grade 50 was assumed for the cutoff wall. Tip elevations were calculated utilizing Lane's Weighted Creep Ratio for each structure. Details and tips for the cut-off wall are shown on Plate S-029 (3% AEP LORR) and S-029A (1% AEP LORR).

#### 5.2.6.3.5 Steel Sector Gate

##### 5.2.6.3.5.1 General

The structural design of the sector gates was performed in accordance with Corps engineering guidance and applicable industry standards. The Corps criterion is specified in EM1110-2-2105 and EM 1110-2-2703. The sector gates will consist of structural pipe sections supporting the vertical ribs and skin plate with a central angle of 70. All connections will be welded connections. The GIWW West gate was designed and the GIWW East gate quantities were pro-rated based on that design. A rack and pinion gear system will operate the gate. All steel members on the gate will be painted with a coal tar epoxy paint system. Details of the steel sector gate are shown on Plates S-030 to S-041 (3% AEP) and S-030A to S-041A (1% AEP).

##### 5.2.6.3.5.2 Skin Plate

The skin plate was designed conservatively as a simply supported member by vertical angles, spaced 2' on center. An allowable stress of 0.50 times the yield stress was permitted for basic loading conditions with a permissible increase of one-third for abnormal loading conditions. EM 1110-2-2703 requires that the skin plate be designed with a 1/16" reduction in thickness.

##### 5.2.6.3.5.3 Vertical Ribs

The skin plate will be attached to the vertical ribs by continuous welds. The ribs were designed as simply supported members between the horizontal built-up plate girders. The skin plate was considered as an effective part of the vertical ribs, with the effective width of skin plate determined according to the AISC specifications for a non-compact flange. A minimum depth of ribs will be required to be 8 in. to facilitate painting and maintenance. The ribs are also constructed from material conforming to ASTM A-588 Grade 50 steel.

##### 5.2.6.3.5.4 Horizontal Beams

The gate leaf consists of horizontal beams supporting the vertical ribs and skin plate. The beam will be designed as a continuous member supported by the horizontal struts and braces at midpoint between the struts. The curve of the beam will be neglected, with the length used for design equal to the arc length along the center line of the beam. The beams are constructed from material conforming to ASTM A-572 Grade 50 steel. The dead weight applied to the girders included, where applicable, the walkway weight, the weight of the intercostals and ribs, and the self-weight of the girder.

### 5.2.6.3.5.5 3D Modeling of Gate

The trusses and frames were analyzed as a three-dimensional space frame in STAAD Pro 2006. The chords of the trusses were analyzed as fixed members while the minor members of the trusses along with the members of the frames were analyzed as pinned connections.

The hinge was modeled to resist forces in the horizontal plane ($F_x$, $F_y$) while the pintle was modeled as a pinned connection to resist forces in both the horizontal and vertical planes ($F_x$, $F_y$, $F_z$). For gate open cases with boat impact, a roller support was added at the location of the gate stop to stabilize the structure during boat impacts while in the gate closed cases with boat impact, a roller support was added to the machinery to resist boat impacts and stabilize the structure. The vertical dead load was carried only by the pintle.

### 5.2.6.3.5.6 Hinge and Pintle

The gate frames will be supported at the top by a hinge and at the bottom by a pintle. In order to assure good pintle and hinge alignment, a spherical pin will be provided in the hinge to compliment the spherical pintle. All vertical loads will be transferred to the concrete base through the pintle. Horizontal reactions will be transferred to the thrust block through bronze bushings. Bearing pressures on the bushings were limited to 2500 psi for operating conditions and 5000psi for maintenance conditions. The hinge and pintle were designed for the GIWW East sector gate for the 3% AEP LORR and 1% AEP LORR at a 175' opening. The hinge and pintle for the GIWW East and West gates at a 125' opening were pro-rated based on the GIWW East sector gate design at a 175' opening.

### 5.2.6.3.5.7 Fender

A fendering system was provided on the channel side truss of the sector gate to protect the truss from a barge impact of 125 kips. This load corresponds to the load recommended in EM 1110-2-2703 "Lock Gates and Operating Equipment" for sector gates. The entire fendering system will be removable to permit maintenance and painting of the gate as needed.

The impact load was assumed to be distributed evenly between two 8 in x 12 in composite marine timbers, supported on 5 ft centers by vertical W 10 x 77 sections. The composite marine timbers were designed as continuous members supported by the vertical members. The vertical members were designed as simply supported members between the horizontal members. Two large horizontal W27X146 sections, which are bolted on at panel points on the channel side truss of the gate, transfer the impact load back to the channel side truss and were designed as continuous members.

##### 5.2.6.3.5.8 Walkway

The walkway extends around the trusses of the gate leaf as well as along the skin plate. A 4'-6" walkway width was provided, designed for an imposed live load of 200 psf. Aluminum grating with 1 1/4 in by 3/16 in bearing bars was selected to span the 4 ft required width of walkway. Aluminum handrails are provided along the entire walkway to resist a force of 200 lb applied at the top rail in accordance with EM 385-1-1.

#### 5.2.6.3.6 Needle Girders, Needles and Supports

The needle girder system arrangement was designed to dewater the entire gatebay to permit maintenance of the sector gates. The needle girder system was designed for a sill elevation of -16.0 with a water elevation of +5.0. Each gate structure will be provided with 24 steel needles (12 on each side of the structure), measuring 14'-6" in width, used to dewater the concrete gatebay monoliths. The steel needles will consist of vertical WT 8X38.5 members with a 7/16" skin plate. The needles will be supported by the sill of the concrete gatebay and the needle girder at El 5.0. The needle girder was designed as a simply supported, built-up girder, spanning across the 125' gate opening. The girder will be supported along its weak axis by 3 support towers. The girder at mid-span has a depth of 8'-4" with 3/4" web and 2"x20" flanges. The girder will taper down to a depth of 5'-4" at the ends. The support towers will consist of welded HSS connections, supporting the dead and vertical live loads of the needle girder. Details of the needle girder, needles and support are shown on Plates S-043 to S-044.

#### 5.2.6.3.7 Needle Girder Storage Platform

The needle girder storage platform will be a reinforced concrete structure measuring 71 ft wide by 135 ft long. The structure will consist of an 8" cast in-place slab supported by 40" wide by 30" deep cast in-place beams, spaced 9' O.C. The storage platform will be supported by 60 twenty-four inch square precast pre-stressed concrete (PPC) piles, 80' long. Details of the needle girder storage platform are shown on Plates S-045 to S-046.

#### 5.2.6.3.8 Guidewalls

Guidewalls will be provided as aids to navigation and to protect the main flood gate structure from impact. Details were taken from the HNC Lock structure as both structures will see similar vessel traffic. The wall lengths and details on the walls are shown on Plates S-047 to S-048.

#### 5.2.6.3.9 End Cell Dolphins

End Cell Dolphins will protect the main flood gate structure and guidewalls from head-on impact from errant vessels. The end cell design was taken from the Western Closure Complex 225' Sector Gate, where similar vessel traffic is seen along the GIWW. The end cell will consist of a 60' sheet pile cellular structure with a concrete ring in the interior or the cell. The inside of the concrete ring will be in-filled with lightweight fill material. The concrete structure will be supported by 18" diameter pipe piles. Details are shown on Plate S-049.

#### 5.2.6.3.10 Control Houses

A precast 14'x14' concrete control house will be provided for each gate leaf to shelter the gate control systems and machinery and provide space for a gate operator as required. The buildings are considered small and were not designed, so historical dimensions were used for cost estimation purposes. It is assumed that these buildings will be pre-fabricated during construction.

#### 5.2.6.3.11 Sluice Gate Monolith Concrete

See Section 5.2.5.3.9

##### 5.2.6.3.11.1 Sluice Gate Walls

See Section 5.2.5.3.9.1

##### 5.2.6.3.11.2 Sluice Gate Base Slab

The sluice gate base slab thickness was determined utilizing a 2D strip with a width equal to the width of one sluice gate bay. The strips were designed as solid beams, given the property of the width of the slab that was examined. All loads acting along the width of the beams were input into STAAD (Structural Analysis and Design) and resolved along the centroid of the beam. Piles were modeled as pinned supports. The 2D strips were analyzed for the Bayou Grand Caillou sluice gates, which had similar hydrostatic loadings as the GIWW West and East sluice gates. The base slab thicknesses are summarized in Table 141.

Table 141 - Sluice Gate Base Slab Thickness

| Structure | Slab Thickness (ft) (3% AEP) | Slab Thickness (ft) (1% AEP) |
|---|---|---|
| GIWW West | 5 | 8 |
| GIWW East | 5 | 8 |

#### 5.2.6.3.12 Sluice Gate Pile Foundation

##### 5.2.6.3.12.1 General

See Section 5.2.5.3.10.1

##### 5.2.6.3.12.2 CPGA Analysis

See Section 5.2.5.3.10.1

##### 5.2.6.3.12.3 Pile Curves and Horizontal Subgrade Modulus

Pile curves and horizontal subgrade modulus were calculated. The resulting pile tips are summarized in Table 142.

Table 142 - Sluice Gate Pile Tips

| Structure | Pile Tip (ft) (3% AEP) | Pile Tip (ft) (1% AEP) |
|---|---|---|
| GIWW West | -130.0 | -130.0 |
| GIWW East | -137.0 | -131.5 |

##### 5.2.6.3.12.4 Cut-off Wall

See Section 5.2.5.3.10.4

#### 5.2.6.3.13 Sluice Gates

The sluice gates will be manufactured 16'x16' or 16'x12' cast iron gates.

#### 5.2.6.3.14 Sluice Gate Bulkheads

See Section 5.2.5.3.12.

#### 5.2.6.3.15 Tie-in T-Walls

See Section 5.2.5.3.13.

### 5.2.6.4 Electrical Design

#### 5.2.6.4.1 Electrical Service

The Electrical service to the structure will be 480/277 volt, 3 phase, 4 wire grounded secondary service from the local utility company. The service will be sized to support the structure loads including power for Gate machinery, lighting, controls, and any other miscellaneous loads.

#### 5.2.6.4.2 Emergency Generator

A diesel generator will be provided for back-up power in the case of loss of utility power. The fuel supply for the generator will be provided from a fuel tank to a skid mounted UL-Listed double-walled day tank. Alarms will be locally annunciated on the generator.

#### 5.2.6.4.3 Grounding System

The structure grounding system will be in accordance with the NFPA 70 - National Electrical Code. The grounding system will consist of copper ground rods interconnected with copper conductors. All jumpers and grounding electrode conductor connections will be done by exothermic weld. All electrical equipment, machinery, and exposed metal will be bonded to the grounding electrode system.

#### 5.2.6.4.4 Lighting System

All exterior lighting fixtures will be provided with vandal-proof shields. The fixtures will be HPS and shall be controlled by photocells. Fluorescent light fixtures will be provided in the control houses.

#### 5.2.6.4.5 Conduit and Boxes

All wiring will be installed in rigid metal conduit except that motors and other electrical equipment subject to vibration will be connected with liquid-tight flexible metal conduit. All pull boxes and junction boxes will be of cast metal of sufficient thickness or provided with bosses to accommodate the required threads for the conduit connections of size specified. All outlet boxes for receptacles, switches, and lighting fixtures will be of cast metal with bosses drilled and tapped or with threaded hubs of sizes specified. The edges will be designed to take a heavy cover gasket with four or more screws for attaching covers or fixtures.

#### 5.2.6.4.6 Controls

A hard wired control system will be installed to operate the Gates. The control consoles will be installed in the control houses. Additionally, local controls will be provided at each sluice gate.

#### 5.2.6.4.7 Lightning Protection System

A lightning protection system will be designed to protect the structure from lightning strikes. The system will be designed in accordance with NFPA 780-Installation of Lightning Protection Systems. Surge suppression devices on all incoming power and communication lines will be provided.

### 5.2.6.5 Mechanical Design

#### 5.2.6.5.1 Gate Operation

Gate operation will be two speeds with a time dependent 1 to 4 second speed ramp at start, stop and speed changes. The dual speed and speed ramp will be accomplished electronically by way of a hydraulic proportional valve. A slow gate speed of 3.5 degrees per minute will be used near the end of gate travel, (1 to 3 feet from fully close or fully open, measured at the skin plate). A higher speed of 30 degrees per minute will be used in between the ends of travel.

#### 5.2.6.5.2 Gate Operating Loads

The gate operating loads consist of friction from hinge, pintle and seal and hydrodynamic loads. The hydrodynamic loads were based on differential hydrostatic head applied over the gate end beams. Four load cases were considered.

#### 5.2.6.5.3 Gate Operating Machinery

The gate operating machinery will be a rack and pinion gear drive. The rack will be attached to the gate along the outside radius of the gate's skin plate. A pinion drive gear will be attached to a low speed high torque hydraulic (LSHT) motor mounted on the wall. A Hagglunds Viking Series 84 LSHT hydraulic motor operating at 3600 psi was used for design purposes. Each gate will be equipped with its own hydraulic power unit (HPU). The HPU will include a variable delivery pressure compensated pump driven by an electric motor. The electric motor will be 30 horsepower. Additional HPU items will include valves, manifold, gauges, filters, clean vent, and storage tank. The gate operating machinery is shown on Plate M-002.

#### 5.2.6.5.4 Hinge and Pintle Bushing Material

Hinge and pintle bushings will be split in the vertical plane. Hinge and pintle bushings will be a greaseless/self-lubricating system with an approved composite. The material will have a dynamic coefficient of friction that is less than or equal to 0.08 dry and 0.10 water-lubricated for a bearing pressure load of 2 ksi at surface speed 90 fpm. The ultimate compressive strength of the material will be a minimum of 50 ksi and its water absorption will be less than 0.10 percent by weight. Bushing material and dowels will meet the requirements of ASTM B 148, Alloy C95500, ASTM B 271, Alloy C95500, or ASTM A705, Type 630, minimum hardness 40 Rc. The hinge bushing shall normally be dry but may be exposed to rain water and a marine environment.

#### 5.2.6.5.5 Sluice Gate Operation

Sluice gate operation will be to raise, lower, or hold in intermediate positions to allow, prevent, or meter drainage water flow and to prevent backflow during storm conditions. Operating time was designed to operate in less than fifteen minutes to totally raise or lower the sluice gate.

#### 5.2.6.5.6 Sluice Gate Operating Loads

The sluice gate operating loads consist of friction from the stem, sluice gate weight, stem weight, hydrodynamic loads. The hydrodynamic loads were developed from differential hydrostatic head applied over the sluice gate.

#### 5.2.6.5.7 Sluice Gate Operating Machinery

The sluice gate operating machinery will be an operating stem, bevel gearbox, and electric actuator. The operating stem will be attached to the top of the sluice gate within the stem pocket. The operating stem will be machine threaded AISI 316 stainless steel. The aluminum bronze ASTM B505 lift nut within the bevel gearbox will be machine threaded to mate with the AISI 316 stainless steel operating stem. The electric actuator will mount onto the bevel gearbox used to rotate the operating stem to raise or lower the sluice gate. The bevel gearbox used for design purposes for the 16'x16' sluice gates was a Diamond Gear 105BG7. The bevel gearbox used for design purposes for the 16'x12' sluice gates was a Diamond Gear 57BG6. The electric actuator considered for the 16'x16' sluice gates was a 30 horsepower Biffi Icon 2000 050/1440-173. The electric actuator considered for the 16'x12' sluice gates was a 10 horsepower Biffi Icon 2000 040/720-173. The sluice gate operating machinery is shown on Plate S-055.

### 5.2.7 Stop-Log Gates

This section contains a summary of work for the 3, 30' stop log gate structures and the 2, 20' stop log gate structures, which are part of the Morganza to the Gulf Alignment for both the 3% AEP and the 1% AEP alternatives. Table 143 lists the structures examined-

**Table 143 - Stop-Log Gates**

| Structure | Sill Elevation | Top Elevation (3% AEP) | Top Elevation (1% AEP) | Top of Guidewalls |
|---|---|---|---|---|
| Elliot Jones | -8.0 | 16.0 | 23.5 | 10.0 |
| Humphreys Canal | -8.0 | 16.0 | 23.5 | 10.0 |
| Shell Canal West | -8.0 | 16.0 | 23.5 | 10.0 |
| Marmande Canal | -8.0 | 16.5 | 23.0 | 10.0 |
| Four Point Bayou | -8.0 | 22.5 | 30.0 | 10.0 |

#### 5.2.7.1 Physical Features

The physical features associated with the construction of the stop log gate structures are-

- Interior Braced Cofferdams
- Stop Log Gate Concrete Monolith
- Stop Log Gate Pile Foundation
- Stop Log Gate
- Crane Platform T-Wall
- Needle Girder and Needles
- Bulkhead Storage Platform
- Guidewalls & Pile Clusters
- Tie-in T-Walls
- Mechanical Equipment

#### 5.2.7.2 Construction Sequencing

All stop log gates will be constructed approximately in the center of the existing channels. A minimum 20' or 30' (depending on gate opening size) temporary bypass channel will be constructed as the first order of construction, allowing navigation passage during construction. Once navigation is routed through the temporary bypass channel, a cofferdam will be constructed, permitting the construction of the stop log gate monolith and the crane platform T-Wall monolith. Reduced power will be required for vessels passing through the construction area to reduce the risk of impact to the cofferdam. A timber guidewall and pile clusters will be provided along the bypass channel to prevent vessel impact on the cofferdam. Once construction of the stop log gate monolith and the crane platform TWall monolith is completed, navigation will be re-routed through the permanent stop log gate structure. A phase 2 cofferdam will be required for the T-Wall adjacent to the stop log gate structures. Once navigation is re-routed, the phase 2 cofferdam, bulkhead storage platform, permanent guidewalls and pile clusters, tie-in T-Walls and final civil site work can be completed.

### 5.2.7.3 Structural Design

#### 5.2.7.3.1 Cofferdams

A Phase 1 cofferdam will be constructed to permit the in the dry construction of the stop log concrete monolith and the crane platform T-Wall monolith. The cofferdam is an internally braced cofferdam with wide flange walers and pipe braces supporting PZ sheet piling. Anchor forces, bending moment in the sheet piling, and required sheet piling tip elevation were calculated for Bayou Dularge sector gate and conservatively used for the stop log gate structures. Details of the Phase 1 cofferdam for the sluice gate can be found on Plate S-101.

A phase 2 cofferdam will be constructed to permit the construction of the adjacent T-Walls to the stop log gate that will be in the water. The same anchor forces, moments, and tips used for the Phase 1 cofferdams will be conservatively used for the Phase 2 cofferdams. Details of the Phase 2 cofferdam can be found on Plate S-100.

ER 1110-2-8152 will be followed throughout the project design process, requiring that all cofferdams will be designed by the Government.

#### 5.2.7.3.2 Stop Log Gate Monolith Concrete

Details of the concrete monolith are shown on Plates S-061 to S-062 (3% AEP) and S-061A to S-062A (1% AEP).

##### 5.2.7.3.2.1 Stop Log Gate Walls

Stop log gate walls were designed as a cantilever beam extending from the base slab. A constant wall thickness was assumed the full height of the wall. A typical wall was designed for each sluice gate. Because the walls act as very deep beams when receiving the load from the stoplogs, the dewatering load case governed the design of the walls, resulting in a required wall thickness of 4’ for all stop log gates.

#### 5.2.7.3.2.2 Stop Log Gate Base Slab

Stop log gate base slabs were not designed rather historical data from previously constructed sluice gates was utilized to size the base slab. The selected base slab thicknesses are summarized in Table 144.

**Table 144 - Stop Log Gate Base Slab Thickness**

| Structure | Slab Thickness (ft) (3% AEP) | Slab Thickness (ft) (1% AEP) |
|---|---|---|
| Elliot Jones | 6 | 6 |
| Humphreys Canal | 6 | 6 |
| Shell Canal West | 6 | 6 |
| Marmande Canal | 6 | 8 |
| Four Point Bayou | 6 | 8 |

### 5.2.7.3.3 Stop Log Gate Pile Foundation

#### 5.2.7.3.3.1 General

The pile foundation for the 3% AEP LORR 20'stop log gates will include 30 HP 14X73 piles battered on 3 vertical to 1 horizontal slope while the pile foundation for the 1% AEP LORR 20' stop log gates will include 30 HP 14X73 piles on a similar batter. The pile foundation for the 3% AEP LORR 30 'stop log gates will include 49 HP 14X73 piles battered on 3 vertical to 1 horizontal slope while the pile foundation for the 1% AEP LORR 30' stop log gates will include 56 (49 for Shell Canal West) HP 14X73 piles on a similar batter. The design Factors of Safety utilized for the design comply with EM 1110-2-2906 and the latest requirements Hurricane and Storm Damage Risk Reduction System Design Guidelines. All pile capacities used assumed compression pile testing, but no tension pile testing. Tension hooks will be provided on all piles. CPGA analysis was performed for each stop log gate with the exception of Marmande Canal, where the Four Point Bayou was used. Details for the pile foundation are shown on Plates S-063 and S-070 (3% AEP LORR) and S-066A and S-070A (1% AEP LORR). Alternative pile types and arrangements will be investigated during detailed design for each structure to optimize the pile foundation.

#### 5.2.7.3.3.2 CPGA Analysis

CPGA was utilized to develop the pile layouts for the gate structures and determine the required tip elevation. The piles were modeled as pinned connections with the piles providing all of the lateral resistance. The horizontal subgrade modulus was based on the soil in the top ten pile diameters. The horizontal subgrade modulus was reduced for group effects in accordance with EM 1110-2-2906.

###### 5.2.7.3.3.3 Pile Curves and Horizontal Subgrade Modulus

Pile curves and horizontal subgrade modulus were calculated for a limited number of structures. Existing pile curve were utilized for those structures where no pile curve was calculated. A summary of the pile curve used for each structure is summarized below-

| Stop Log Gate Structure | | Pile Curve Utilized |
|---|---|---|
| *Ellio Jones* | → | *Box Culverts for Barrier Alignment* |
| *Humphreys Canal* | → | *Box Culverts for Barrier Alignment* |
| *Shell Canal West* | → | *Box Culverts for Barrier Alignment* |
| *Four Point Bayou* | → | *Lapeyrouse Canal* |
| *Marmande Canal* | → | *Lapeyrouse Canal* |

The resulting pile tips are summarized in Table 145.

**Table 145 - Stop Log Gate Pile Tips**

| Structure | Pile Tip (ft) (3% AEP) | Pile Tip (ft) (1% AEP) |
|---|---|---|
| Elliot Jones | -122.1 | -131.6 |
| Humphreys Canal | -122.1 | -131.6 |
| Shell Canal West | -108.1 | -122.4 |
| Marmande Canal | -117.4 | -129.1 |
| Four Point Bayou | -117.4 | -129.1 |

###### 5.2.7.3.3.4 Cut-off Wall

A cut-off sheetpile wall will be provided to reduce possible seepage, scouring and uplift. A PZC-13 sheetpile meeting the requirements of ASTM A572, Grade 50 was assumed for the cutoff wall. Tip elevations were calculated utilizing Lane's Weighted Creep Ratio for each structure. Details and tips for the cut-off wall are shown on Plates S-066 and S-070 (3% AEP LORR) and S-066A and S-070A (1% AEP LORR).

##### 5.2.7.3.4 Stop Log Gate

###### 5.2.7.3.4.1 General

The structural design of the stop log gates was performed in accordance with Corps engineering guidance and applicable industry standards. The Corps criterion is specified in EM1110-2-2105. The stop log gates will consist of horizontal wide-flanges supporting the vertical ribs and skin plate. All connections will be welded connections. A crane mounted on an adjacent T-Wall will be used to lower the gate in place. All steel members on the gate will be painted with a coal tar epoxy paint system. Details of the steel stop log gates are shown on Plates S-064 and S-071 (3% AEP LORR) and S-064A and S-071A (1% AEP LORR).

##### 5.2.7.3.4.2 **Skin Plate**

The skin plate was designed conservatively as a simply supported member by vertical angles, spaced 2' on center. An allowable stress of 0.50 times the yield stress was permitted for basic loading conditions with a permissible increase of one-third for abnormal loading conditions. EM 1110-2-2703 requires that the skin plate be designed with a 1/16" reduction in thickness.

##### 5.2.7.3.4.3 **Vertical Ribs**

The skin plate will be attached to the vertical ribs by continuous welds. The ribs were designed as simply supported members between the horizontal wide-flanges. The skin plate was considered as an effective part of the vertical ribs, with the effective width of skin plate determined according to the AISC specifications for a non-compact flange. A minimum depth of ribs will be required to be 8 in. to facilitate painting and maintenance. The ribs are also constructed from material conforming to ASTM A-588 Grade 50 steel.

##### 5.2.7.3.4.4 **Horizontal Beams**

The gate consists of horizontal beams supporting the vertical ribs and skin plate, spanning between the walls of the stop log gate concrete monolith. The beams are constructed from material conforming to ASTM A-572 Grade 50 steel.

#### 5.2.7.3.5 Crane Platform T-Wall

The crane platform T-Wall will be located adjacent to the stop log gate monolith and functions as a T-Wall, as detailed in Section 5.2.5.3.13, with the addition of a crane load imposed on the monolith.

#### 5.2.7.3.6 Needle Girders and Needles

The needle girder system arrangement was designed to dewater the entire gatebay to permit maintenance of the sluice gate concrete gatebay if necessary. The needle girder system was designed for a sill elevation of -8.0 with a water elevation of +5.0. Each stop log gate structure will utilize existing steel needles from other structures in the Morganza to the Gulf alignment as it is not anticipated that maintenance dewatering will be necessary during the design life of the structure. The needles are supported by the sill of the concrete gatebay and the needle girder at El 5.0. The needle girder was designed as a simply supported, built-up girder, spanning across the 20' or 30' gate opening. The girder will be a plate girder with a depth of 2'–1½" with 5/8" web and ¾"x12" flanges. Details of the needle girder are shown on Plates S-064 and S-071.

#### 5.2.7.3.7 Bulkhead Storage Platform

The bulkhead storage platform for the 20' stop log gate structures will be a reinforced concrete structure measuring 22'-6" wide by 30' long. The structure consists of a 12" cast in-place slab supported by 22" wide by 16" deep cast in-place beams, spaced 14'-1" O.C. The storage platform will be supported by 15, 14" square precast pre-stressed concrete (PPC) piles. Details of the bulkhead storage platform for the 20' stop log gate structures are shown on Plates S-065.

The bulkhead storage platform for the 30' stop log gate structures will be a reinforced concrete structure measuring 22'-6" wide by 30' long. The structure consists of a 15" cast in-place slab supported by 22" wide by 24" deep cast in-place beams, spaced 19'-1" O.C. The storage platform will be supported by fifteen 14" square precast pre-stressed concrete (PPC) piles. Details of the bulkhead storage platform for the 30' stop log gate structures are shown on Plates S-072.

#### 5.2.7.3.8 Guidewalls and Pile Clusters

Guidewalls and pile clusters will be provided as aids to navigation and to protect the main flood gate structure from impact. Details were taken from historical 56' sector gate structures constructed in New Orleans District rather than performing actual design on this component. The wall lengths and details on the walls and pile clusters are shown on Plates S-021 to S-023.

#### 5.2.7.3.9 Tie-in T-Walls

See Section 5.2.5.3.13.

### 5.2.7.4 Electrical Design

There is no electrical design associated with the stop log gate structures.

### 5.2.7.5 Mechanical Design

#### 5.2.7.5.1 Crane Operation

The crane will be provided with a turret mounted operator cabin. The control station will provide two-lever joystick control of the hoisting, slewing, extend/retract, and luffing functions. All motions will have step-less speed control from zero to maximum. Two motions may be operated at the same time at full capacity, but with reduced speed. The control station will include a panel mounted display screen, power on-off switch, local-remote selector switch, emergency pump unit stop switch, audible warning horn, start and stop switches for the pump unit motor.

#### 5.2.7.5.2 Crane Operating Machinery

Crane operation will be accomplished by a pedestal mounted, double tapered, sealed box section boom crane incorporating a hydraulically driven winch. The hydraulically driven winches with planetary reduction gearing will be designed for operating in a marine environment. Winches will be provided with both a multiple disc wet friction brake which is spring set and hydraulically released and a counterbalance brake valve attached directly to a hydraulic piston motor for controlled load movement. Sufficient rope for the maximum hook drop will be specified. Load blocks will include roller bearings, center pin lubricated sheaves, dual action forged quenched and tempered alloy steel hooks and automatic safety latches. The pedestal will be manufactured from high strength low alloy structural steel in accordance with ASTM 514 Grade B. The upper flange of the pedestal will be machined to receive a slew bearing with an inspection access opening. A hydraulic connection plate, electrical and control junction box and hydraulic pressure filter will be mounted to the body of the pedestal. 360 degree continuous rotation will be provided via a planetary slew drive with fail-safe brake and dynamic motion control valve. The slew bearing will have a three-point contact ball bearing designed for heavy duty applications. Fasteners for the slew bearing will be high-grade tension bolts ensuring the rigidity of the bearing during operation. The gear and pinion will be located internally to protect the gearing from the dusty environment and will be equipped with suitable grease nipples. Hydraulic tube assemblies will be of AISI 316 stainless steel. Hydraulic supply hose will be neoprene or synthetic rubber tube with stainless steel braid reinforcement. Suction and return hose will be synthetic rubber tube with two or four layers of spiral textile reinforcement.

#### 5.2.7.5.3 Crane Operating Loads

The crane operating loads were calculated based on the dead weight of the individual stop logs to be placed within the stop log gate. The lifting capacity of the crane was calculated using a safety factor of 1.35.

### 5.2.8 Environmental Control Structures

This section contains a summary of work for the 23 environmental control structures, which are part of the Morganza to the Gulf Alignment for both the 3% AEP and the 1% AEP level of protections. Table 146 lists the structures examined.

**Table 146 - Environmental Control Structures**

| Structure | Culvert Type | Sill Elevation | Top Elevation (3% AEP) | Top Elevation (1% AEP) |
|---|---|---|---|---|
| Barrier 1 | 6 – 6' X 6' | -4.5 | 16.0 | 23.5 |
| Barrier 2 | 6 – 6' X 6' | -4.5 | 16.0 | 23.5 |
| Barrier 3 | 6 – 6' X 6' | -4.5 | 16.0 | 23.5 |
| Barrier 4 | 6 – 6' X 6' | -4.5 | 16.0 | 23.5 |
| Barrier 5 | 6 – 6' X 6' | -4.5 | 16.0 | 23.5 |
| Barrier 6 | 6 – 6' X 6' | -4.5 | 16.0 | 23.5 |
| Barrier 7 | 6 – 6' X 6' | -4.5 | 16.0 | 23.5 |
| Reach A | 6 – 6' X 6' | -4.5 | 16.0 | 22.5 |
| Reach E-1 | 9 – 6' X 6' | -4.5 | 18.0 | 25.5 |
| Reach E-2 | 9 – 6' X 6' | -4.5 | 18.0 | 25.5 |
| Reach G-2 - 1 | 6 – 6' X 6' | -4.5 | 22.5 | 30.5 |
| Reach G-2 - 2 | 4 – 6' X 6' | -4.5 | 22.5 | 30.5 |
| Reach G-3 - 1 | 4 – 6' X 6' | -4.5 | 22.5 | 30.5 |
| Reach H-1 – 1 | 1 – 6' X 6' | -4.5 | 22.5 | 30.5 |
| Reach H-1 – 2 | 6 – 6' X 6' | -4.5 | 22.5 | 30.5 |
| Reach J2 – 1 | 4 – 5' X 10' | -3.5 | 25.0 | 33.0 |
| Reach J2 – 2 | 4 – 5' X 10' | -3.5 | 25.0 | 33.0 |
| Reach J2 – 3 | 5 – 5' X 10' | -3.5 | 25.0 | 33.0 |
| Reach K – 1 | 2 – 6' X 6' | -4.5 | 21.0 | 29.5 |
| Reach K – 2 | 2 – 6' X 6' | -4.5 | 21.0 | 29.5 |
| Reach L | 6 – 6' X 6' | -4.5 | 21.0 | 29.5 |
| Larose to Lockport 1 | 3 – 5' X 10' | -3.5 | 15.0 | 18.0 |
| Larose to Lockport 2 | 2 – 6.5' X 7.5' | -4.5 | 15.0 | 18.0 |

All elevations listed in this text and shown on the Tables and Plates, unless otherwise noted, are in feet, NAVD88.

#### 5.2.8.1 Physical Features

The physical features associated with the construction of the environmental control structures are-

- Interior Braced Cofferdam
- Concrete Monolith
- Pile Foundation
- Sluice Gate
- Bulkheads
- Trash Racks
- Wingwalls
- Tie-in T-Walls
- Mechanical Equipment

### 5.2.8.2 Construction Sequencing

All environmental control structures will be constructed approximately in the center of the existing channels. A cofferdam will be constructed, permitting the construction of the environmental control structure concrete monolith and the wingwalls.

### 5.2.8.3 Structural Design

#### 5.2.8.3.1 Cofferdams

A cofferdam will be constructed to permit the in the dry construction of the environmental control structure. The cofferdam is an internally braced cofferdam with wide flange walers and pipe braces supporting PZ sheet piling. Anchor forces, bending moment in the sheet piling, and required sheet piling tip elevation were calculated for Bayou Dularge sector gate and conservatively used for the environmental control structures.

ER 1110-2-8152 will be followed throughout the project design process, requiring that all cofferdams will be designed by the Government.

#### 5.2.8.3.2 Environmental Control Structure Concrete Monolith

Details of the concrete monolith are shown on Plates S-081 to S-084 (3% AEP LORR) and S-081A to S-084A (1% AEP LORR).

##### 5.2.8.3.2.1 Walls

The dimensions for the interior and exterior walls for the environmental control structures were not designed. Historical data from previously constructed environmental control structures was utilized to size these exterior and interior walls. The stem wall (main wall resisting hydrostatic forces) was designed as a cantilever from the driveway slab.

##### 5.2.8.3.2.2 Base Slab

The sluice gate base slab thickness was determined utilizing a 2D strip with a width equal to the width of one pile spacing. The strip was designed as a solid beam, given the property of the width of the slab that was examined. All loads acting along the width of the beam were input into STAAD (Structural Analysis and Design) and resolved along the centroid of the beam. Piles reactions from CPGA were applied to the beam, which was assumed to be cantilevered off of the stem. The 2D strips were analyzed for all of the environmental control structures. The selected base slab thicknesses are summarized in Table 147.

**Table 147 - Environmental Control Structure Base Slab Thickness**

| Structure | Slab Thickness (ft) (3% AEP) | Slab Thickness (ft) (1% AEP) |
|---|---|---|
| Barrier 1 | 4.5 | 5.0 |
| Barrier 2 | 4.5 | 5.0 |
| Barrier 3 | 4.5 | 5.0 |
| Barrier 4 | 4.5 | 5.0 |
| Barrier 5 | 4.5 | 5.0 |
| Barrier 6 | 4.5 | 5.0 |
| Barrier 7 | 4.5 | 5.0 |
| Reach A | 4.5 | 5.0 |
| Reach E-1 | 4.5 | 5.0 |
| Reach E-2 | 4.5 | 5.0 |
| Reach G-2 - 1 | 4.5 | 5.0 |
| Reach G-2 - 2 | 4.5 | 5.0 |
| Reach G-2 - 3 | 4.5 | 5.0 |
| Reach H-1 – 1 | 4.5 | 5.0 |
| Reach H-1 – 2 | 4.5 | 5.0 |
| Reach J2 – 1 | 4.5 | 5.0 |
| Reach J2 – 2 | 4.5 | 5.0 |
| Reach J2 – 3 | 4.5 | 5.0 |
| Reach K – 1 | 4.5 | 5.0 |
| Reach K – 2 | 4.5 | 5.0 |
| Reach L | 4.5 | 5.0 |
| Larose to Lockport 1 | 4.5 | 4.5 |
| Larose to Lockport 2 | 4.5 | 4.5 |

### 5.2.8.3.3 Environmental Control Structure Pile Foundation

#### 5.2.8.3.3.1 General

The pile foundation for the environmental control structures will include HP 14X73 piles battered on 3 vertical to 1 horizontal slope. The design Factors of Safety utilized for the design comply with EM 1110-2-2906 and the latest requirements Hurricane and Storm Damage Risk Reduction System Design Guidelines. All pile capacities used assumed compression pile testing, but no tension pile testing. Tension hooks are provided on all piles on the flood side of the sheet pile cutoff. CPGA analysis was performed for each environmental control structure. Details for the pile foundation are shown on Plates S-085 (3% AEP LORR) and S-085A (1% AEP LORR). Alternative pile types and arrangements will be investigated during detailed design for each structure to optimize the pile foundation.

###### 5.2.8.3.3.2 **CPGA Analysis**

CPGA was utilized to develop the pile layouts for the gate structures and determine the required tip elevation. The piles were modeled as pinned connections with the piles providing all of the lateral resistance. The horizontal subgrade modulus was based on the soil in the top ten pile diameters. The horizontal subgrade modulus was reduced for group effects in accordance with EM 1110-2-2906.

###### 5.2.8.3.3.3 **Pile Curves and Horizontal Subgrade Modulus**

Pile curves and horizontal subgrade modulus were calculated for a limited number of structures. Existing pile curves were utilized for those structures where no pile curve was calculated. A summary of the pile curve used for each structure is summarized below:

| Stop Log Gate Structure | | Pile Curve Utilized |
|---|---|---|
| *Barrier Alignment* | → | *Box Culverts for Barrier Alignment* |
| *Reach A* | → | *Box Culverts for Reach B* |
| *Reach E* | → | *Box Culverts for Reach E & G* |
| *Reach G* | → | *Box Culverts for Reach E & G* |
| *Reach H* | → | *Box Culverts for Reach H* |
| *Reach J* | → | *Box Culverts for Reach H* |
| *Reach K* | → | *Box Culverts for Reach H* |
| *Reach L* | → | *Box Culverts for Reach H* |
| *Lockport to Larose* | → | *Box Culverts for Barrier Alignment* |

The resulting pile tips are summarized in Table 148.

**Table 148 - Environmental Control Structures Pile Tips**

| Structure | Pile Tip (ft) (3% AEP) | Pile Tip (ft) (1% AEP) |
|---|---|---|
| Barrier 1 | -75 | -85 |
| Barrier 2 | -75 | -85 |
| Barrier 3 | -75 | -85 |
| Barrier 4 | -75 | -85 |
| Barrier 5 | -75 | -85 |
| Barrier 6 | -75 | -85 |

| Structure | Pile Tip (ft) (3% AEP) | Pile Tip (ft) (1% AEP) |
|---|---|---|
| Barrier 7 | -75 | -85 |
| Reach A | -75 | -90 |
| Reach E-1 | -70 | -90 |
| Reach E-2 | -70 | -90 |
| Reach G-2 - 1 | -85 | -105 |
| Reach G-2 - 2 | -85 | -105 |
| Reach G-3 - 1 | -85 | -105 |
| Reach H-1 – 1 | -65 | -80 |
| Reach H-1 – 2 | -65 | -80 |
| Reach J2 – 1 | -75 | -90 |
| Reach J2 – 2 | -75 | -90 |
| Reach J2 – 3 | -75 | -90 |
| Reach K – 1 | -70 | -85 |
| Reach K – 2 | -70 | -85 |
| Reach L | -65 | -80 |
| Larose to Lockport 1 | -80 | -80 |
| Larose to Lockport 2 | -80 | -80 |

5.2.8.3.3.4 **Cut-off Wall**

A cut-off sheetpile wall will be provided to reduce possible seepage, scouring and uplift. A PZC-13 sheetpile meeting the requirements of ASTM A572, Grade 50 was assumed for the cutoff wall. Tip elevations were calculated utilizing Lane's Weighted Creep Ratio for each structure. Details and tips for the cut-off wall are shown on Plates S-085 (3% AEP LORR) and S-085A (1% AEP LORR).

#### 5.2.8.3.4 Sluice Gates

The sluice gates will be manufactured 6'x6', 5'x10', 6.5'x7.5' or 5'x10' cast iron gates.

#### 5.2.8.3.5 Bulkheads

The bulkheads are designed to dewater the sluice gate bays to permit maintenance of the sluice gates and concrete gatebay. The bulkheads were designed for a sill elevation of -4.5 with a water elevation of +5.0. Each sluice gate structure will be provided with 2 bulkheads, permitting the dewatering of 1 sluice gate bay at a time.

The steel bulkheads consist of horizontal angle shapes with a 3/8" skin plate. The skin plate was designed conservatively as a simply supported member between the horizontal angles. The horizontal angles were designed as simply supported members between the sluice gates walls. The skin plate was considered as an effective part of the horizontal angles, with the effective width of skin plate determined according to the AISC specifications for a non-compact flange. All steel will be constructed from material conforming to ASTM A-572 Grade 50. Details of the sluice gate bulkheads are shown on Plate S-086.

#### 5.2.8.3.6 Trash Racks

Trash racks will be provided on both the flood and protected sides of the sluice gates to prevent large debris from blocking the closure of the sluice gates. Historical data from previously constructed environmental control structures was utilized to size the trash racks. The tracks will be constructed of galvanized steel plate conforming to the requirements of ASTM A-572 Grade 50. Details of the trash racks are shown on Plate S-088.

#### 5.2.8.3.7 Wingwalls

Wingwalls will be provided on all 4 corners of the environmental control structure to retain fill and to provide a smooth flow transition into the environmental control structures. The wingwalls are pile founded TWall type concrete monoliths. Historical data from previously constructed environmental control structures was utilized to size the wing walls. The wing walls will be supported on HP 14X73 steel piling, whose tips will be extended to the same tip elevation of the environmental control structure pile tips to prevent differential settlement. Details of the wingwalls are shown on Plate S-087.

#### 5.2.8.3.8 Tie-in T-Walls

See Section 5.2.5.3.13.

### 5.2.8.4 Electrical Design

There is no electrical design associated with the environmental control structures.

### 5.2.8.5 Mechanical Design

#### 5.2.8.5.1 Sluice Gate Operation

Sluice gate operation will be raised, lowered, or held in intermediate positions to allow, prevent, or meter water flow respectively. Operating time is designed to operate in less than fifteen minutes to totally raise or lower the sluice gate.

#### 5.2.8.5.2 Sluice Gate Operating Loads

The sluice gate operating loads consist of friction from the stem, sluice gate weight, stem weight, hydrodynamic loads. The hydrodynamic loads were developed from differential hydrostatic head applied over the sluice gate.

#### 5.2.8.5.3 Sluice Gate Operating Machinery

The sluice gate operating machinery will be an operating stem, bevel gearbox, and portable actuator. The operating stem will be attached to the top of the sluice gate within the stem pocket. The operating stem will be machine threaded AISI 316 stainless steel. The aluminum bronze ASTM B505 lift nut within the bevel gearbox shall be machine threaded to mate with the AISI 316 stainless steel operating stem. The portable actuator will be able to exercise the sluice gate via the 2” AWWA nut installed within the bevel gearbox. The bevel gearbox used for design purposes was a Diamond Gear 7.2BG3. The portable actuator considered was a Waterman GP-6 gasoline powered portable actuator. The sluice gate operating machinery is shown on Plate S-082.

### 5.2.9 Pump Station Fronting Protection

This section contains a summary of work for the 4 pump station fronting protections, which are part of the Morganza to the Gulf Alignment for both the 3% AEP and the 1% AEP level of protections. Table 149 lists the structures examined.

**Table 149 - Pump Stations**

| Pump Station | Pump Sizes | Top Elevation (3% AEP) | Top Elevation (1% AEP) |
|---|---|---|---|
| Madison | 2 – 48” | 25.0 | 33.0 |
| Pointe Aux Chenes | 2 – 20” | 25.0 | 33.0 |
| Bayou Black | 2 – 42” | 16.0 | 23.5 |
| Hanson Canal | 2 – 42” | 16.0 | 23.5 |

#### 5.2.9.1 Physical Features

The physical features associated with the construction of the pump station fronting protection are as follows:

- Fronting Protection T-Walls
- Mechanical Equipment – Butterfly Valves

#### 5.2.9.2 Construction Sequencing

All fronting protections will be constructed on the flood side of the existing protection. Based on site visits conducted for this report, the discharge pipes extend far enough such that additional pipe length will not be needed.

#### 5.2.9.3 Structural Design

##### 5.2.9.3.1 Fronting Protection Walls

All fronting protection walls were designed as T-Walls as described in Section 5.2.5.3.13.

#### 5.2.9.4 Electrical Design

There is no electrical design associated with the butterfly valves.

#### 5.2.9.5 Mechanical Design

No calculations were performed on the existing pumps and engines to determine effects (if any) from head losses associated with butterfly valves and discharge piping modifications. It was assumed that the existing pumps and engines will be adequate.

##### 5.2.9.5.1 Butterfly Valve Operation

Butterfly valve operation will be opened to allow pumping discharge for interior drainage or closed to prevent backflow during storm conditions. Operating time was designed to operate in less than fifteen minutes to totally open or close the butterfly valve.

##### 5.2.9.5.2 Butterfly Valve Operating Loads

The butterfly valve operating loads consist of friction from the disc, disc weight, and hydrodynamic loads. The hydrodynamic loads considered closing against a full discharge pipe in a backflow condition.

##### 5.2.9.5.3 Butterfly Valve Operating Machinery

The butterfly valve operating machinery will be the butterfly valve, gearbox, and portable actuator. Butterfly valves on the discharge piping lines will conform to AWWA C504. The valve will be suitable for air tight seating in either direction. The body will be ASTM A 126 Class B heavy cast iron. All valves will have flanged by flanged ends. 75# ANSI B16.1 or AWWA C207 flanged ends, with shaft of ASTM A 276 Type 304 Stainless

Steel. Packing will be self adjusting "V" type made of PTFE. Shaft bearings will be corrosion resistant, self-lubricating type, Teflon lined, sleeve-type bearings. The valve disc will be constructed of ASTM A 536 ductile iron with a stainless steel seating edge. The disc will not have any hollow chambers that can entrap water. Disc and shaft connection will be made with stainless steel pins. Valves will be painted on its interior and exterior with the same coatings used for the discharge piping. The portable actuator will be able to exercise the sluice gate via the 2" AWWA nut installed within the gearbox. The portable actuator considered was a Waterman GP-6 gasoline powered portable actuator. The butterfly valve and operating machinery is shown on Plate M-003.

### 5.2.10 Roadway/Railroad Gates

This section contains a summary of work for the 10 roadway/railroad swing gates, which are part of the Morganza to the Gulf Alignment for both the 3% AEP and the 1% AEP level of protections. Table 150 lists the structures examined.

**Table 150 - Roadway Gates**

| Roadway | Gate Opening (ft) | Top Elevation (3% AEP) | Top Elevation (1% AEP) |
|---|---|---|---|
| Hwy 315 | 36 | 18.0 | 25.5 |
| Hwy 55 | 36 | 25.0 | 33.0 |
| Hwy 56 | 36 | 22.5 | 30.0 |
| Hwy 665 | 36 | 25.0 | 33.0 |
| NAFTA | 36 | 16.0 | 23.5 |
| Four Point Road | 36 | 22.5 | 30.0 |
| Hwy 24 | 36 | 14.0 | 17.0 |
| Hwy 3235 - 1 | 36 | 14.0 | 17.0 |
| Hwy 3235 - 2 | 36 | 14.0 | 17.0 |
| Union Pacific RR | 36 | 15.0 | 18.0 |

#### 5.2.10.1 Physical Features

The physical features associated with the construction of the roadway gates structures are as follows:

- Steel Swing Gate
- Traffic Control Devices
- Falsework (Railroad Gates)
- Concrete Monolith
- Tie-in T-Walls

### 5.2.10.2 Construction Sequencing

All roadway gates except for the NAFTA gate are directly adjacent to navigation gates; therefore they will be constructed concurrent with those structures. The roadway gate concrete monoliths will be constructed in two- halves to permit traffic flow during construction of the concrete monoliths. Detours and traffic control will conform to LADOTD Standards. Railroad gates will be constructed with temporary falsework to minimize disruptions to the railroad during construction

### 5.2.10.3 Structural Design

#### 5.2.10.3.1 Steel Swing Gates

##### 5.2.10.3.1.1 General

The structural design of the steel swing gates was performed in accordance with Corps engineering guidance and applicable industry standards. The Corps criterion is specified in EM1110-2-2105 and EM 1110-2-2705. The swing gates will consist of structural wide flange sections supporting the vertical ribs and skin plate. All connections will be welded connections. All steel members on the gate will be painted with a vinyl paint system. Details of the steel swing gate are shown on Plate S-076 (3% AEP) and S-076A (1% AEP).

##### 5.2.10.3.1.2 Skin Plate

The skin plate was designed conservatively as a continuously supported member by vertical intercostals. An allowable stress of 0.50 times the yield stress was permitted for basic loading conditions with a permissible increase of one-third for abnormal loading conditions.

##### 5.2.10.3.1.3 Vertical Intercostals

The skin plate will be attached to the vertical intercostals by continuous welds. The intercostals were designed as simply supported members between the horizontal girders. The skin plate was considered as an effective part of the vertical intercostals, with the effective width of skin plate determined according to the AISC specifications for a non-compact flange. A minimum depth of intercostals will be required to be 8 in. to facilitate painting and maintenance. The intercostals will be constructed from material conforming to ASTM A-572 Grade 50 steel.

##### 5.2.10.3.1.4 **Horizontal Beams**

The gate will consist of horizontal wide flange sections supporting the vertical intercostals and skin plate. The beam was designed as simply supported between the concrete pilasters of the swing gate monolith. The beams are constructed from material conforming to ASTM A-992 Grade 50 steel.

#### 5.2.10.3.2 Swing Gate Concrete Monolith and Pile Foundation

The swing gate concrete monolith and pile foundation was not designed, rather the typical T-Wall design as described in Section 5.2.5.3.13 was utilized for quantity estimation.

#### 5.2.10.3.3 Traffic Control Devices

Each roadway gate will include guardrails meeting the requirements of LADOTD GR-200 and end treatment on all four sides of the structure. Removable Vulcan barriers will be provided as guardrails in the gate swing radius.

### 5.2.11 Pipeline Crossings

This section contains a summary of work for the 3 pipeline crossing T-Walls, which are part of the Larose to Lockport Reach of the Morganza to the Gulf Alignment for both the 3% AEP and the 1% AEP level of protections. Table 151 lists the structures examined.

**Table 151 - Roadway Gates**

| Pump Station | Top Elevation (3% AEP) | Top Elevation (1% AEP) |
|---|---|---|
| C North Gulf South Pipeline | 18.0 | 23.0 |
| C North American Midstream Pipeline | 18.0 | 23.0 |
| C North Williams Discovery Pipeline | 18.0 | 23.0 |

#### 5.2.11.1 Physical Features

The physical features associated with the construction of the roadway gates structures are as follows:

- Utility Crossing T-Wall
- Utility Sleeve
- Cofferdam
- Tie-in T-Walls (Union Pacific Railroad Gate Only)

#### 5.2.11.2 Construction Sequencing

A cofferdam will be constructed to construct the sleeve of the pipeline crossing through the T-Wall.

#### 5.2.11.3 Structural Design

##### 5.2.11.3.1 Utility Crossing T-Wall Concrete Monolith and Pile Foundation

The utility crossing concrete monolith and pile foundation was not designed, rather the typical T-Wall design as described in previous sections was utilized for quantity estimation.

##### 5.2.11.3.2 Cofferdam

The cofferdam design as described in Paragraph 5.2.5.3.1 was used to develop quantities for the cofferdam required to construct the pipeline crossing sleeve.

##### 5.2.11.3.3 Tie-in T-Walls

Tie-in T-Walls extend from the utility crossing T-Wall to the full levee section. See Paragraph 5.2.5.3.13 for design details.

# 6 RELOCATIONS

## 6.1 Scope and Purpose

Relocation data was collected, tabulated and detailed in this Section by the U.S. Army Corps of Engineers, New Orleans District, Engineering Division, Design Service Branch, Relocations Team, to a feasibility level of design. The Relocations Team made contact with pipeline owners to obtain detailed information on existing facilities. Approximately half of the pipeline owners responded with information. Three pipeline databases were used where information was not available from the owners, and to supplement it when it was available. The databases used were the National Pipeline Mapping System (NPMS) database, the Louisiana Department of Natural Resources (LA DNR) database, and the commercial database HTSI. Because of the number of pipelines in the Barrier Alignment Reach, duplication between databases, and some apparent errors in the

HTSI data in the Barrier Alignment Reach, the HTSI data was not used for the Barrier Alignment Reach. With the exception of Entergy, none of the other utility owners (Terrebonne Parish government, Lafourche Parish government, or the local utility and cable companies) were contacted. It should further be noted that the Relocations Team was unable to obtain Right of Entry for about half of the project alignment, including the Barrier Alignment Reach, Reach A, Reach B, Reach G, and about half of Reach L. The Relocations Team then made assumptions based on the proposed project design and project location to determine project relocation requirements. Oil wells were assumed to not be relocation items, and the levee alignment may need to be changed, or T-walls used, during the project Plans and Specifications (P&S) phase to avoid them. The cost estimates presented in this report were developed by New Orleans District, Engineering Division, Design Service Branch, Cost Engineering Team by developing cost estimates for the relocation items. These relocation costs represent a feasibility level of design and will be further refined during the development of the project P&S.

Additional relocations details will be furnished upon request.

## 6.2 Estimated Relocations Cost

### 6.2.1 General

The cost estimates presented herein are based on conceptual relocations designs. We developed these plans with the criteria input that we received from the owners (for those that submitted input), and from the pipeline databases used. Included in the construction cost estimates are the facility owners engineering design, contract supervision, and administration.

### 6.2.2 Methods of Relocation

Four methods of relocating affected pipelines were investigated as follows:

a. Above ground installation on the levee surface covered by additional fill.
b. Above ground installation, supported by temporary (until final lift is completed) pile bents.
c. Permanent Pipeline Bridge supported by pile founded piers.
d. Directional drilling.

The main conditions influencing the selection of relocation methods is the substantial subsidence anticipated by the proposed levee, and the costs associated with each method.

#### 6.2.2.1 Pipeline Relocation on the Levee Surface

This method of relocation is typically used for pipelines affected by main line Mississippi River and Atchafalaya Basin levees. Typically, the pipeline is installed on the levee net grade and follows the contour of the levee until it proceeds underground on the flood side and protected side of the levee. Additional fill producing the gross grade is placed over the pipeline to provide protection. This method presented problems in some places due to the anticipated subsidence of the levees on which the pipeline would rest. Since the levee provides support for the pipeline, the anticipated levee subsidence would result in undesirable stresses on the pipeline. The multiple lifts expected to meet project flood protection elevations also raised concerns about multiple relocations, a prospect which would not be welcomed by the pipeline owners. Although the cost for initial pipeline relocation by this method would probably be the least costly, the future cost of subsequent adjustments, modifications, and relocations of the pipeline would diminish this advantage.

#### 6.2.2.2 Pipeline Relocation using Temporary Pile Bents

This method is similar to the above, but uses temporary pile bents in the levee to support the pipeline and prevent excessive settlements. Since the pile bents penetrate the levee 1-4 slope line, a sheetpile cutoff wall is required in the levee at or near the centerline.

#### 6.2.2.3 Permanent Pipeline Bridge

This method of relocation centers around installations of affected pipelines on bents supported by pile piers. The advantage of this method is that it would diminish the affects of the expected subsidence. However, it is possible that subsidence of the permanent pipeline bridge would also cause stress on the pipeline, requiring additional modification of the bridge. Another disadvantage would be that the pipeline would be exposed and vulnerable to vandalism. Additionally, the presence of a permanent structure over the levee would impede levee maintenance and construction of future levee lifts.

#### 6.2.2.4 Directional Drilling

Directional drilling of pipelines under existing levees is an acceptable method of pipeline relocation, but pressures must be monitored to prevent possible fracturing of the levee from the pressure of the drilling fluid. Directional drilling is a reliable method of relocation and can be done prior to construction of the levee. From a geotechnical perspective, the pipeline should be installed deep enough under the levee section and any berm sections to avoid stresses from the levee and berm subsidence. The advantage of this method is that it eliminates additional modification and/or relocation in the future.

Additionally, the pipeline cannot be vandalized or damaged by levee maintenance or future construction. From a negative viewpoint, the initial cost of directional drilling would be greater than that of the other two relocation methods studied. However the cost of future modifications and/or relocations resulting from the use of either of these two methods would most likely make the final relocation costs comparable to directional drilling.

### 6.2.3 Highways and Roads

The flood protection alignment being studied impacts several State and Parish highways and roads. Traversing the proposed flood protection requires either relocating the highways and roads over the protection, using ramps, or construction of permanent floodgates at the points of intersection of the protection and highways and roads. These structures would remain open except for times of anticipated flooding, which at that time they would be closed and remain closed until the flood threat subsided. The alternatives selected for this study were an earthen ramp for highway 182 (aka Bayou Black Drive), and floodgates for all the others.

### 6.2.4 Estimated Cost

#### 6.2.4.1 Utilities

The total estimated cost for relocation of all utilities is $222,810,775.28 for the 3% AEP level of risk reduction, and $223,689,602.50 for the 1% AEP level of risk reduction. Engineering and Design (E&D) costs and Supervision and Administration (S&A) costs are included, but Contingency costs and Escalation costs are not. For pipelines, the costs are the same for both 3% AEP and 1% AEP levels of risk reduction, since the directional drill distances were taken as the same for both levels of risk reduction, because a 3% AEP Microstation dgn (electronic footprint) file was not available during the Relocations study, because the sleeve-through costs were taken as the same, and because the up-and-over relocation costs were taken as the same. Estimated 1% AEP relocation costs are summarized in Table 152 (except roads), and estimated 3% AEP relocation costs are summarized in Table 153 (except roads). Relocation costs for roads are in Table 154. All utilities affected by the project along with the associated maps will be furnished upon request. It should be noted that if a public facility owner has an interest in the land occupied by its compensable facilities that require relocation, the Government is obligated to provide substitute facilities in exchange for the owner subordinating or releasing its interest in land to the Government. The Government usually reimburses the owner for relocation of its facilities. However, the Government may provide all or part of the substitute facilities for the owner. Any relocation subsequent to the owner subordinating its interest in the land to the Government, that is not consequential to the current project, would be at the owner's expense.

Table 152 1% AEP Relocations Cost

| Relocation Item ID | ED-L Station (100yr = 35yr) | Relocation Cost | Mitigation Cost | Total |
|---|---|---|---|---|
| **BARRIER ALIGNMENT** | | | | |
| BAR-P1 | 1023+00 | $291,146.89 | $0.00 | $291,146.89 |
| BAR-P2 | 1023+00 | $16,221.92 | $0.00 | $16,221.92 |
| BAR-P2 | 1110+28 | $400,176.80 | $0.00 | $400,176.80 |
| BAR-P3 | 1110+15 | $16,648.64 | $0.00 | $16,648.64 |
| BAR-P4 | 1109+50 | $15,987.02 | $0.00 | $15,987.02 |
| BAR-P5 | 1110+00 | $15,728.63 | $0.00 | $15,728.63 |
| BAR-P6 | 1109+10 | $16,433.31 | $0.00 | $16,433.31 |
| BAR-P6 | 1423+00 | $0.00 | $0.00 | $0.00 |
| BAR-P7 | 1023+00 | $16,221.92 | $0.00 | $16,221.92 |
| BAR-P7 | 1110+00 | $16,237.56 | $0.00 | $16,237.56 |
| BAR-P8 | 1110+78 | $15,728.63 | $0.00 | $15,728.63 |
| BAR-P9 | 1112+64 | $15,728.63 | $0.00 | $15,728.63 |
| BAR-P10 | 1176+18 | $291,342.64 | $0.00 | $291,342.64 |
| BAR-P11 | 1176+50 | $16,402.02 | $0.00 | $16,402.02 |
| BAR-P12 | 1213+10 | $509,184.41 | $0.00 | $509,184.41 |
| BAR-P13 | 1210+65 | $0.00 | $0.00 | $0.00 |
| BAR-P13 | 1333+35 | $5,583,045.85 | $516,878.93 | $6,099,924.78 |
| BAR-P13 | 1505+00 | $5,583,045.85 | $516,878.93 | $6,099,924.78 |
| BAR-P13 | 1639+00 | $0.00 | $0.00 | $0.00 |
| BAR-P14 | 1327+03 | $291,557.96 | $0.00 | $291,557.96 |
| BAR-P15 | 1327+13 | $291,146.89 | $0.00 | $291,146.89 |
| BAR-P16 * | n/a | $0.00 | $0.00 | $0.00 |
| BAR-P17 | 1433+00 | $0.00 | $0.00 | $0.00 |
| BAR-P18 | 1442+24 | $1,086,368.10 | $0.00 | $1,086,368.10 |
| BAR-P19 | 1462+50 | $509,185.48 | $0.00 | $509,185.48 |
| BAR-P20 | 1484+50 | $0.00 | $0.00 | $0.00 |
| BAR-P21 | 1575+65 | $613,487.09 | $0.00 | $613,487.09 |
| BAR-P22 | 1564+00 | $0.00 | $0.00 | $0.00 |
| BAR-P23 | 1578+50 | $1,644,105.22 | $0.00 | $1,644,105.22 |
| BAR-P24 | 1585+75 | $18,660.36 | $8,760.66 | $27,421.02 |

| Relocation Item ID | ED-L Station (100yr = 35yr) | Relocation Cost | Mitigation Cost | Total |
|---|---|---|---|---|
| BAR-P25 | 1621+10 | $509,185.48 | $0.00 | $509,185.48 |
| BAR-P26 | 1629+40 | $559,989.62 | $0.00 | $559,989.62 |
| BAR-P27 | 1766+00 | $0.00 | $0.00 | $0.00 |
| BAR-P28 | 1780+40 | $509,185.48 | $0.00 | $509,185.48 |
| BAR-P29 | 1780+43 | $559,989.62 | $0.00 | $559,989.62 |
| BAR-P29 | 1782+90 | $290,508.25 | $0.00 | $290,508.25 |
| BAR-P30 | 1782+90 | $290,387.13 | $0.00 | $290,387.13 |
| BAR-P31 | 1410+40 | $0.00 | $0.00 | $0.00 |
| BAR-P32 | 1410+40 | $0.00 | $0.00 | $0.00 |
| BAR-P33 | 1410+40 | $0.00 | $0.00 | $0.00 |
| BAR-P34 | 1410+40 | $0.00 | $0.00 | $0.00 |
| **REACH A** | | | | |
| A-P1 | 1836+20 | $613,487.09 | $0.00 | $613,487.09 |
| A-P1 | 1881+90 | $290,658.54 | $0.00 | $290,658.54 |
| A-P1 | 1900+55 | $618,180.30 | $0.00 | $618,180.30 |
| A-P2 | 1931+00 | $2,044,997.82 | $516,878.93 | $2,561,876.75 |
| A-P3 | 1931+00 | $2,066,735.79 | $516,878.93 | $2,583,614.72 |
| A-P4 | 1985+53 | $35,751.63 | $26,281.98 | $62,033.61 |
| A-P5 | 1985+53 | $35,751.63 | $26,281.98 | $62,033.61 |
| A-P6 | 1997+70 | $559,989.62 | $0.00 | $559,989.62 |
| A-P7 | 2010+05 | $559,989.62 | $0.00 | $559,989.62 |
| A-P8 | 2015+50 | $788,602.94 | $0.00 | $788,602.94 |
| A-P8 | 2193+10 | $788,602.94 | $0.00 | $788,602.94 |
| A-P9 | 2025+25 | $509,281.14 | $0.00 | $509,281.14 |
| A-P10 | 2025+25 | $509,185.48 | $0.00 | $509,185.48 |
| A-P11 | 2193+65 | $624,593.39 | $0.00 | $624,593.39 |
| **REACH B** | | | | |
| B-P1 | 2340+15 | $2,037,966.61 | $0.00 | $2,037,966.61 |
| B-P2 | 2339+40 | $0.00 | $0.00 | $0.00 |
| B-P3 | 2514+60 | $61,278.95 | $47,557.87 | $108,836.82 |
| **REACH E-2** | | | | |
| E2-P1 | 2622+30 | $65,077.76 | $40,048.73 | $105,126.49 |
| E2-P2 | 2629+30 | $5,617,436.63 | $516,878.93 | $6,134,315.56 |
| E2-P3 | 2626+30 | $0.00 | $0.00 | $0.00 |
| **REACH E-1** | | | | |
| E1-P1 | 2751+40 | $0.00 | $0.00 | $0.00 |
| E1-P2 | 2800+00 | $248,188.54 | $0.00 | $248,188.54 |
| **REACH F-2** | | | | |

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**DRAFT ENGINEERING APPENDIX**

| Relocation Item ID | ED-L Station (100yr = 35yr) | Relocation Cost | Mitigation Cost | Total |
|---|---|---|---|---|
| F2-P1 | 2779+05 | $0.00 | $0.00 | $0.00 |
| **REACH F-1** | | 0 | 0 | 0 |
| NONE | | $0.00 | $0.00 | $0.00 |
| **REACH G-1** | | 0 | 0 | 0 |
| NONE | | $0.00 | $0.00 | $0.00 |
| **REACH G-2** | | 0 | 0 | 0 |
| NONE | | $0.00 | $0.00 | $0.00 |
| **REACH G-3** | | 0 | 0 | 0 |
| NONE | | $0.00 | $0.00 | $0.00 |
| **REACH H-1** | | 0 | 0 | 0 |
| H1-P1 | 3313+75 | $0.00 | $0.00 | $0.00 |
| H1-P2 | 3313+75 | $1,398,516.75 | $0.00 | $1,398,516.75 |
| H1-P3 | 3316+15 | $42,075.34 | $0.00 | $42,075.34 |
| **REACH H-2** | | 0 | 0 | 0 |
| H2-P1 | 3457+10 | $0.00 | $0.00 | $0.00 |
| H2-P2 | 3457+10 | $0.00 | $0.00 | $0.00 |
| H2-P3 | 3457+10 | $0.00 | $0.00 | $0.00 |
| H2-P4 | 3457+10 | $0.00 | $0.00 | $0.00 |
| H2-P5 | 3457+10 | $0.00 | $0.00 | $0.00 |
| H2-P6 | 3439+10 | $0.00 | $0.00 | $0.00 |
| H2-P7 | 3439+10 | $0.00 | $0.00 | $0.00 |
| H2-P8 | 3449+10 | $0.00 | $0.00 | $0.00 |
| **REACH H-3** | | 0 | 0 | 0 |
| H3-P1 | 3571+60 | $0.00 | $0.00 | $0.00 |
| H3-P2 | 3636+60 | $0.00 | $0.00 | $0.00 |
| H3-P3 | 3611+53 | $0.00 | $0.00 | $0.00 |
| H3-P4 | 3611+53 | $0.00 | $0.00 | $0.00 |
| H3-P5 | 3467+73 | $0.00 | $0.00 | $0.00 |
| H3-P6 | 3464+33 | $0.00 | $0.00 | $0.00 |
| H3-P7 | 3464+13 | $0.00 | $0.00 | $0.00 |
| H3-P8 | 3466+38 | $0.00 | $0.00 | $0.00 |
| H3-P9 | 3463+53 | $0.00 | $0.00 | $0.00 |
| H3-P10 | 3463+53 | $0.00 | $0.00 | $0.00 |
| H3-P11 | 3611+13 | $0.00 | $0.00 | $0.00 |
| H3-P12 | 3507+13 | $0.00 | $0.00 | $0.00 |
| **REACH I-1** | | 0 | 0 | 0 |
| NONE | | $0.00 | $0.00 | $0.00 |
| **REACH I-2** | | 0 | 0 | 0 |

| Relocation Item ID | ED-L Station (100yr = 35yr) | Relocation Cost | Mitigation Cost | Total |
|---|---|---|---|---|
| I2-P1 | 3808+00 | $62,803.04 | $47,557.87 | $110,360.91 |
| I2-P2 | 3807+11 | $0.00 | $0.00 | $0.00 |
| I2-E1 | 3760+60 | $1,093,844.82 | $83,852.03 | $1,177,696.85 |
| **REACH I-3** | | | | |
| I3-P1 | 3922+60 | $5,320,942.19 | $516,878.93 | $5,837,821.12 |
| I3-P2 | 3918+13 | $6,315,581.00 | $516,878.93 | $6,832,459.93 |
| I3-P3 | 3915+67 | $5,521,277.53 | $516,878.93 | $6,038,156.46 |
| I3-P4 | 3914+50 | $5,498,280.79 | $516,878.93 | $6,015,159.72 |
| I3-P5 | 3900+90 | $4,653,726.48 | $516,878.93 | $5,170,605.41 |
| I3-P6 | 3900+10 | $6,895,810.27 | $516,878.93 | $7,412,689.20 |
| I3-P7 | 3896+89 | $4,326,481.01 | $516,878.93 | $4,843,359.94 |
| I3-P8 | 3865+54 | $4,297,679.41 | $516,878.93 | $4,814,558.34 |
| I3-P9 | 3919+20 | $0.00 | $0.00 | $0.00 |
| I3-W1 | 3928+60 | $344,189.89 | $103,876.40 | $448,066.29 |
| **REACH J-2** | | | | |
| J2-P1 * | n/a | $0.00 | $0.00 | $0.00 |
| J2-P2 | 3999+14 | $0.00 | $0.00 | $0.00 |
| J2-P3 | 4162+40 | $10,478,095.41 | $2,277,771.56 | $12,755,866.97 |
| J2-P4 | 4161+60 | $10,375,194.05 | $516,878.93 | $10,892,072.98 |
| J2-P5 | 4037+50 | $12,618,256.87 | $516,878.93 | $13,135,135.80 |
| J2-P6 | 3990+50 | $0.00 | $0.00 | $0.00 |
| J2-P7 | 3986+48 | $0.00 | $0.00 | $0.00 |
| J2-P8 | 3963+08 | $9,289,042.99 | $516,878.93 | $9,805,921.92 |
| J2-P9 | 3956+02 | $5,760,341.62 | $516,878.93 | $6,277,220.55 |
| J2-P10 | 3955+90 | $999,052.03 | $0.00 | $999,052.03 |
| J2-P11 | | $162,835.33 | $103,876.40 | $266,711.73 |
| J2-P12 | | $0.00 | $0.00 | $0.00 |
| J2-P13 | | $0.00 | $0.00 | $0.00 |
| J2-P14 | | $0.00 | $0.00 | $0.00 |
| J2-P15 | | $0.00 | $0.00 | $0.00 |
| J2-E1 | 3984+96 | $0.00 | $0.00 | $0.00 |
| **REACH J-1** | | | | |
| J1-P1 | 4233+75 | $0.00 | $0.00 | $0.00 |
| J1-P2 * | n/a | $0.00 | $0.00 | $0.00 |
| J1-P3 | 4204+30 | $16,557,557.05 | $1,198,958.88 | $17,756,515.93 |
| J1-P4 * | n/a | $0.00 | $0.00 | $0.00 |
| J1-P5 | 4330+15 | $0.00 | $0.00 | $0.00 |
| **REACH J-3** | | | | |

| Relocation Item ID | ED-L Station (100yr = 35yr) | Relocation Cost | Mitigation Cost | Total |
|---|---|---|---|---|
| J3-P1 | 4431+10 | $6,089,591.21 | $516,878.93 | $6,606,470.14 |
| **REACH K** | | | | |
| K-P1 | 4606+00 | $0.00 | $0.00 | $0.00 |
| **REACH L** | | | | |
| L-P1 | 4777+80 | $283,141.57 | $0.00 | $283,141.57 |
| L-P1 | 4841+50 | $1,353,315.09 | $0.00 | $1,353,315.09 |
| L-P2 | 4808+30 | $1,086,755.28 | $0.00 | $1,086,755.28 |
| L-P2 | 4861+30 | $1,086,368.10 | $0.00 | $1,086,368.10 |
| L-P3 | 4866+05 | $1,327,779.56 | $0.00 | $1,327,779.56 |
| L-P4 | 4867+40 | $1,223,618.66 | $0.00 | $1,223,618.66 |
| L-P5 | 5017+90 | $1,074,586.37 | $0.00 | $1,074,586.37 |
| L-P6 | 5019+40 | $2,045,788.63 | $0.00 | $2,045,788.63 |
| L-P7 | c. 4914+20 | $563,118.43 | $0.00 | $563,118.43 |
| L-P8 | 5019+40 | $1,710,575.94 | $0.00 | $1,710,575.94 |
| L-P9 | c.4914+20 | $24,242.90 | $12,515.23 | $36,758.13 |
| L-P10 | 4732+35 | $0.00 | $0.00 | $0.00 |
| **REACH LGM** | **LGM PAC station values** | | | |
| LGM-P1 | None, see map | $192,491.32 | $0.00 | $192,491.32 |
| LGM-P2 | None, see map | $192,491.32 | $0.00 | $192,491.32 |
| LGM-P3 | None, see map | $203,731.02 | $0.00 | $203,731.02 |
| LGM-P4 | None, see map | $188,735.37 | $0.00 | $188,735.37 |
| LGM-P5 | None, see map | $188,735.37 | $0.00 | $188,735.37 |
| LGM-P6 | None, see map | $0.00 | $0.00 | $0.00 |
| LGM-P7 | 742+90 | $188,735.37 | $0.00 | $188,735.37 |
| LGM-P8 | 740+00 | $188,735.37 | $0.00 | $188,735.37 |
| LGM-P9 | 740+00 | $75,581.33 | $0.00 | $75,581.33 |
| LGM-W1 | 743+15 | $92,021.61 | $0.00 | $92,021.61 |
| LGM-W2 | 740+80 | $92,319.08 | $0.00 | $92,319.08 |
| LGM-W3 | 741+60 | $92,021.61 | $0.00 | $92,021.61 |
| LGM-C1 | 743+20 | $84,971.10 | $0.00 | $84,971.10 |
| LGM-C2 | 743+20 | $3,911.01 | $0.00 | $3,911.01 |
| LGM-E1 | 740+65 | $60,029.44 | $0.00 | $60,029.44 |
| LGM-E2 | 761+00 | $58,902.38 | $0.00 | $58,902.38 |
| LGM-E3 | 761+41 | $2,563.68 | $0.00 | $2,563.68 |
| LGM-E4 | 765+50 | $22,563.01 | $0.00 | $22,563.01 |
| LGM-E5 | 769+76 | $2,957.08 | $0.00 | $2,957.08 |
| LGM-P10 | 762+18 to | $135,336.32 | $0.00 | $135,336.32 |

| Relocation Item ID | ED-L Station (100yr = 35yr) | Relocation Cost | Mitigation Cost | Total |
|---|---|---|---|---|
| | 762+92 | | | |
| LGM-P11 | 762+31 | $188,735.37 | $0.00 | $188,735.37 |
| LGM-P12 | 767+73 | $1,511,799.78 | $0.00 | $1,511,799.78 |
| LGM-C3 | 772+55 | $0.00 | $0.00 | $0.00 |
| LGM-W4 | 771+70 | $192,491.32 | $0.00 | $192,491.32 |
| LGM-W5 | 786+36 | $192,491.32 | $0.00 | $192,491.32 |
| LGM-P13 | 791+15 | $1,392,700.49 | $0.00 | $1,392,700.49 |
| LGM-P14 | 792+67 | $1,277,371.85 | $0.00 | $1,277,371.85 |
| LGM-W6 | 792+85 | $142,172.75 | $0.00 | $142,172.75 |
| LGM-C4 | On Bayou Lafourche | $312,657.74 | $0.00 | $312,657.74 |
| LGM-C5 | On Bayou Lafourche | $312,657.74 | $0.00 | $312,657.74 |
| LGM-E6 | On Bayou Lafourche | $317,547.85 | $0.00 | $317,547.85 |
| LGM-E7 | On Bayou Lafourche | $231,708.38 | $0.00 | $231,708.38 |
| LGM-E8 | On Bayou Lafourche | $188,735.37 | $0.00 | $188,735.37 |
| LGM-P15 | On Bayou Lafourche | $1,511,799.78 | $0.00 | $1,511,799.78 |
| LGM-C6 | none | $0.00 | $0.00 | $0.00 |
| LGM-W7 | 1064+70 | $192,491.32 | $0.00 | $192,491.32 |
| LGM-C7 | 1064+70 | $188,735.37 | $0.00 | $188,735.37 |
| LGM-C8 | 1064+70 | $188,735.37 | $0.00 | $188,735.37 |
| LGM-C9 | none | $0.00 | $0.00 | $0.00 |
| LGM-P16 | 1064+70 | $192,491.32 | $0.00 | $192,491.32 |
| LGM-W8 | 1042+16 | $192,491.32 | $0.00 | $192,491.32 |
| LGM-P17 | 941+50 | $0.00 | $0.00 | $0.00 |
| LGM-P18 | 920+87 | $192,491.32 | $0.00 | $192,491.32 |
| LGM-P19 | 905+28 | $192,491.32 | $0.00 | $192,491.32 |
| LGM-P20 | 890+77 | $192,491.32 | $0.00 | $192,491.32 |
| LGM-E9 | 868+90 | $0.00 | $0.00 | $0.00 |
| LGM-P21 | approx 856+00 | $561,662.05 | $62,576.14 | $624,238.19 |
| LGM-P22 | 843+73 | $519,201.40 | $62,576.14 | $581,777.54 |
| LGM-P23 | 843+43 | $0.00 | $0.00 | $0.00 |
| LGM-P24 | 821+38 | $607,035.00 | $62,576.14 | $669,611.14 |
| LGM-P25 | 821+08 | $519,201.40 | $62,576.14 | $581,777.54 |

| Relocation Item ID | ED-L Station (100yr = 35yr) | Relocation Cost | Mitigation Cost | Total |
|---|---|---|---|---|
| **REACH LL** | | 0 | 0 | 0 |
| LL-C1 | 2160+70 | $590,534.46 | $62,576.14 | $653,110.60 |
| LL-P1 | 2261+20 | $1,117,364.05 | $62,576.14 | $1,179,940.19 |
| LL-P1 | 2506+70 | $1,073,875.84 | $62,576.14 | $1,136,451.98 |
| LL-P1 | 2705+15 | $1,412,117.52 | $62,576.14 | $1,474,693.66 |
| LL-P1 | 2775+00 to 2778+85 | $0.00 | $0.00 | $0.00 |
| LL-P2 | 2261+20 | $1,168,093.53 | $62,576.14 | $1,230,669.67 |
| LL-P2 | 2506+70 | $1,153,084.38 | $62,576.14 | $1,215,660.52 |
| LL-P2 | 2705+15 | $1,509,117.36 | $62,576.14 | $1,571,693.50 |
| LL-P2 | 2775+00 to 2778+85 | $0.00 | $0.00 | $0.00 |
| LL-P3 | 2263+80 | $2,426,909.61 | $62,576.14 | $2,489,485.75 |
| LL-P3 | 2488+00 | $2,426,909.61 | $62,576.14 | $2,489,485.75 |
| LL-P3 | 2712+80 | $2,919,743.85 | $62,576.14 | $2,982,319.99 |
| LL-P3 | 2771+00 to 2789+00 | $0.00 | $0.00 | $0.00 |
| LL-P4 | 2269+05 | $1,080,244.57 | $62,576.14 | $1,142,820.71 |
| LL-P5 | 2495+70 | $0.00 | $0.00 | $0.00 |
| LL-P6 | See text | $372,818.00 | $0.00 | $372,818.00 |
| LL-P7 | None | $0.00 | $0.00 | $0.00 |
| LL-P8 | 2309+25 | $1,953,061.80 | $62,576.14 | $2,015,637.94 |
| LL-P9 | 2312+40 | $1,073,875.84 | $62,576.14 | $1,136,451.98 |
| LL-P10 | 2533+72 to 2717+17 | $0.00 | $0.00 | $0.00 |
| LL-P11 | 2715+35 | $2,221,200.94 | $62,576.14 | $2,283,777.08 |
| LL-P12 | 2713+50 | $0.00 | $0.00 | $0.00 |
| LL-P13 | 2753+67 | $1,305,669.94 | $62,576.14 | $1,368,246.08 |
| LL-P14 | 2753+67 | $1,970,290.46 | $62,576.14 | $2,032,866.60 |
| | | 0 | 0 | 0 |
| Totals for all Reaches | | $209,073,067.34 | $14,616,535.16 | $223,689,602.50 |

Note- 1% AEP Relocation Items and Costs (* indicates Item ID was not used). Item IDs listed more than once in an alignment Reach have multiple impact locations within that alignment Reach. Reaches are listed in the order in which they occur in the overall alignment, from West to East. Project stationing also increases from West to East. Roads affected are in a separate table.

During the development of this Feasibility Study, it was determined that if the levee alignment were shifted slightly in a few areas, several pipelines would be avoided. The costs in this report assume the following levee shifts will take place during P&S. 1% AEP alignment stationing is used in the following:

1) Barrier Alignment shift south, about ½ alignment width, between stations 1210+00 and 1270+00, resulting in 1st impact location for pipeline BAR-P13 changing to no impact.
2) Barrier Alignment shift south, 1 alignment width or less, between stations 1422+00 and 1640+00, resulting in-
   a. Pipeline BAR-P13- 3rd impact location changing from "shift 11,800 feet of pipeline south" to "directional drill at station 1510+00".
   b. Pipeline BAR-P13- 4th impact location changing to no impact.
   c. Pipeline BAR- P6- 2nd impact location changing to no impact.
   d. Pipeline BAR-P17- changing to no impact.
   e. Pipelines BAR-P31 through BAR P34- changing to no impact.
   f. Pipeline BAR-P22- changing to no impact.
   g. Pipeline BAR-P21- changing to needing an up-and-over relocation.
3) Barrier Alignment shift south, about ¼ alignment width, between stations 1770+00 and 1795+00, resulting in pipeline BAR-P27 changing to no impact.
4) Reach J1 alignment shift with a floodside enlargement approximately retaining protected side toe location of existing levee, resulting in pipeline J1-P1 changing to no impact.

Table 153 3% AEP Relocation Costs

| Relocation Item ID | 35-yr Station = 100-yr Station | Relocation Cost | Mitigation Cost | Total |
|---|---|---|---|---|
| **Reach I-2** | | | | |
| I2-E1 | | $1,093,919.91 | $83,852.03 | $1,177,771.94 |
| **Reach J-2** | | | | |
| J2-E1 | | $879,857.88 | $83,852.03 | $963,709.91 |
| **Pipelines for all Reaches** | n/a | $206,220,462.33 | $14,448,831.10 | $220,669,293.43 |
| Totals for all Reaches | | $208,194,240.12 | $14,616,535.16 | $222,810,775.28 |

Note- Pipelines relocations cost for 1% AEP is same as for 3% AEP (see text)

#### 6.2.4.2 Roadways

Roadways affected by this project are as follows: LA Highway 182 (Bayou Black Drive), LA Highway 315 (Bayou Dularge Road), Four Point Road, LA Highway 56, LA Highway 55, and LA Highway 665 (Pointe Aux Chenes Road). All are assumed to have a flood gate, except LA 182 which will have a ramp. For LA 182, alternate access for locals will need to be made available during the construction of the earthen ramp, which will need to be raised each time the levee is raised.

The relocation assumptions for the roadways were as follows: 3000 feet of overhead lines (poles, electric, cable, telephone) and two underground lines (2" natural gas and 12" water lines). For the floodwalls, it includes passing the gas and water lines through a sleeve. For the ramp at LA 182, it includes directionally drilling the gas and water lines. The flood gates are not considered relocation items, but the ramp is considered a relocation item. The costs include Engineering and Design, and Supervision and Administration, but not Contingency or Escalation.

Table 154 Roadway Relocation Costs

| ROADWAY | REACH | 1% AEP STATION | 3% AEP COST | 1% AEP COST |
|---|---|---|---|---|
| LA HWY 182 (BAYOU BLACK DR) | BARRIER ALIGN. | 1003+00 | $14,894,274.03 | $18,479,437.33 |
| LA HWY 315 (BAYOU DULARGE RD) | E-2 | 2542+15 | $631,347.78 | $631,321.37 |
| FOUR POINT ROAD | G-1 | 3099+20 | $631,347.78 | $631,231.37 |
| LA HWY 56 | H-1 | 3316+30 | $631,347.78 | $631,231.37 |
| LA HWY 55 | I-2 | 3737+25 | $631,347.78 | $631,231.37 |
| LA HWY 665 (POINTE AUX CHENES RD) | K | 4437+80 | $631,347.78 | $631,231.37 |
| TOTALS- | | | $18,051,012.93 | $21,635,684.18 |

# 7 COST

## 7.1 1%AEP Cost Estimate

#### 7.1.1.1 General

The project cost estimate was developed in the TRACES MII cost estimating software and used the standard approaches for a feasibility estimate structure regarding labor, equipment, materials, crews, unit prices, quotes, sub- and prime contractor markups. This philosophy was taken wherever practical within the time constraints. It was supplemented with estimating information from other sources where necessary such as quotes, bid data, and A-E estimates. The intent was to provide or convey a "fair and reasonable" estimate that which depicts the local market conditions. The estimates assume a typical application of tiering subcontractors. Given the long time over which this project/program is to be constructed and the unknown economic status during that time, demands from non-governmental civil works projects were not considered to dampen the competition and increase prices.

### 7.1.2 Estimate Structure

The estimate is structured to reflect the projects performed. The estimates are subdivided by USACE feature codes and by local "reach" name.

### 7.1.3 Bid competition

It is assumed that there will not be an economically saturated market and that bidding competition will be present.

### 7.1.4 Contract Acquisition Strategy

It is assumed that the contract acquisition strategy will be similar to past projects with some negotiated contracts, focus and preference of small business/8(a), and large, unrestricted design/bid/build contracts. There is no declared contract acquisition plan/types at this time, so typical MVN goals for small business/set-aside contracts have been included on overall cost basis by assigning approximately 25% of construction dollars to the small business/set-aside contractor type.

### 7.1.5 Labor Shortages

It is assumed there will be a normal labor market.

### 7.1.6 Labor Rates

Local labor market wages are above the local Davis-Bacon Wage Determination and actual rates have been used. This is based upon local information and payroll data received from the New Orleans District Construction Representatives and estimators with experiences in past years.

### 7.1.7 Cost quotes

Cost quotes are used on major construction items when available. Recent quotes may include borrow material, concrete, steel and concrete piling, rock, gravel and sand, and deep soil mixing.

### 7.1.8 Assumptions

#### 7.1.8.1 Materials

Materials will be purchased as part of the construction contract. The estimate does not anticipate government furnished materials. Prices include delivery of materials.

#### 7.1.8.2 Concrete

Concrete will be purchased from commercial batch plants.

#### 7.1.8.3 Borrow Material and Haul

Borrow material is considered the highest risk in the contracts, given the large quantities required, uncertainties of sources and materials near the many contract locations. Specific borrow sources have not been established so a conservative estimated haul distance was used when using off-site material. Borrow pits currently in use are within this distance. All borrow material is assumed Government furnished as it is a local sponsor responsibility. NO contractor furnished borrow source are used. The borrow quantity calculations followed the MVN Geotechnical guidance.

#### 7.1.8.4 Hauled Levee

10 BCY of borrow material = 12 LCY hauled = 8 ECY compacted.

An assumed average one-way haul distance of 25 miles for 100yr was used unless a committed borrow source has been confirmed available. This decision is based upon discussions with the New Orleans District cost engineers and MTG pdt.

Haul speeds are estimated using 40 mph speed average given the long distances and rural areas.

#### 7.1.8.5 Rock and stone

The New Orleans delta area has no rock sources. Historically, rock is barged from northern sources on the Mississippi River. This decision is based upon local knowledge, experience and supported with cost quotes.

#### 7.1.8.6 Rates

Rates are based on the latest USACE EP-1110-1-8, Region III. Adjustments are made for fuel and facility capital cost of money (FCCM). Judicious use of owned verses rental rates was considered based on typical contractor usage and local equipment availability. Only a few select pieces of marine\marsh equipment are considered rental. Full FCCM/Cost of Money rate is latest available; Mii program takes EP recommended discount, no other adjustments have been made to the FCCM.

#### 7.1.8.7 Trucking

The estimate assumed independent self-employed trucking subcontractors due to the large numbers of trucks required.

#### 7.1.8.8 Dozers

Dozers of the D-5/D-6 variety were chosen based on historical knowledge. Heavier equipment gets mired in the mud and soft soils.

#### 7.1.8.9 Rental Rates

Rental rates were used for various pieces of marine and marsh equipment where rental is typical such as marsh backhoes. Severe equipment rates were used where appropriate.

#### 7.1.8.10 Fuel

Gasoline, on and off-road diesel were based on local market averages for on-road and off-road for the Gulf Coast area. The Team found that fuels fluctuate irrationally; thus, used an average.

#### 7.1.8.11 Crews

Major crew and productivity rates were developed and studied by senior USACE estimators familiar with the type of work. All of the work is typical to the New Orleans District. The crews and productivities were checked by local MVN estimators, discussions with contractors and comparisons with historical cost data. Major crews include haul, earthwork, piling, concrete, and deep soil mixing.

#### 7.1.8.12 Unit Prices

The unit prices found within the various project estimates will fluctuate within a range between similar construction units such as floodwall concrete, earthwork, and piling. Variances are a result of differing haul distances (trucked or barged), small or large business markups, subcontracted items, designs and estimates by others.

#### 7.1.8.13 Relocation Cost

Relocation costs are defined as the relocation of public roads, bridges, railroads, and utilities required for project purposes. In cases where potential significant impacts were known, costs were included within the cost estimate.

### 7.1.9 Mobilization

Contractor mobilization and demobilization are based on the assumption that most of the contractors will be coming from within the Gulf Coast/Southern region. Mob/demob costs are based on historical studies of detailed Government estimate mob/demobs which averaged 4.9 to 5% of the construction costs. With undefined acquisition strategies and assumed individual project limits for the large number of potential contracts in this program, the estimate utilizes a more comprehensive approx. 5% value applied at each contract rather than risking minimizing mob/demob costs by detailing costs based on an assumed number of contracts. The 5% value also matches well with the 5% value previously prescribed by Walla Walla District, which has studied historical rates.

### 7.1.10 Field Office Overhead

The estimate used a field office overhead rate of 12% for the prime contractors at budget level development. Based on historical studies and experience, Walla Walla District has recommended typical rates ranging from 9% to 11% for large civil works projects; however, the 9-11% rate does not consider possible incentives such as camps, allowances, travel trailers, meals, etc. which have been used previously to facilitate projects. With undefined acquisition strategies and assumed individual project limits for the large number of potential contracts in this program, the estimate utilizes a more comprehensive percentage based approach applied at each contract rather than risking minimizing overhead costs by detailing costs based on an assumed number of contracts. The applied rates were previously discussed among numerous USACE District cost engineers including Walla Walla, Vicksburg, Norfolk, Huntington, St. Paul and New Orleans.

### 7.1.11 Overhead Assumptions

Overhead assumptions may include superintendent, office manager, pickups, periodic travel, costs, communications, temporary offices (contractor and government), office furniture, office supplies, computers and software, as-built drawings and minor designs, tool trailers, staging setup, camp and kitchen maintenance and utilities, utility service, toilets, safety equipment, security and fencing, small hand and power tools, project signs, traffic control, surveys, temp fuel tank station, generators, compressors, lighting, and minor miscellaneous.

### 7.1.12 Home Office Overhead

Estimate percentages range based upon consideration of 8(a), small business and unrestricted prime contractors. The rates are based upon estimating and negotiating experience, and consultation with local construction representatives. Different percents are used when considering the contract acquisition strategy regarding small business 8(a), competitive small business and large business, high to low respectively. The applied rates were previously discussed among numerous USACE District cost engineers including Walla Walla, Vicksburg, Norfolk, Huntington, St. Paul and New Orleans.

### 7.1.13 Taxes

Local taxes will be applied, using an average between the parishes that contain the work. Reference the LA parish tax rate website: http-//www.laota.com/pta.htm

### 7.1.14 Bond

Bond is assumed 1% applied against the prime contractor, assuming large contracts. No differentiation was made between large and small businesses.

### 7.1.15 E&D and S&A

USACE Costs to manage design (PED) and construction (S&A) are based on New Orleans District Programmatic Cost Estimate guidance-

### 7.1.16 Planning, Engineering & Design (PED)

The PED cost includes such costs as project management, engineering, planning, designs, investigations, studies, reviews, value engineering and engineering during construction (EDC). Historically New Orleans District has used an approximate 12% rate for E&D/EDC, applied against the estimated construction costs. Other USACE civil works districts such as St. Paul, Memphis and St. Louis have reported values ranging from 10-15%. Additional costs were added for project management, engineering, planning, designs, investigations, studies, reviews, value engineering.

### 7.1.17 Supervision & Administration (S&A)

Historically, New Orleans District used a range from 5% to 15% depending on project size and type applied against the estimated construction costs. Other USACE civil works districts such as St. Paul, Memphis and St. Louis report values ranging from 7.5-10%. Consideration includes that a portion of the S&A effort could be performed by contractors. Based on discussions with MVN Construction Division, an S&A cost based on contract durations was developed rather than applying a percentage.

**7.1.18 Contingencies**

Contingencies were developed using the USACE Cost and Schedule Risk Analysis (CSRA) process and the Crystal Ball software that evaluates schedule and cost related risks. See summary in Cost Schedule Risk Analysis (CSRA) section.

**7.1.19 Escalation**

Escalation used in the TPCS is based upon the US Army Corps of Engineers Engineering Manual (EM) 1110-2-1304 Civil Works Construction Cost Index System (CWCCIS) revised 30 Mar 2012.

**7.1.20 HTRW**

The estimate includes no costs for any potential Hazardous, Toxic, and Radioactive Waste (HTRW) concerns. Phase 1 HTRW investigations are already complete and the result of this investigation is that no further investigation is recommended.

**7.1.21 Schedule**

The project schedule was developed based on the construction of the individual features of work to include the entire 1% AEP Morganza to the Gulf program which includes construction of earthen levees, floodwalls, floodgates, and other structures along a 98-mile alignment south of Houma. The alignment is sub-divided into 13 main reaches (Barrier, A, B, E, F, G, H, I, J, K, L, Larose C-North, and Lockport to Larose). Final levee elevations vary from +15 to +26.5 feet NAVD88 and structure elevations range from +17 to +33 ft NAVD88. Structures include a multi-purpose lock, 22 navigable floodgates, 23 environmental water control structures, 9 road / RR gates, and fronting protection for 4 existing pumping stations. The structures located on Federally maintained navigation channels include a 110-ft wide by 800-ft long lock with an adjacent 250-ft wide sector gate on the Houma Navigation Canal and two 125-ft sector gates on the GIWW east and west of Houma. Fourteen 56-ft sector gates and five 20- to 30-ft stop log gates are located on various waterways that cross the levee system.-

The team focused the earliest construction efforts on the areas most vulnerable to storm surge inundation. Since we received authority to proceed to PED for the HNC Lock Complex ahead of the remainder of the project, we gave first priority to the HNC Lock complex, tie-in levees, and the adjacent Bayou Grand Caillou structure. From there, a levee lift schedule was laid out that allows for a minimum of 3 years of settlement between levee lifts, minimizes adjacent/conflicting work zones, reduces the cost of interest during construction, and delivers the specified level of risk reduction (1%) by the project base year and maintains that level 50-years into the future.

## 7.2 3% AEP

### 7.2.1 General

#### 7.2.1.1 Cost estimate development

The project cost estimate was developed in the TRACES MII cost estimating software and used the standard approaches for a feasibility estimate structure regarding labor, equipment, materials, crews, unit prices, quotes, sub- and prime contractor markups. This philosophy was taken wherever practical within the time constraints. It was supplemented with estimating information from other sources where necessary such as quotes, bid data, and A-E estimates. The intent was to provide or convey a “fair and reasonable” estimate that which depicts the local market conditions. The estimates assume a typical application of tiering subcontractors. Given the long time over which this project/program is to be constructed and the unknown economic status during that time, demands from non-governmental civil works projects were not considered to dampen the competition and increase prices.

#### 7.2.1.2 Estimate Structure

The estimate is structured to reflect the projects performed. The estimates are subdivided by USACE feature codes and by local "reach" name.

#### 7.2.1.3 Bid Competition

It is assumed that there will not be an economically saturated market and that bidding competition will be present.

### 7.2.2 Contract Acquisition Strategy

It is assumed that the contract acquisition strategy will be similar to past projects with some negotiated contracts, focus and preference of small business/8(a), and large, unrestricted design/bid/build contracts. There is no declared contract acquisition plan/types at this time, so typical MVN goals for small business/set-aside contracts have been included on overall cost basis by assigning approximately 25% of construction dollars to the small business/set-aside contractor type.

### 7.2.3 Labor Shortages

It is assumed there will be a normal labor market.

### 7.2.4 Labor Rates

Local labor market wages are above the local Davis-Bacon Wage Determination and actual rates have been used. This is based upon local information and payroll data received from the New Orleans District Construction Representatives and estimators with experiences in past years.

### 7.2.5 Materials

Cost quotes are used on major construction items when available. Recent quotes may include borrow material, concrete, steel and concrete piling, rock, gravel and sand, and deep soil mixing. Assumptions include materials will be purchased as part of the construction contract. The estimate does not anticipate government furnished materials. Prices include delivery of materials. Concrete will be purchased from commercial batch plants.

### 7.2.6 Borrow Material and Haul

Borrow material is considered the highest risk in the contracts, given the large quantities required, uncertainties of sources and materials near the many contract locations. Specific borrow sources have not been established so a conservative estimated haul distance was used when using off-site material. Borrow pits currently in use are within this distance. All borrow material is assumed Government furnished as it is a local sponsor responsibility. NO contractor furnished borrow source are used. The borrow quantity calculations followed the MVN Geotechnical guidance.

### 7.2.7 Hauled Levee

10 BCY of borrow material = 12 LCY hauled = 8 ECY compacted. An assumed average one-way haul distance of 20 miles for 35yr was used unless a committed borrow source has been confirmed available. This decision is based upon discussions with the New Orleans District cost engineers and MTG pdt. Haul speeds are estimated using 40 mph speed average given the long distances and rural areas.

### 7.2.8 Quantities

Levee degrade qtys were determined by the levee design sections. The 1st lift is dual hatting as a preload and an initial lift. The ultimate design section requires the preload/1st lift to be degraded to approx elev 4.0 and install reinforcement geotextile prior to adding the 2nd lift. 2nd lift qty assumes construction begins at the pre-degraded 1st lift elevation. A 20% "loss" or really non-available is allowed (probably on the conservative side), but is meant more to express the resulting amount of in-place material that is felt garunteed to be credited to the re-built section (back to pre-degrade elev) and to be sure that the section used for the "existing" condition prior to the 2nd lift qty is actually there. There may be slightly different compaction levels when replaced, the material will be stockpiled nearby and some will be left behind, and some will be misplaced in the transfer out and back into the levee as the stockpiles may not be exactly adjacent to the new placement area. The lost material will be replaced with new material.

### 7.2.9 Rock and stone

The New Orleans delta area has no rock sources. Historically, rock is barged from northern sources on the Mississippi River. This decision is based upon local knowledge, experience and supported with cost quotes.

### 7.2.10 Equipment

Rates used are based from the latest USACE EP-1110-1-8, Region III. Adjustments are made for fuel and facility capital cost of money (FCCM). Judicious use of owned verses rental rates was considered based on typical contractor usage and local equipment availability. Only a few select pieces of marine \ marsh equipment are considered rental. Full FCCM/Cost of Money rate is latest available; Mii program takes EP recommended discount, no other adjustments have been made to the FCCM.

### 7.2.11 Trucking

The estimate assumed independent self-employed trucking subcontractors due to the large numbers of trucks required.

### 7.2.12 Dozers

Dozers of the D-5/D-6 variety were chosen based on historical knowledge. Heavier equipment gets mired in the mud and soft soils.

### 7.2.13 Severe Rates

Severe equipment rates were used for various pieces of equipment in the hydraulic dredging crews where they may come in contact with a saltwater environment.

### 7.2.14 Rental Rates

Rental rates were used for various pieces of marine and marsh equipment where rental is typical such as marsh backhoes.

### 7.2.15 Fuels

Fuels (gasoline, on and off-road diesel) were based on local market averages for on-road and off-road for the Gulf Coast area. The Team found that fuels fluctuate irrationally; thus, used an average.

### 7.2.16 Crews

Major crew and productivity rates were developed and studied by senior USACE estimators familiar with the type of work. All of the work is typical to the New Orleans District. The crews and productivities were checked by local MVN estimators, discussions with contractors and comparisons with historical cost data. Major crews include haul, earthwork, piling, concrete, and deep soil mixing.

Most crew work hours are assumed to be 10 hrs 6 days/wk which is typical to the area. Marine based bucket excavation/dredging operations for levee construction are assumed to work 2-12 hours shifts 7 days / week.

A 10% "markup on labor for weather delay" is selectively applied to the labor in major earthwork placing detail items and associated items that would be affected by small amounts of weather making it unsafe or difficult to place (trying to run dump trucks on a wet levee) or be detrimental/non-compliant to the work being done (trying to place/compact material in the rain). The 10% markup is to cover the common practice of paying for labor "showing up" to the job site and then being sent home due to minor weather which is part of known average weather impacts as reflected within the standard contract specifications. The markup was not applied to small quantities where this can be scheduled around.

### 7.2.17 Unit Prices

The unit prices found within the various project estimates will fluctuate within a range between similar construction units such as floodwall concrete, earthwork, and piling. Variances are a result of differing haul distances (trucked or barged), small or large business markups, subcontracted items, designs and estimates by others.

### 7.2.18 Relocation Costs

Relocation costs are defined as the relocation of public roads, bridges, railroads, and utilities required for project purposes. In cases where potential significant impacts were known, costs were included within the cost estimate.

### 7.2.19 Mobilization

Contractor mobilization and demobilization are based on the assumption that most of the contractors will be coming from within the Gulf Coast/Southern region. Mob/demob costs are based on historical studies of detailed Government estimate mob/demobs which averaged 4.9 to 5% of the construction costs. With undefined acquisition strategies and assumed individual project limits for the large number of potential contracts in this program, the estimate utilizes a more comprehensive approx. 5% value applied at each contract rather than risking minimizing mob/demob costs by detailing costs based on an assumed number of contracts. The 5% value also matches well with the 5% value previously prescribed by Walla Walla District, which has studied historical rates.

### 7.2.20 Field Office Overhead

The estimate used a field office overhead rate of 12% for the prime contractors at budget level development. Based on historical studies and experience, Walla Walla District has recommended typical rates ranging from 9% to 11% for large civil works projects; however, the 9-11% rate does not consider possible incentives such as camps, allowances, travel trailers, meals, etc. which have been used previously to facilitate projects. With undefined acquisition strategies and assumed individual project limits for the large number of potential contracts in this program, the estimate utilizes a more comprehensive percentage based approach applied at each contract rather than risking minimizing overhead costs by detailing costs based on an assumed number of contracts. The applied rates were previously discussed among numerous USACE District cost engineers including Walla Walla, Vicksburg, Norfolk, Huntington, St. Paul and New Orleans.

### 7.2.21 Overhead Assumptions

Overhead assumptions may include superintendent, office manager, pickups, periodic travel, costs, communications, temporary offices (contractor and government), office furniture, office supplies, computers and software, as-built drawings and minor designs, tool trailers, staging setup, camp and kitchen maintenance and utilities, utility service, toilets, safety equipment, security and fencing, small hand and power tools, project signs, traffic control, surveys, temp fuel tank station, generators, compressors, lighting, and minor miscellaneous.

### 7.2.22 Home Office Overhead

Estimate percentages range based upon consideration of 8(a), small business and unrestricted prime contractors. The rates are based upon estimating and negotiating experience, and consultation with local construction representatives. Different percents are used when considering the contract acquisition strategy regarding small business 8(a), competitive small business and large business, high to low respectively. The applied rates were previously discussed among numerous USACE District cost engineers including Walla Walla, Vicksburg, Norfolk, Huntington, St. Paul and New Orleans.

### 7.2.23 Taxes

Local taxes will be applied, using an average between the parishes that contain the work. Reference the LA parish tax rate website: http-//www.laota.com/pta.htm

### 7.2.24 Bond

Bond is assumed 1% applied against the prime contractor, assuming large contracts. No differentiation was made between large and small businesses.
E&D and S&A: USACE Costs to manage design (PED) and construction (S&A) are based on New Orleans District Programmatic Cost Estimate guidance-

### 7.2.25 Planning, Engineering & Design (PED)

The PED cost includes such costs as project management, engineering, planning, designs, investigations, studies, reviews, value engineering and engineering during construction (EDC). Historically New Orleans District has used an approximate 12% rate for E&D/EDC, applied against the estimated construction costs. Other USACE civil works districts such as St. Paul, Memphis and St. Louis have reported values ranging from 10-15%. Additional costs were added for project management, engineering, planning, designs, investigations, studies, reviews, value engineering.

### 7.2.26 Supervision & Administration (S&A)

Historically, New Orleans District used a range from 5% to 15% depending on project size and type applied against the estimated construction costs. Other USACE civil works districts such as St. Paul, Memphis and St. Louis report values ranging from 7.5-10%. Consideration includes that a portion of the S&A effort could be performed by contractors.

Based on discussions with MVN Construction Division, an S&A cost based on contract durations was developed rather than applying a percentage.

### 7.2.27 Contingencies

Contingencies were developed using the USACE Cost and Schedule Risk Analysis (CSRA) process and the Crystal Ball software that evaluates schedule and cost related risks. See summary in Cost Schedule Risk Analysis (CSRA) section.

### 7.2.28 Escalation

Escalation used in the TPCS is based upon the US Army Corps of Engineers Engineering Manual (EM) 1110-2-1304 Civil Works Construction Cost Index System (CWCCIS) revised 30 Mar 2012.

### 7.2.29 HTRW

The estimate includes no costs for any potential Hazardous, Toxic, and Radioactive Waste (HTRW) concerns. Phase 1 HTRW investigations are already complete and the result of this investigation is that no further investigation is recommended.

### 7.2.30 Schedule

The 3% AEP project schedule was developed based on the construction of the individual features of work to include the entire Morganza to the Gulf program which includes construction of earthen levees, floodwalls, floodgates, and other structures along a 98-mile alignment south of Houma. The alignment is sub-divided into 13 main reaches (Barrier, A, B, E, F, G, H, I, J, K, L, Larose C-North, and Lockport to Larose). Final levee elevations vary from +12 to +20 feet NAVD88 and structure elevations range from +14 to +25 ft NAVD88. Structures include a multi-purpose lock, 22 navigable floodgates, 23 environmental water control structures, 9 road/RR gates, and fronting protection for 4 existing pumping stations. The structures located on Federally maintained navigation channels include a 110-ft wide by 800-ft long lock with an adjacent 250-ft wide sector gate on the Houma Navigation Canal and two 125-ft sector gates on the GIWW east and west of Houma. Fourteen 56-ft sector gates and five 20- to 30-ft stop log gates are located on various waterways that cross the levee system.

The team focused the earliest construction efforts on the areas most vulnerable to storm surge inundation. Since we received authority to proceed to PED for the HNC Lock Complex ahead of the remainder of the project, we gave first priority to the HNC Lock complex, tie-in levees, and the adjacent Bayou Grand Caillou structure. From there, a levee lift schedule was laid out that allows for a minimum of 3 years of settlement between levee lifts, minimizes adjacent/conflicting work zones, reduces the cost of interest during construction, and delivers the specified level of risk reduction (3%) by the project base year and maintains that level 50-years into the future.

### 7.3 Cost Estimate

Table 155 through 160 show the baseline project cost, October 2012 cost and fully funded project cost for the 1% AEP and 3% AEP. This information is taken from the Total Project Cost Sheet (TPCS).

Table 155 1% AEP Baseline Cost

| Feature | Cost | Contingency | Total |
|---|---|---|---|
| 01 Lands & Damages | $282,437,000 | $72,391,000 | $354,828,000 |
| 02 Relocations | $230,710,000 | $59,985,000 | $290,695,000 |
| 05 Locks | $460,439,000 | $161,154,000 | $621,593,000 |
| 06 Fish & Wildlife Facilities | $719,794,000 | $221,419,000 | $941,213,000 |
| 11 Levees & Floodwalls | $4,225,556,000 | $1,125,924,000 | $5,351,000,000 |
| 15 Fldwy Control & Div Str | $791,153,000 | $276,904,000 | $1.068,057,000 |
| 30 PED | $780,935,000 | $225,254,000 | $1,006,189,000 |
| 31 Construction Management | $489,774,000 | $141,271,000 | $631,045,000 |
| TOTAL | $7,980,798,000 | $2,284,302,000 | $10,265,100,000 |

Table 156 1% AEP Oct 2012 Cost

| Feature | Cost | Contingency | Total |
|---|---|---|---|
| 01 Lands & Damages | $282,437,000 | $72,391,000 | $354,828,000 |
| 02 Relocations | $230,710,000 | $59,985,000 | $290,695,000 |
| 05 Locks | $460,439,000 | $161,154,000 | $621,593,000 |
| 06 Fish & Wildlife Facilities | $719,794,000 | $221,419,000 | $941,213,000 |
| 11 Levees & Floodwalls | $4,225,556,000 | $1,125,924,000 | $5,351,000,000 |
| 15 Fldwy Control & Div Str | $791,153,000 | $276,904,000 | $1.068,057,000 |
| 30 PED | $780,935,000 | $225,254,000 | $1,006,189,000 |
| 31 Construction Management | $489,774,000 | $141,271,000 | $631,045,000 |
| TOTAL | $7,980,798,000 | $2,284,302,000 | $10,265,100,000 |

Table 157 1% AEP Fully Funded Cost

| Feature | Cost | Contingency | Total |
|---|---|---|---|
| 01 Lands & Damages | $290,073,000 | $74,331,000 | $364,404,000 |
| 02 Relocations | $246,753,000 | $64,156,000 | $310,908,000 |
| 05 Locks | $500,269,000 | $175,094,000 | $675,363,000 |
| 06 Fish & Wildlife Facilities | $830,079,000 | $254,747,000 | $1,084,826,000 |
| 11 Levees & Floodwalls | $5,475,122,000 | $1,460,444,000 | $6,935,566,000 |
| 15 Fldwy Control & Div Str | $914,620,000 | $320,117,000 | $1,234,738,000 |

| Feature | Cost | Contingency | Total |
|---|---|---|---|
| 30 PED | $1,047,988,000 | $303,076,000 | $1,351,064,000 |
| 31 Construction Management | $710,533,000 | $205,443,000 | $915,976,000 |
| TOTAL | $10,015,438,000 | $2,857,408,000 | $12,872,846,000 |

Table 158 3% AEP Baseline Cost

| Feature | Cost | Contingency | Total |
|---|---|---|---|
| 01 Lands & Damages | $270,609,000 | $68,196,000 | $338,805,000 |
| 02 Relocations | $226,246,000 | $47,512,000 | $273,758,000 |
| 05 Locks | $407,410,000 | $122,223,000 | $529,633,000 |
| 06 Fish & Wildlife Facilities | $493,352,000 | $125,462,000 | $618,814,000 |
| 11 Levees & Floodwalls | $2,021,674,000 | $445,149,000 | $2,466,823,000 |
| 15 Fldwy Control & Div Str | $587,261,000 | $176,178,000 | $763,439,000 |
| 30 PED | $459,946,000 | $113,901,000 | $763,439,000 |
| 31 Construction Management | $308,568,000 | $76,413,000 | $384,981,000 |
| TOTAL | $4,775,066,000 | $1,175,035,000 | $5,950,101,000 |

Table 159 3% AEP October 2012 Cost

| Feature | Cost | Contingency | Total |
|---|---|---|---|
| 01 Lands & Damages | $270,609,000 | $68,196,000 | $338,805,000 |
| 02 Relocations | $226,246,000 | $47,512,000 | $273,758,000 |
| 05 Locks | $407,410,000 | $122,223,000 | $529,633,000 |
| 06 Fish & Wildlife Facilities | $493,352,000 | $125,462,000 | $618,814,000 |
| 11 Levees & Floodwalls | $2,021,674,000 | $445,149,000 | $2,466,823,000 |
| 15 Fldwy Control & Div Str | $587,261,000 | $176,178,000 | $763,439,000 |
| 30 PED | $459,946,000 | $113,901,000 | $763,439,000 |
| 31 Construction Management | $308,568,000 | $76,413,000 | $384,981,000 |
| TOTAL | $4,775,066,000 | $1,175,035,000 | $5,950,101,000 |

Table 160 3% AEP Fully Funded Cost

| Feature | Cost | Contingency | Total |
|---|---|---|---|
| 01 Lands & Damages | $278,009,000 | $70,055,000 | $348,064,000 |
| 02 Relocations | $245,484,000 | $51,552,000 | $297,036,000 |
| 05 Locks | $430,939,000 | $129,282,000 | $560,220,000 |
| 06 Fish & Wildlife Facilities | $588,555,000 | $148,415,000 | $736,971,000 |
| 11 Levees & Floodwalls | $2,546,699,000 | $563,675,000 | $3,110,374,000 |
| 15 Fldwy Control & Div Str | $684,388,000 | $205,316,000 | $889,704,000 |
| 30 PED | $611,686,000 | $152,197,000 | $763,883,000 |
| 31 Construction Management | $431,494,000 | $107,332,000 | $538,826,000 |
| TOTAL | $5,817,255,000 | $1,427,825,000 | $7,245,080,000 |

# 8 DESIGN AND CONSTRUCTION SCHEDULE

The detailed design and construction schedules for the 1% AEP and 3% AEP are available upon request.

**MORGANZA TO THE GULF OF MEXICO, LOUISIANA DRAFT PAC
DRAFT ENGINEERING APPENDIX**

## REFERENCES

**(All Listed References Are Available Upon Request)**

ANNEX 1 HYDROLOGY, HYDRAULICS AND WATER QUALITY
- Appendix A JPM-OS, ADCIRC And STWAVE Modeling
- Appendix B Future Condition SLR Case Two Sensitivity Analysis
- Appendix C ERDC Statistical Results
- Appendix D Frequency and Fragility Curves
- Appendix E Hindcast Plots
- Appendix F Design plots for levees, structures, and wave loads
- Appendix G Evaluation of Authorized 1% Designs In Light of New Design Criteria
- Appendix H MTOG - Environmental Flow Control Structures Study
- Appendix I ADH Floodgate Evaluation Study
- Appendix J TABS – MD Floodgate Evaluation Study for GIWW and Vicinity
- Appendix K Rip Rap Design for Navigation and Environmental Structures
- Appendix L Validation of the Morganza to the Gulf of Mexico TABS-MDS Numerical Model
- Appendix M Comparison of Plan Alternatives for the MTOG Levee System
- Appendix N MTOG Hurricane Projects Interior Drainage Study
- Appendix O Review of Hydraulic Engineering Analysis and Design

ANNEX 2 SOILS REPORT
- Attachment 2.1 Hydraulic Requirements
- Attachment 2.2 Stability – Spencer Analysis 35-Year LORR
- Attachment 2.3 Stability – Spencer Analysis 100-Year LORR
- Attachment 2.4 Boring and CPT Locations
- Attachment 2.5 Geologic Profiles
- Attachment 2.6 Boring Logs
- Attachment 2.7 Cone Penetrometer Data
- Attachment 2.8 Settlement
- Attachment 2.9 Seepage Analysis
- Attachment 2.10 Structures
- Attachment 2.11 Pile Curves
- Attachment 2.12 Shear Lines
- Attachment 2.13 Settlement Calcs
- Attachment 2.14 Soil Lab Testing Results

ANNEX 3 STRUCTURES
- 3.1 Cofferdams
- 3.2 56' Sector Gates

1 of 2 Reach F-2 & F-1 Plan View Station 2788+92.72 to Station 2863+83
2 of 2 Reach F-1 and G-1 Plan View Station 2863+83 to Station 3007+34.70
1 of 3 Reach G-1 Plan View Station 3007+34.70 to Station 3087+35
2 of 3 Reach G-1, G-2 Plan View Station 3087+35 to Station 3162+35
3 of 3 Reach G-1 & G-2 Plan View Station 3087+35 to Station 3162+35
1 of 4 Reach H-1 Plan View Station 3224+12.12 to Station 3313+12
2 of 4 Reach H-1 & H-2 Plan View Station 3313+12 to Station 3416+12
3 of 4 Reach H-2 & H-3 Plan View Station 3416+12 to Station 3531+12
4 of 4 Reach H-3 Plan View Station 3531+12 to Station 3640+67
1 of 3 Reach I-1 & I-2 Plan View Station 3640+67 to Station 3750+65
2 of 3 Reach I-2 & I-3 Plan View Station 3750+65 to Station 3855+70
3 of 3 Reach I-3 Plan View Station 3855+70 to Station 3941+76
1 of 5 Reach J-2 Plan View Station 3941+75.55 to Station 4048+75
2 of 5 Reach J-2 Plan View Station 4048+75 to Station 4156+69
3 of 5 Reach J-2 & J-1 Plan View Station 4156+69 to Station 4261+76
4 of 5 Reach J-1 Plan View Station 4261+76 to Station 4367+74
5 of 5 Reach J-1 Plan View Station 4367+74 to Station 4438+85.25
1 of 3 Reach K Plan View Station 4438+85+25 to Station 4543+85
2 of 3 Reach K Plan View Station 4543+85 to Station 4658+86
3 of 3 Reach K Plan View Station 4658+86 to Station 4706+98.84
1 of 3 Reach L Plan View Station 4706+98.84 to Station 4812+00
2 of 3 Reach L Plan View Station 4812+00 to Station 4942+00
3 of 3 Reach L Plan View Station 4942+00 to Station 5021+78
M2G-L-01 Plan Sta 2160+70 to Sta 2245+00
M2G-L-02 Plan Sta 2245+00 to Sta 2220+00
M2G-L-03 Plan Sta 2320+00 to Sta 2400+00
M2G-L-04 Plan Sta 2400+00 to Sta 2520+00
M2G-L-05 Plan Sta 2520+00 to Sta 2640+00
M2G-L-06 Plan Sta 2640+00 to Sta 2760+00
M2G-L-07 Plan Sta 2760+00 to Sta 2816+79
M2G-L-08 Plan Sta 1042+90.18 to Sta 925+48.62
M2G-L-09 Plan Sta 925+48.62 to Sta 798+31.98

Civil Plates 3% Design

1 of 5 Reach A Plan View Station 1828+22.13 to Station 1907+62
2 of 5 Reach A Plan View Station 1907+62 to Station 2032+60
3 of 5 Reach A Plan View Station 2032+60 to Station 2073+25
4 of 5 Reach A Plan View Station 2073+25 to Station 2183+22
5 of 5 Reach A Plan View Station 2183+22 to Station 2259+26.41
1 of 3 Reach B Plan View Station 2259+26.41 to Station 2364+25
2 of 3 Reach B Plan View Station 2364+25 to Station 2469+26
3 of 3 Reach B Plan View Station 2469+26 to Station 2526+35.62

**MORGANZA TO THE GULF OF MEXICO, LOUISIANA DRAFT PAC**
**DRAFT ENGINEERING APPENDIX**

1 of 8 Barrier Alignment Plan View Station 1000+00 to Station 1075+00
2 of 8 Barrier Alignment Plan View Station 1075+00 to Station 1190+00
3 of 8 Barrier Alignment Plan View Station 1190+00 to Station 1305+00
4 of 8 Barrier Alignment Plan View Station 1305+00 to Station 1415+17
5 of 8 Barrier Alignment Plan View Station 1415+17 to Station 1530+17
6 of 8 Barrier Alignment Plan View Station 1530+17 to Station 1630+17
7 of 8 Barrier Alignment Plan View Station 1630+17 to Station 1745+17
8 of 8 Barrier Alignment Plan View Station 1745+17 to Station 1828+22.13
3 of 4 Reach E-2 & E-1 Plan View Station 2621+34 to Station 2726+33
4 of 4 Reach E-1 and F-2 Plan View Station 2726+33 to Station 2788+92.72
1 of 4 Reach E2 Plan View Station 2526+62 to Station 2571+43
2 of 4 Reach E-2 Plan View Station 2571+43 to Station 2621+34
1 of 2 Reach F-2 & F-1 Plan View Station 2788+92.72 to Station 2863+83
2 of 2 Reach F-1 and G-1 Plan View Station 2863+83 to Station 3007+34.70
1 of 3 Reach G-1 Plan View Station 3007+34.70 to Station 3087+35
2 of 3 Reach G-1, G-2 Plan View Station 3087+35 to Station 3162+35
3 of 3 Reach G-1 & G-2 Plan View Station 3087+35 to Station 3162+35
1 of 4 Reach H-1 Plan View Station 3224+12.12 to Station 3313+12
2 of 4 Reach H-1 & H-2 Plan View Station 3313+12 to Station 3416+12
3 of 4 Reach H-2 & H-3 Plan View Station 3416+12 to Station 3531+12
4 of 4 Reach H-3 Plan View Station 3531+12 to Station 3640+67
1 of 3 Reach I-1 & I-2 Plan View Station 3640+67 to Station 3750+65
2 of 3 Reach I-2 & I-3 Plan View Station 3750+65 to Station 3855+70
3 of 3 Reach I-3 Plan View Station 3855+70 to Station 3941+76
1 of 5 Reach J-2 Plan View Station 3941+75.55 to Station 4048+75
2 of 5 Reach J-2 Plan View Station 4048+75 to Station 4156+69
3 of 5 Reach J-2 & J-1 Plan View Station 4156+69 to Station 4261+76
4 of 5 Reach J-1 Plan View Station 4261+76 to Station 4367+74
5 of 5 Reach J-1 Plan View Station 4367+74 to Station 4438+85.25
1 of 3 Reach K Plan View Station 4438+85+25 to Station 4543+85
2 of 3 Reach K Plan View Station 4543+85 to Station 4658+86
3 of 3 Reach K Plan View Station 4658+86 to Station 4706+98.84
1 of 3 Reach L Plan View Station 4706+98.84 to Station 4812+00
2 of 3 Reach L Plan View Station 4812+00 to Station 4942+00
3 of 3 Reach L Plan View Station 4942+00 to Station 5021+78
M2G-L-01 Plan Sta 2160+70 to Sta 2245+00
M2G-L-02 Plan Sta 2245+00 to Sta 2220+00
M2G-L-03 Plan Sta 2320+00 to Sta 2400+00
M2G-L-04 Plan Sta 2400+00 to Sta 2520+00
M2G-L-05 Plan Sta 2520+00 to Sta 2640+00
M2G-L-06 Plan Sta 2640+00 to Sta 2760+00
M2G-L-07 Plan Sta 2760+00 to Sta 2816+79
M2G-L-08 Plan Sta 1042+90.18 to Sta 925+48.62

**MORGANZA TO THE GULF OF MEXICO, LOUISIANA DRAFT PAC**
**DRAFT ENGINEERING APPENDIX**

M2G-L-09 Plan Sta 925+48.62 to Sta 798+31.98

Levee Section Plates
A Levee Reach A and Barrier Alignment 100 Yr LORR Base Yr Conditions with Overbuild Section
B Levee Reach B 100 Yr LORR Base Yr Conditions with Overbuild Section
E Levee Reach E 100 Yr LORR Base Yr Conditions with Overbuild Section
F Levee Reach F 100 Yr LORR Base Yr Conditions with Overbuild Section
G Levee Reach G 100 Yr LORR Base Yr Conditions with Overbuild Section
H1 Levee Reach H1 100 Yr LORR Base Yr Conditions with Overbuild Section
H2 Levee Reach H2 & H3 100 Yr LORR Base Yr Conditions with Overbuild Section
I Levee Reach I 100 Yr LORR Base Yr Conditions with Overbuild Section
J3 Levee Reach J3 100 Yr LORR Base Yr Conditions with Overbuild Section
J Levee Reach J 100 Yr LORR Base Yr Conditions with Overbuild Section
KL Levee Reach K & L 100 Yr LORR Base Yr Conditions with Overbuild Section
SWL-A Lockport to Larose Reach (a) 100 Yr LORR Base Yr Conditions with Overbuild Section

Structures Plates
C-701 Bayou Black Canal 56' Sector Gate Plan Phase 1 Construction
C-702 Bayou Black Canal 56' Sector Gate Plan Phase 2 Construction
C-703 Black Bayou 56' Sector Gate Plan Final Site Plan
C-703A Black Bayou 56' Sector Gate 100 Yr Final Site Plan
C-704 Black Bayou Canal 56' Sector Gate Cross Sections
C-705 Black Bayou Canal 56' Sector Gate Cross Sections
C-707 Shell Canal West 30' Stop Log Gate Plan Phase 1 Construction
C-708 Shell Canal West 30' Stop Log Gate Plan Phase 2 Construction
C709 Shell Canal West 30' Stop Log Gate Plan Final Plan
C-709AShell Canal West 30' Stop Log Gate 100 Yr Final Plan
C-710 Shell Canal West 30' Stop Log Gate Cross Sections
C-711 Shell Canal West 35' Sector Gate Cross Sections
C-713 Shell Canal East 56' Sector Gate Plan Phase 1
C-714 Shell Canal East 56' Sector Gate Plan Phase 2
C-715 Shell Canal East 56' Sector Gate Final Plan
C-715A Shell Canal East 56' Sector Gate 100 Yr Final Plan
C-716 Shell Canal East 56' Sector Gate Cross Sections
C-717 Shell Canal East 56' Sector Gate Cross Sections
C-719 Elliot Jones 20' Stop Log Gate Plan Phase 1 Construction
C-720 Elliot Jones 20' Stop Log Gate Plan Phase 2 Construction
C-721 Elliot Jones 20' Stop Log Gate Final Site Plan
C-721A Elliot Jones 20' Stop Log Gate 100 Yr Final Site Plan
C-722 Elliot Jones 20' Stop Log Gate Cross Sections
C-723 Elliot Jones 20' Stop Log Gate Cross Sections

**MORGANZA TO THE GULF OF MEXICO, LOUISIANA DRAFT PAC**
**DRAFT ENGINEERING APPENDIX**

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|---|---|
| C-727 | NAFTA T-Wall and 36' Swing Gate Final Site Plan |
| C-727A | NAFTA T-Wall and 36' Swing Gate Final Site Plan 100 Yr |
| C-728 | NAFTA T-Wall And 36' Swing Gate Cross Sections |
| C-731 | Humphries Canal 20' Stop Log Gate Plan Phase 1 Construction |
| C-732 | Humphries Canal 20' Stop Log Gate Plan Phase 2 Construction |
| C-733 | Humphries Canal 20' Stop Log Gate Final Site Plan |
| C-733A | Humphries Canal 20' Stop Log Gate 100 Yr Final Site Plan |
| C-734 | Humphries Canal 20' Stop Log Gate Cross Sections |
| C-735 | Humphries Canal 20' Stop Log Gate Cross Sections |
| C-737 | Minors Canal 56' Sector Gate Plan Phase 1 Construction |
| C-738 | Minors Canal 56' Sector Gate Plan Phase 2 Construction |
| C-739 | Minors Canal 56' Sector Gate Final Site Plan |
| C-739A | Minors Canal 56' Sector Gate 100 Yr Final Site Plan |
| C-740 | Minors Canal 56' Sector Gate Cross Sections |
| C-741 | Minors Canal 56' Sector Gate Cross Sections |
| C-743 | GIWW West 125' Sector Gate Plan Phase 1 Construction |
| C-744 | GIWW West 125' Sector Gate Plan Phase 2 Construction |
| C-745 | GIWW West 125' Sector Gate Final Site Plan |
| C-745A | GIWW West 125' Sector Gate Plan 100 Yr Final Site Plan |
| C-746 | GIWW West 125' Sector Gate Cross Sections |
| C-747 | GIWW West 125' Sector Gate 35 Yr Cross Sections |
| C-748 | GIWW West 125' Sector Gate 100 Yr Cross Sections |
| C-749 | Falgout Canal 56' Sector Gate Plan Phase 1 Construction |
| C-750 | Falgout Canal 56' Sector Gate Plan Phase 2 Construction |
| C-751 | Falgout Canal 56' Sector Gate Final Site Plan |
| C-751A | Falgout Canal 56' Sector Gate 100 Yr Final Site Plan |
| C-752 | Falgout Canal 56' Sector Gate Cross Sections |
| C-753 | Falgout Canal 56' Sector Gate Cross Sections |
| C-755 | Bayou Dularge 56' Sector Gate & Hwy 315 Swing Gate Plan Phase 1 Construction |
| C-756 | Bayou Dularge 56' Sector Gate & Hwy 315 Swing Gate Plan Phase 2 Construction |
| C-757 | Bayou Dularge 56' Sector Gate & Hwy 315 Swing Gate Final Site Plan |
| C-757A | Bayou Dularge 56' Sector Gate & Hwy 315 Swing Gate 100 Yr Final Site Plan |
| C-758 | Bayou Dularge 56' Sector Gate & Hwy 315 Swing Gate Cross Sections |
| C-759 | Bayou Dularge 56' Sector Gate & Hwy 315 Swing Gate Cross Sections |
| C-761 | Houma Navigation Canal Lock and Floodgate Plan |
| C-762 | Houma Navigation Canal Lock and Floodgate Typical Sections |
| C-764 | Bayou Grand Caillou 56' Sector Gate Plan Phase 1 Construction |
| C-765 | Bayou Grand Caillou 56' Sector Gate Plan Phase 2 Construction |
| C-766 | Bayou Grand Caillou 56' Sector Gate Plan Phase 2 Construction |
| C-766A | Bayou Grand Caillou 56' Sector Gate 100 Yr Final Site Plan |

| | |
|---|---|
| C-767 | Bayou Grand Caillou 56' Sector Gate Cross Sections |
| C-768 | Bayou Grand Caillou 56' Sector Gate Cross Sections |
| C-770 | Bayou Four Points 30' Stop Log Gate Plan & Four Point RD Swing Gate Plan Phase 1 Construction |
| C-771 | Bayou Four Points 30' Stop Log Gate Plan & Four Point RD Swing Gate Plan Phase 2 Construction |
| C-772 | Bayou Four Points 30' Stop Log Gate Plan & Four Point RD Relocation Final Site Plan |
| C-772A | Bayou Four Points 30' Stop Log Gate Plan & Four Point RD Relocation 100 Yr Final Site Plan |
| C-773 | Bayou Four Points 30' Stop Log Gate Plan & Four Point RD Relocation Cross Sections |
| C-774 | Bayou Four Points 30' Stop Log Gate Plan & Four Point RD Relocation Cross Sections |
| C-779 | Bayou Petit Caillou 56' Sector Gate & Hwy 56 Swing Gate Plan Phase 1 Construction |
| C-780 | Bayou Petit Caillou 56' Sector Gate & Hwy 56 Swing Gate Plan Phase 2 Construction |
| C-781 | Bayou Petit Caillou 56' Sector Gate & Hwy 56 Swing Gate Final Site Plan |
| C-781A | Bayou Petit Caillou 56' Sector Gate & Hwy 56 Swing Gate 100 Yr Final Site Plan |
| C-782 | Bayou Petit Caillou 56' Sector Gate & Hwy 56 Swing Gate Cross Sections |
| C-783 | Bayou Petit Caillou 56' Sector Gate & Hwy 56 Swing Gate Cross Sections |
| C-788 | Placid Canal 56' Sector Gate Plan Phase 1 Construction |
| C-789 | Placid Canal 56' Sector Gate Plan Phase 2 Construction |
| C-790 | Placid Canal 56' Sector Gate Final Site Plan |
| C-790A | Placid Canal 56' Sector Gate 100 Yr Final Site Plan |
| C-791 | Placid Canal 56' Sector Gate Cross Sections |
| C-792 | Placid Canal 56' Sector Gate Cross Sections |
| C-794 | Bush Canal 56' Sector Gate Plan Phase 1 Construction |
| C-795 | Bush Canal 56' Sector Gate Plan Phase 2 Construction |
| C-796 | Bush Canal 56' Sector Gate Final Site Plan |
| C-796A | Bush Canal 56' Sector Gate 100 Yr Final Site Plan |
| C-797 | Bush Canal 56' Sector Gate Cross Sections |
| C-798 | Bush Canal 56' Sector Gate Cross Sections |
| C-800 | Bayou Terrebonne 56' Sector Gate & Hwy 55 Swing Gate Plan Phase 1 Construction |
| C-801 | Bayou Terrebonne 56' Sector Gate & Hwy 55 Swing Gate Plan Phase 2 Construction |
| C-802 | Bayou Terrebonne 56' Sector Gate & Hwy 55 Swing Gate Final Site Plan |
| C-802A | Bayou Terrebonne 56' Sector Gate & Hwy 55 Swing Gate 100 Yr Final Site Plan |
| C-803 | Bayou Terrebonne 56' Sector Gate & Hwy 55 Swing Gate Cross Sections |

**MORGANZA TO THE GULF OF MEXICO, LOUISIANA DRAFT PAC DRAFT ENGINEERING APPENDIX**

| | |
|---|---|
| C-804 | Bayou Terrebonne 56' Sector Gate & Hwy 55 Swing Gate Cross Sections |
| C-806 | Humble Canal 56' Sector Gate Plan Phase 1 Construction |
| C-807 | Humble Canal 56' Sector Gate Plan Phase 2 Construction |
| C-808 | Humble Canal 56' Sector Gate Final Site Plan |
| C-808A | Humble Canal 56' Sector Gate 100 Yr Final Site Plan |
| C-809 | Humble Canal 56' Sector Gate Cross Sections |
| C-810 | Humble Canal 56' Sector Gate Cross Sections |
| C-812 | Bayou Point Aux Chenes 56' Sector Gate & Hwy 665 Swing Gate Plan Phase 1 Construction |
| C-813 | Bayou Point Aux Chenes 56' Sector Gate & Hwy 665 Swing Gate Plan Phase 2 Construction |
| C-814 | Bayou Point Aux Chenes 56' Sector Gate & Hwy 665 Swing Gate Final Site Plan |
| C-814A | Bayou Point Aux Chenes 56' Sector Gate & Hwy 665 Swing Gate 100 Yr Final Site Plan |
| C-815 | Bayou Point Aux Chenes 56' Sector Gate & Hwy 665 Swing Gate Cross Sections |
| C-816 | Bayou Point Aux Chenes 56' Sector Gate & Hwy 665 Swing Gate Cross Sections |
| C-820 | Grand Bayou 56' Sector Gate Plan Phase 1 Construction |
| C-821 | Grand Bayou 56' Sector Gate Plan Phase 2 Construction |
| C-822 | Grand Bayou 56' Sector Gate Final Site Plan |
| C-822A | Grand Bayou 56' Sector Gate 100 Yr Final Site Plan |
| C-823 | Grand Bayou 56' Sector Gate Cross Sections |
| C-824 | Grand Bayou 56' Sector Gate Cross Sections |
| C-825 | GIWW East 125' Sector Gate Plan Phase 1 Construction |
| C-826 | GIWW East 125' Sector Gate Plan Phase 2 Construction |
| C-827 | GIWW East 125' Sector Gate Final Site Plan |
| C-827A | GIWW East 125' Sector Gate 100 Yr Final Site Plan |
| C-828 | GIWW East 125' Sector Gate Cross Sections |
| C-829 | GIWW East 125' Sector Gate 35 Yr Cross Sections |
| C-829A | GIWW East 125' Sector Gate 100 Yr Cross Sections |
| C-830 | Marmande Canal 30' Stop Log Gate Plan Phase 1 Construction |
| C-831 | Marmande Canal 30' Stop Log Gate Plan Phase 2 Construction |
| C-832 | Marmande Canal 30' Stop Log Gate Final Site Plan |
| C-832A | Marmande Canal 30' Stop Log Gate 100 Yr Final Site Plan |
| C-833 | Marmande Canal 30' Stop Log Gate Cross Sections |
| C-834 | Marmande Canal 30' Stop Log Gate Cross Sections |
| C-838 | Environmental Control Structure Barrier Construction Plan |
| C-840 | Environmental Control Structure Barrier Final Site Plan |
| C-840A | Environmental Control Structure Barrier Final Site Plan 100 Yr |
| C-841 | Environmental Control Structure Barrier Cross Sections |
| C-842 | Environmental Control Structure Reach E Final Site Plan |

C-842A Environmental Control Structure Reach E Final Site Plan 100 Yr
C-843 Environmental Control Structure Reach E Cross Sections
C-844 Environmental Control Structure Reach G Final Site Plan
C-844A Environmental Control Structure Reach G Final Site Plan 100 Yr
C-845 Environmental Control Structure Reach G Cross Sections
C-846 Environmental Control Structure Reach J Final Site Plan
C-846A Environmental Control Structure Reach J Final Site Plan 100 Yr
C-847 Environmental Control Structure Reach J Cross Sections
C-848 Environmental Control Structure Reach K&L Final Site Plan
C-848A Environmental Control Structure Reach K&L Final Site Plan 100 Yr
C-849 Environmental Control Structure Reach K&L Cross Sections
C-850 Environmental Control Structure Reach H Final Site Plan
C-850A Environmental Control Structure Reach H Final Site Plan 100 Yr
C-851 Environmental Control Structure Reach H Cross Sections
C-852 Environmental Control Structure Reach A Final Site Plan
C-852A Environmental Control Structure Reach A Final Site Plan 100 Yr
C-853 Environmental Control Structure Reach A Cross Sections
C-861 Black Bayou Pump Station Fronting Protection Final Site Plan
C-862 Black Bayou Pump Station Fronting Protection Cross Sections
C-863 Hanson Canal Pump Station Fronting Protection Final Site Plan
C-864 Hanson Canal Pump Station Fronting Protection Cross Sections
C-865 Madison Pump Station Fronting Protection Final Site Plan
C-866 Madison Canal Pump Station Fronting Protection Cross Sections
C-867 Point Aux Chenes Pump Station Fronting Protection Final Site Plan
C-868 Point Aux Chenes Pump Station Fronting Protection Cross Sections
C-900 Environmental Control Structure Larose to Lockport #1 – Final Site Plan 0 35 Year LORR
C-901 Environmental Control Structure Larose to Lockport #1 – Final Site Plan 0 100 Year LORR
C-902 Environmental Control Structure Larose to Lockport #2 – Final Site Plan 0 35 Year LORR
C-903 Environmental Control Structure Larose to Lockport #2 – Final Site Plan 0 100 Year LORR
C-904 Environmental Control Structure Larose to Lockport Cross Sections
C-905 Union Pacific Railroad Crossing Final Site Plan – 35 Year LORR
C-906 Union Pacific Railroad Crossing Final Site Plan – 100 Year LORR
C-907 Union Pacific Railroad Crossing Cross Sections
C-908 Gulf South Pipeline Crossing Final Site Plan – 35 Year LORR
C-909 Gulf South Pipeline Crossing Final Site Plan – 100 Year LORR
C-910 American Midstream Pipeline Crossing Final Site Plan – 35 Year LORR
C-911 American Midstream Pipeline Crossing Final Site Plan – 100 Year LORR
C-912 Williams Discovery Pipeline Crossing Final Site Plan – 35 Year LORR
C-913 Williams Discovery Pipeline Crossing Final Site Plan – 100 Year LORR

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| C-914 | Larose C-North Utility Crossings Cross Sections |
| C-920 | Larose FG 56' Sector Gate Phase 1 Construction |
| C-921 | Larose FG 56' Sector Gate Phase 2 Construction |
| C-922 | Larose FG 56' Sector Gate Final Site Plan View |
| C-923 | Larose FG 56' Sector Gate Cross Sections |
| S-001 | 56' Sector Gate Isometric |
| S-001A | 56' Sector Gate Isometric |
| S-002 | 56' Sector Gate Masonry Plan |
| S-002A | 56' Sector Gate Masonry Plan |
| S-003 | 56' Sector Gate Masonry Elevation Transverse |
| S-003A | 56' Sector Gate Masonry Elevation Transverse |
| S-004 | 56' Sector Gate Masonry Elevation Longitudinal |
| S-004A | 56' Sector Gate Masonry Elevation Longitudinal |
| S-005 | 56' Sector Gate Foundation Plan |
| S-005A | 56' Sector Gate Foundation Plan |
| S-006 | 56' Sector Gate Upper Frame |
| S-006A | 56' Sector Gate Upper Frame |
| S-007 | 56' Sector Gate Upper Middle Frame |
| S-007A | 56' Sector Gate Upper Middle Frame |
| S-008 | 56' Sector Gate Middle Lower Frame |
| S-008A | 56' Sector Gate Middle Frame |
| S-009 | 56' Sector Gate Lower Frame |
| S-009A | 56' Sector Gate Middle Lower Frame |
| S-010A | 56' Sector Gate Lower Frame |
| S-011 | 56' Sector Gate Channel Truss |
| S-011A | 56' Sector Gate Channel Truss |
| S-012 | 56' Sector Gate Recess Truss |
| S-012A | 56' Sector Gate Recess Truss |
| S-013 | 56' Sector Gate Fender System |
| S-013A | 56' Sector Gate Fender System |
| S-014 | 56' Sector Gate Hinge Assembly and Details 1 of 2 |
| S-014A | 56' Sector Gate Hinge Assembly and Details 1 of 2 |
| S-015 | 56' Sector Gate Hinge Assembly and Details 2 of 2 |
| S-015A | 56' Sector Gate Hinge Assembly and Details 2 of 2 |
| S-016 | 56' Sector Gate Pintle Assembly and Details |
| S-016A | 56' Sector Gate Pintle Assembly and Details |
| S-018 | 56' Needle Girder and Support Tower |
| S-019 | Steel Needle Plan, Elevation and Section |
| S-020 | 56' Sector Gate Needle Girder Storage Platform |
| S-021 | 56' Sector Gate Guidewall Plan |
| S-022 | 56' Sector Gate Guidewall Sections and Details |
| S-023 | 56' Sector Gate 7 Pile Cluster |
| S-024 | 56' Sector Gate Cofferdam |

**MORGANZA TO THE GULF OF MEXICO, LOUISIANA DRAFT PAC**
**DRAFT ENGINEERING APPENDIX**

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| S-025 | 175' Sector Gate Isometric |
| S-026 | 125' Sector Gate Masonry Plan |
| S-026A | 125' Sector Gate Masonry Plan |
| S-027 | 125' Sector Gate Masonry Sections |
| S-027A | 125' Sector Gate Masonry Sections |
| S-029 | 125' Sector Gate Foundation Plan |
| S-029A | 125' Sector Gate Foundation Plan |
| S-030 | 125' Sector Gate Upper Frame |
| S-030A | 125' Sector Gate Upper Frame |
| S-031 | 125' Sector Gate Middle Frame |
| S-031A | 125' Sector Gate Upper Middle Frame |
| S-032 | 125' Sector Gate Lower Frame |
| S-032A | 125' Sector Gate Lower Middle Frame |
| S-033 | 125' Sector Gate Lower Frame |
| S-034 | 125' Sector Gate Channel Truss |
| S-034A | 125' Sector Gate Channel Truss |
| S-035 | 125' Sector Gate Middle Channel Truss |
| S-035A | 125' Sector Gate Middle Channel Truss |
| S-036 | 125' Sector Gate Middle Recess Truss |
| S-036A | 125' Sector Gate Middle Recess Truss |
| S-037 | 125' Sector Gate Recess Truss |
| S-037A | 125' Sector Gate Recess Truss |
| S-038 | 125' Sector Gate Fender |
| S-038A | 125' Sector Gate Fender |
| S-040 | 125' Sector Gate Hinge Assembly and Details |
| S-040A | 125' Sector Gate Hinge Assembly and Details |
| S-041 | 125' Sector Gate Pintle Assembly and Details |
| S-041A | 125' Sector Gate Pintle Assembly and Details |
| S-043 | 125' Needle Girder and Support Towers |
| S-044 | 125' Sector Gate Dewatering Needles |
| S-045 | 125' Sector Gate Needle Girder Storage Platform |
| S-046 | 125' Sector Gate Needle Girder Storage Platform Sections |
| S-047 | 125' Sector Gate Guidewall Plan |
| S-048 | 125' Sector Gate Guidewall Section |
| S-049 | 125' Sector Gate End Cell Dolphin |
| S-050 | 125' Sector Gate Cofferdam |
| S-054 | Sluice Gate Masonry Plan |
| S-054A | Sluice Gate Masonry Plan |
| S-055 | Sluice Gate Front Elevation |
| S-055A | Sluice Gate Front Elevation |
| S-056 | Sluice Gate Back Elevation |
| S-056A | Sluice Gate Back Elevation |
| S-057 | Sluice Gate Section |

| | |
|---|---|
| S-057A | Sluice Gate Section |
| S-058 | Sluice Gate Foundation Plan |
| S-058A | Sluice Gate Foundation Plan |
| S-059 | Sluice Gate Dewatering Bulkhead |
| S-060 | 20' Stop Log Isometric |
| S-061 | 20' Stop Log Masonry Plan |
| S-061A | 20' Stop Log Masonry Plan |
| S-062 | 20' Stop Log Masonry Elevation |
| S-062A | 20' Stop Log Masonry Elevation |
| S-063 | 20' Stop Log Foundation Plan |
| S-063A | 20' Stop Log Foundation Plan |
| S-064 | 20' Stop Log Needle Girder |
| S-064A | 20' Stop Log Gate and Needle Girder |
| S-065 | 20' Stop Log Gate Bulkhead and Storage Platform |
| S-065A | 20' Stop Log Gate Bulkhead and Storage Platform |
| S-066 | 20' Stop Log Gate Crane Platform |
| S-066A | 20' Stop Log Gate Crane Platform |
| S-067 | 30' Stop Log Gate Isometric |
| S-068 | 30' Stop Log Masonry Plan |
| S-068A | 30' Stop Log Masonry Plan |
| S-069 | 30' Stop Log Masonry Elevation |
| S-069A | 30' Stop Log Gate Masonry Elevation |
| S-070 | 30' Stop Log Gate Foundation Plan |
| S-070A | 30' Stop Log Gate Foundation Plan |
| S-071 | 30' Stop Log Gate and Needle Girder |
| S-071A | 30' Stop Log Gate and Needle Girder |
| S-072 | 30' Stop Log Gate Bulkhead and Storage Platform |
| S-072A | 30' Stop Log Gate Bulkhead and Storage Platform |
| S-073 | 30' Stop Log Gate Crane Platform |
| S-073A | 30' Stop Log Gate Crane Platform |
| S-075 | Highway Gate Masonry Plan & Section |
| S-075A | Highway Gate Masonry Plan & Section |
| S-076 | Highway Gate Steel Plan & Section |
| S-076A | Highway Gate Steel Plan & Section |
| S-077 | Highway Guardrail |
| S-078 | Highway Excavation Plan & Section |
| S-081 | Environmental Control Structure Masonry Plan |
| S-081A | Environmental Control Structure Masonry Plan |
| S-082 | Environmental Control Structure Masonry Elevation Flood Side |
| S-082A | Environmental Control Structure Masonry Elevation Flood Side |
| S-083 | Environmental Control Structure Masonry Elevation Protected Side |
| S-083A | Environmental Control Structure Masonry Elevation Protected Side |
| S-084 | Environmental Control Structure Section |

| | |
|---|---|
| S-084A | Environmental Control Structure Section |
| S-085 | Environmental Control Structure Foundation Plan |
| S-085A | Environmental Control Structure Foundation Plan |
| S-086 | Environmental Control Structure Dewatering Bulkhead |
| S-086A | Environmental Control Structure Dewatering Bulkhead |
| S-087 | Environmental Control Structure Wingwall Monolith Pile Layout and Section |
| S-087A | Environmental Control Structure Wingwall Monolith Pile Layout and Section |
| S-088 | Environmental Control Structure Trash Rack |
| S-088A | Environmental Control Structure Trash Rack |
| S-089 | Environmental Control Structure Schedule of Variables |
| S-089A | Environmental Control Structure Schedule of Variables |
| S-092 | T-Wall Type 1A-1B |
| S-092A | T-Wall Type 1A-1B |
| S-093 | T-Wall Type 1C-1D |
| S-093A | T-Wall Type 1C-1E |
| S-094 | T-Wall Type 2A-2B |
| S-094A | T-Wall Type 2A-2B |
| S-095 | T-Wall Type 2C-2D |
| S-095A | T-Wall Type 2C-2E |
| S-096 | T-Wall Type 3A-3B |
| S-096A | T-Wall Type 3A-3B |
| S-097 | T-Wall Type 3C-3D |
| S-097A | T-Wall Type 3C-3E |
| S-098 | T-Wall Type 4A-4B |
| S-098A | T-Wall Type 4A-4B |
| S-099 | T-Wall Type 4C-4D |
| S-099A | T-Wall Type 4C-4E |
| S-100 | Phase 2 Cofferdam Plan |
| S-101 | Stop Log Gates Cofferdam |

Electrical Plates

| | |
|---|---|
| E-001 | 56' Sector Gate Electrical |
| E-002 | 56' Sector Gate Electrical |
| E-003 | 56' Sector Gate Electrical |
| E-004 | 56' Sector Gate Electrical |
| E-005 | 175' Sector Gate Electrical |
| E-006 | 175' Sector Gate Electrical |
| E-007 | 175' Sector Gate Electrical |
| E-008 | 175' Sector Gate Electrical |
| E-009 | 175' Sector Gate Electrical |

**MORGANZA TO THE GULF OF MEXICO, LOUISIANA DRAFT PAC**
**DRAFT ENGINEERING APPENDIX**

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|---|---|
| E-010 | 175' Sector Gate Electrical |

Mechanical Plates

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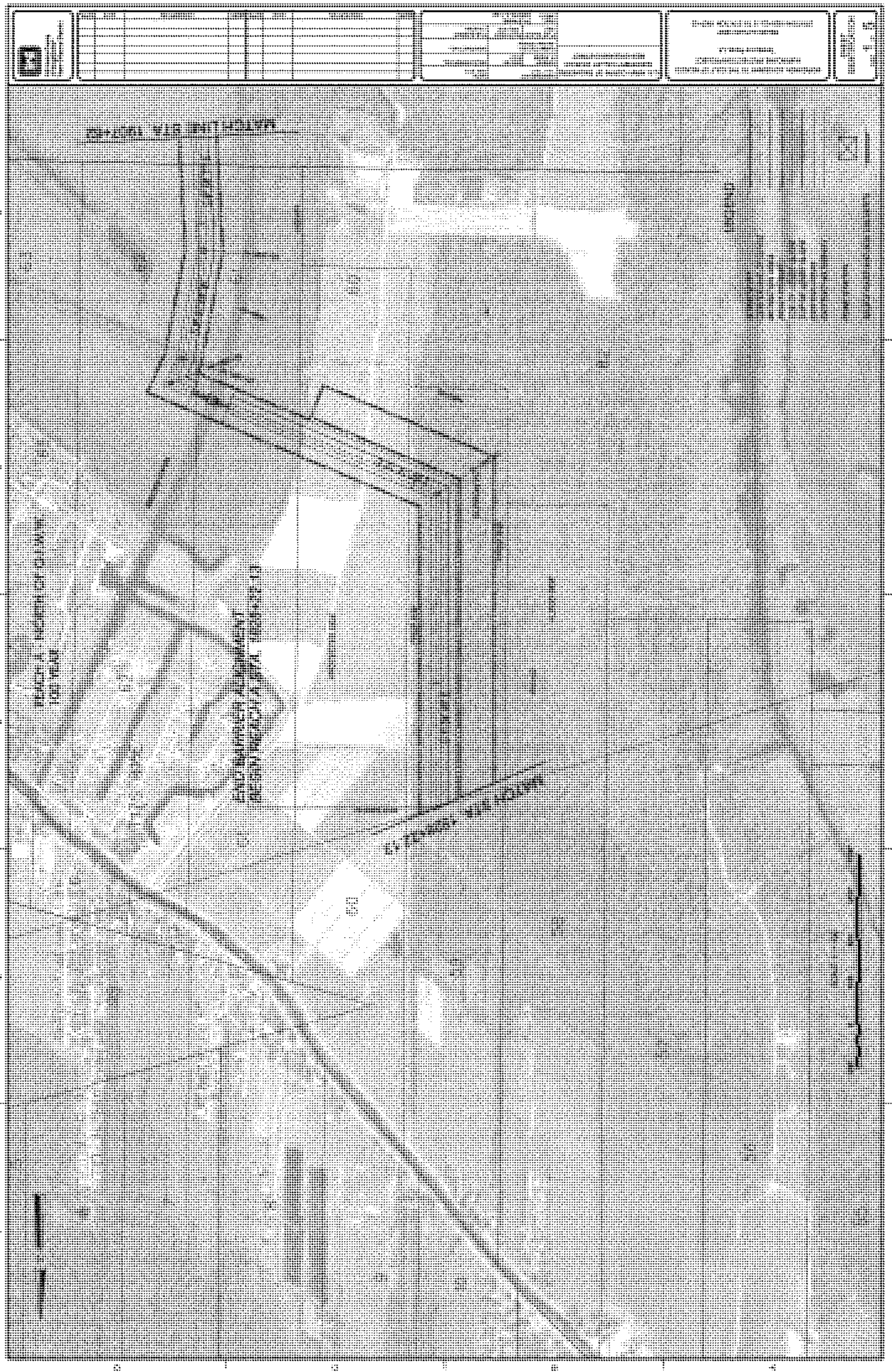
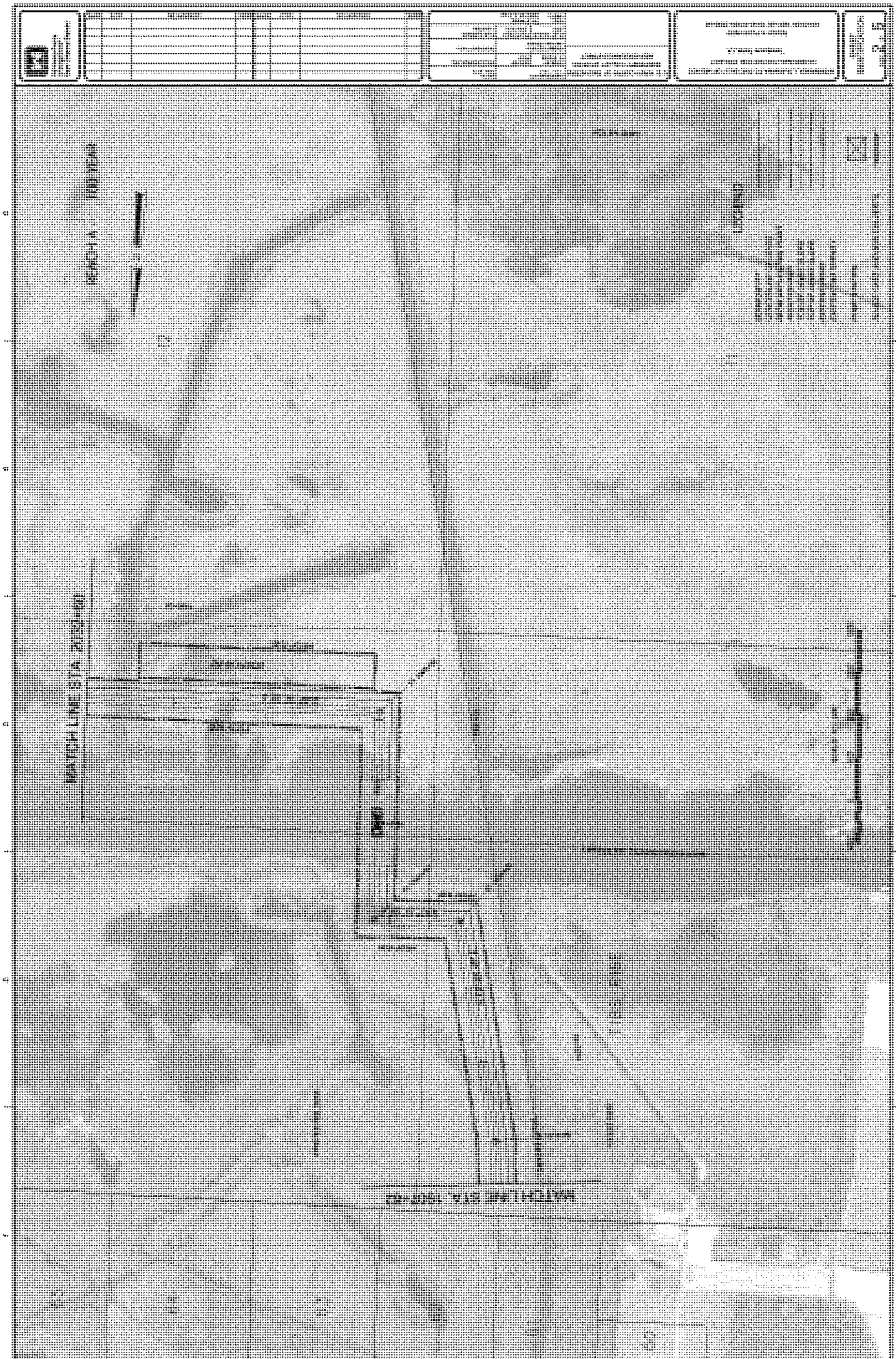
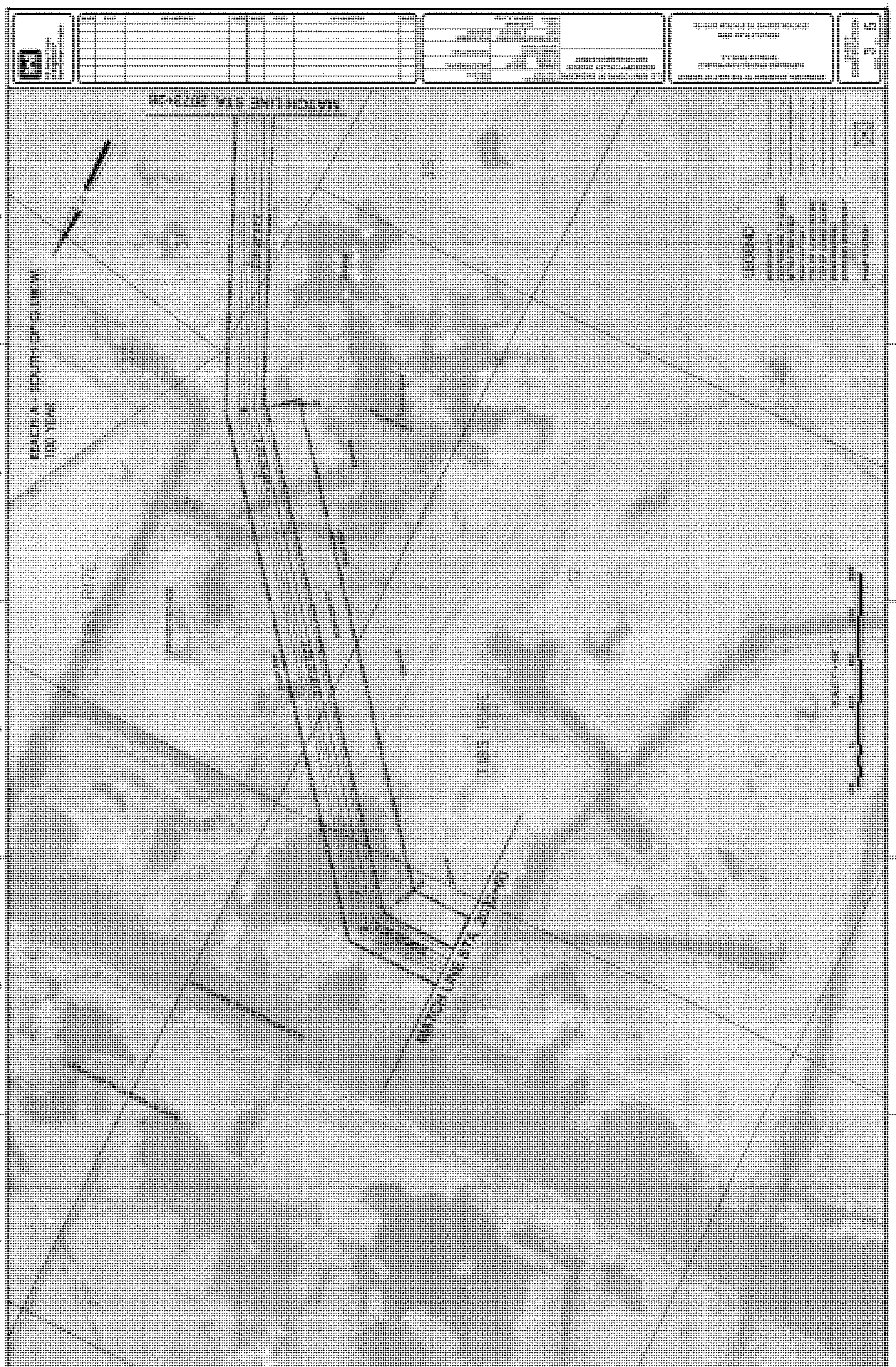
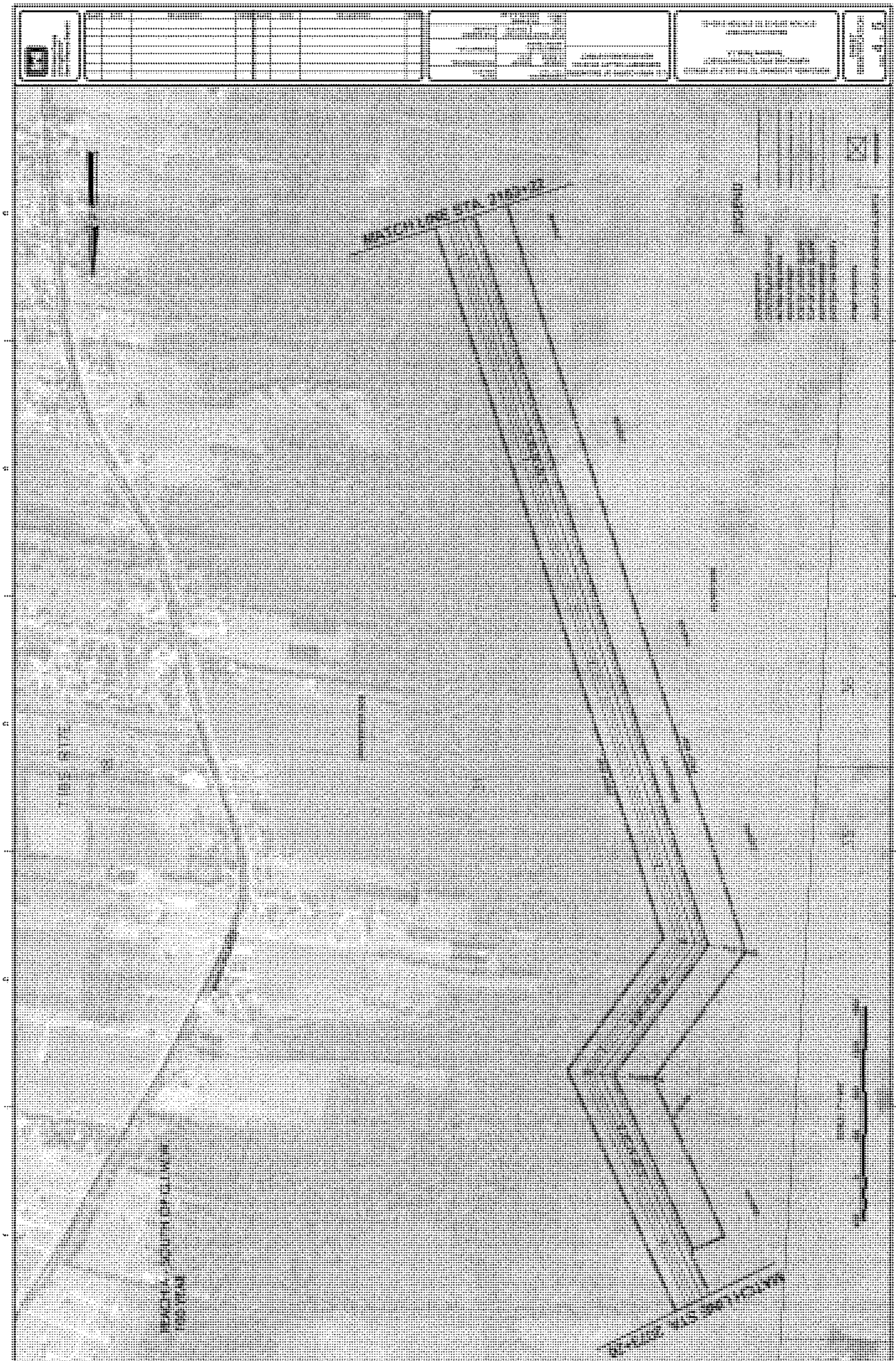
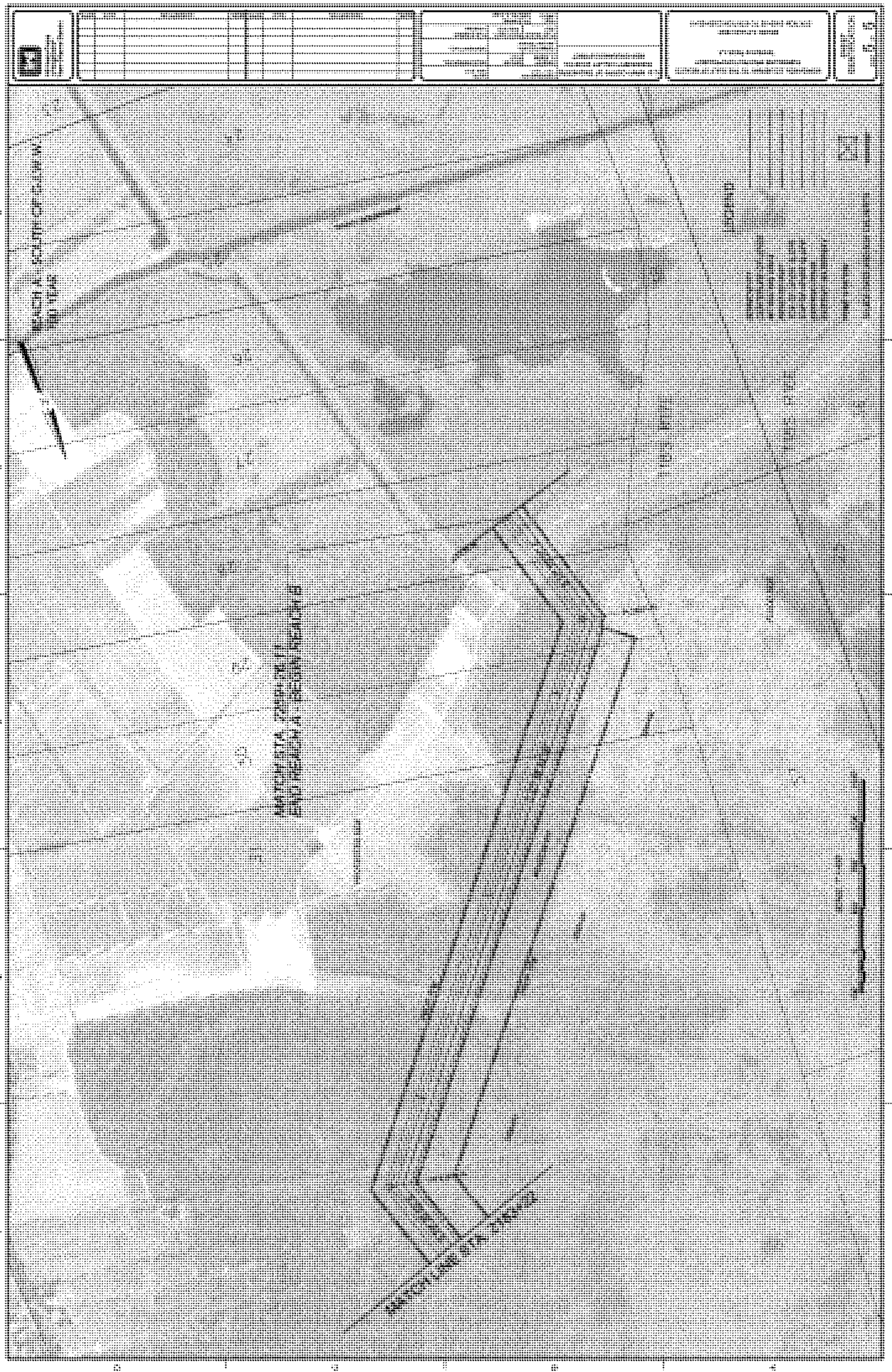
|---|---|
| M-001 | 56' Sector Gate Operating Machinery |
| M-002 | 175' Sector Gate Operating Machinery |
| M012 | Fronting Protection Butterfly Valves |

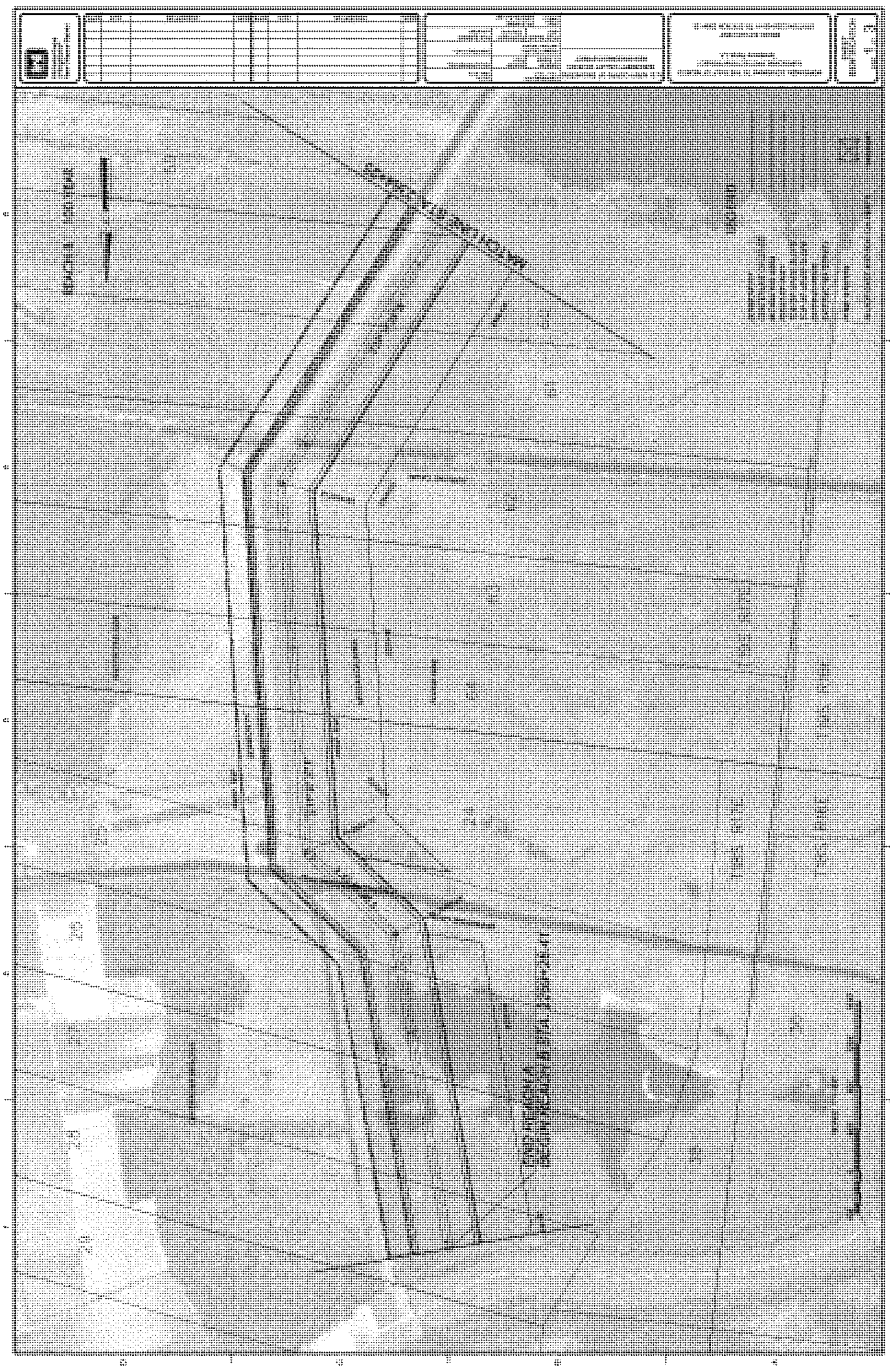


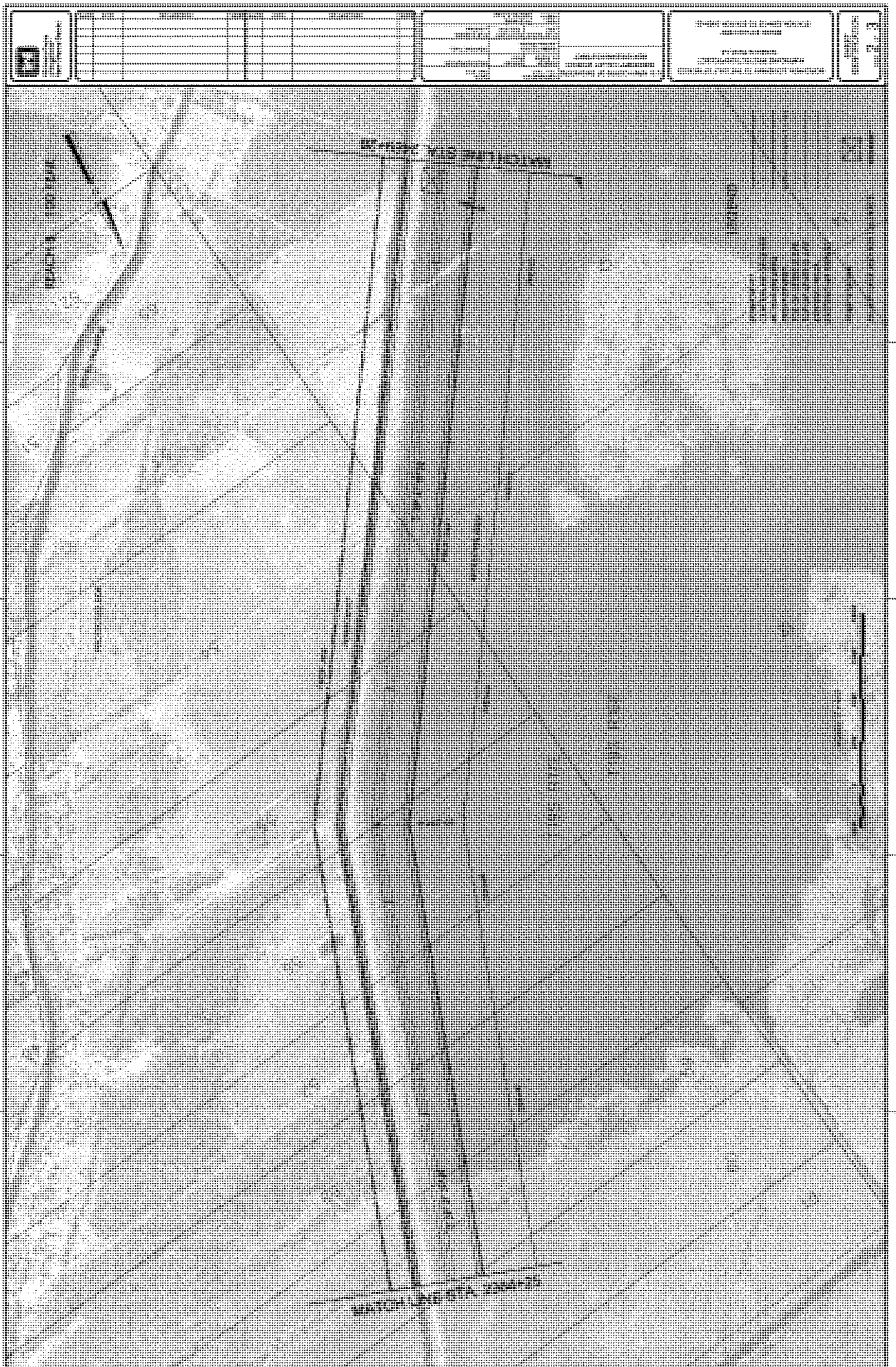


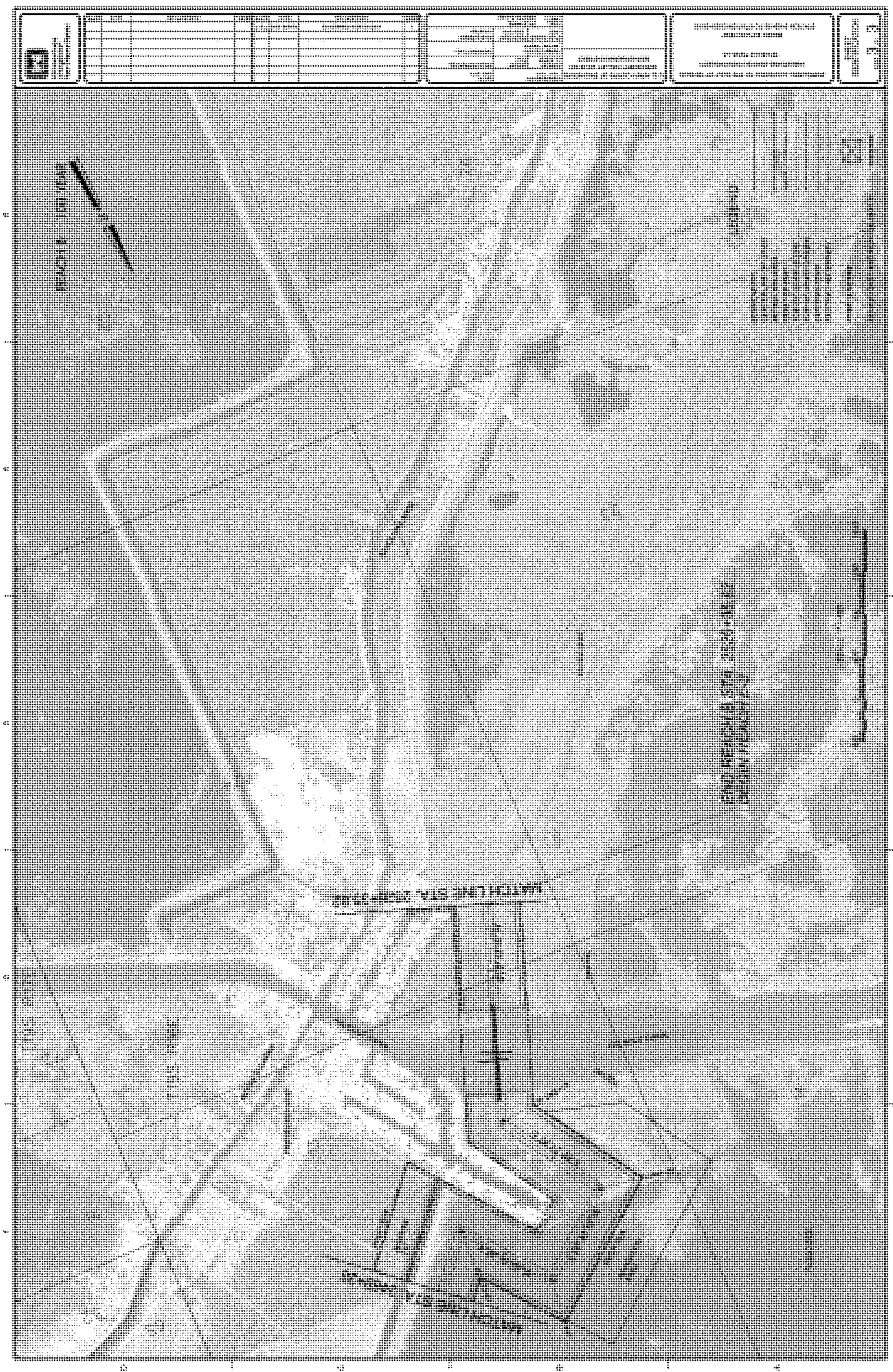


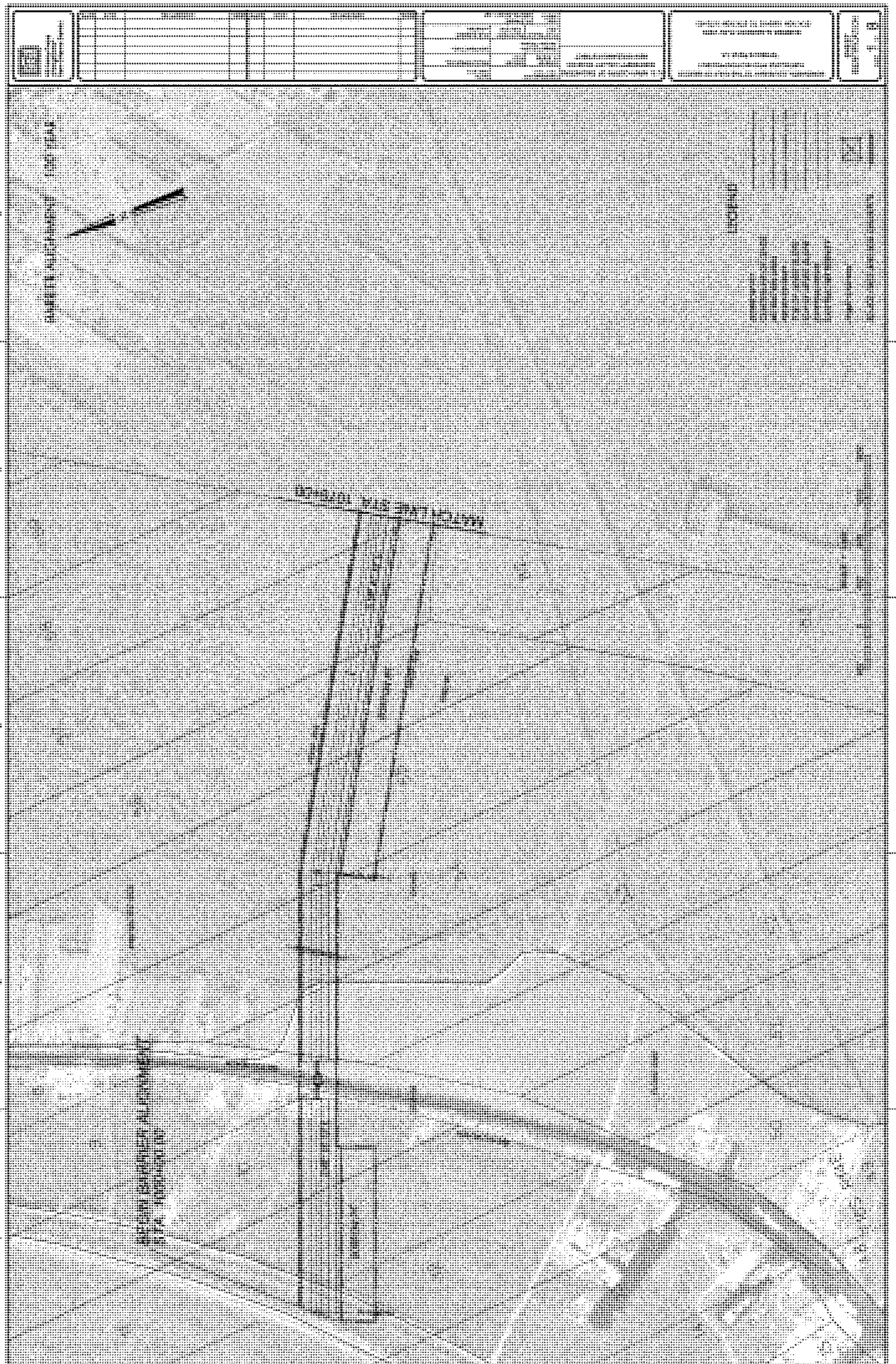


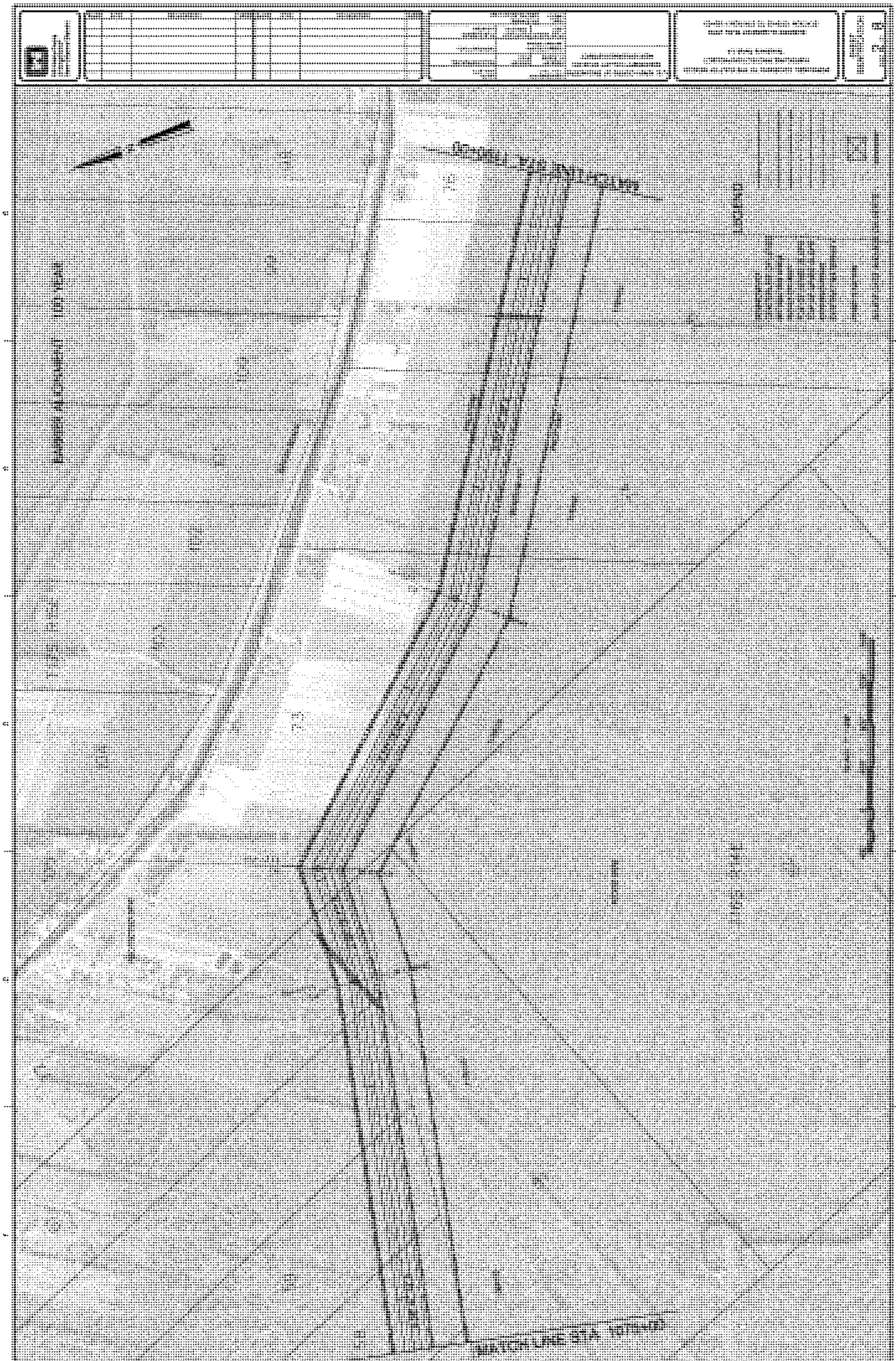


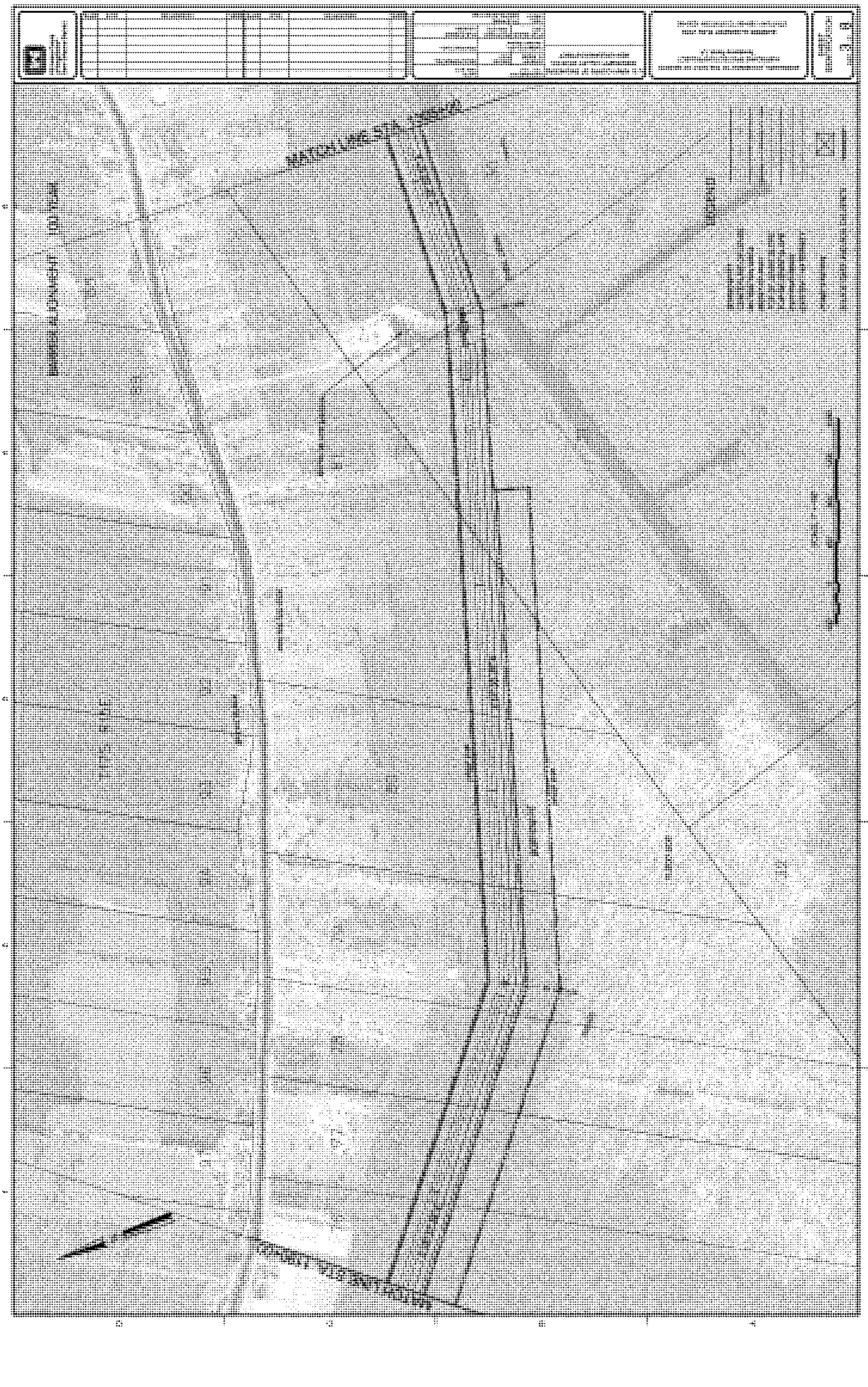


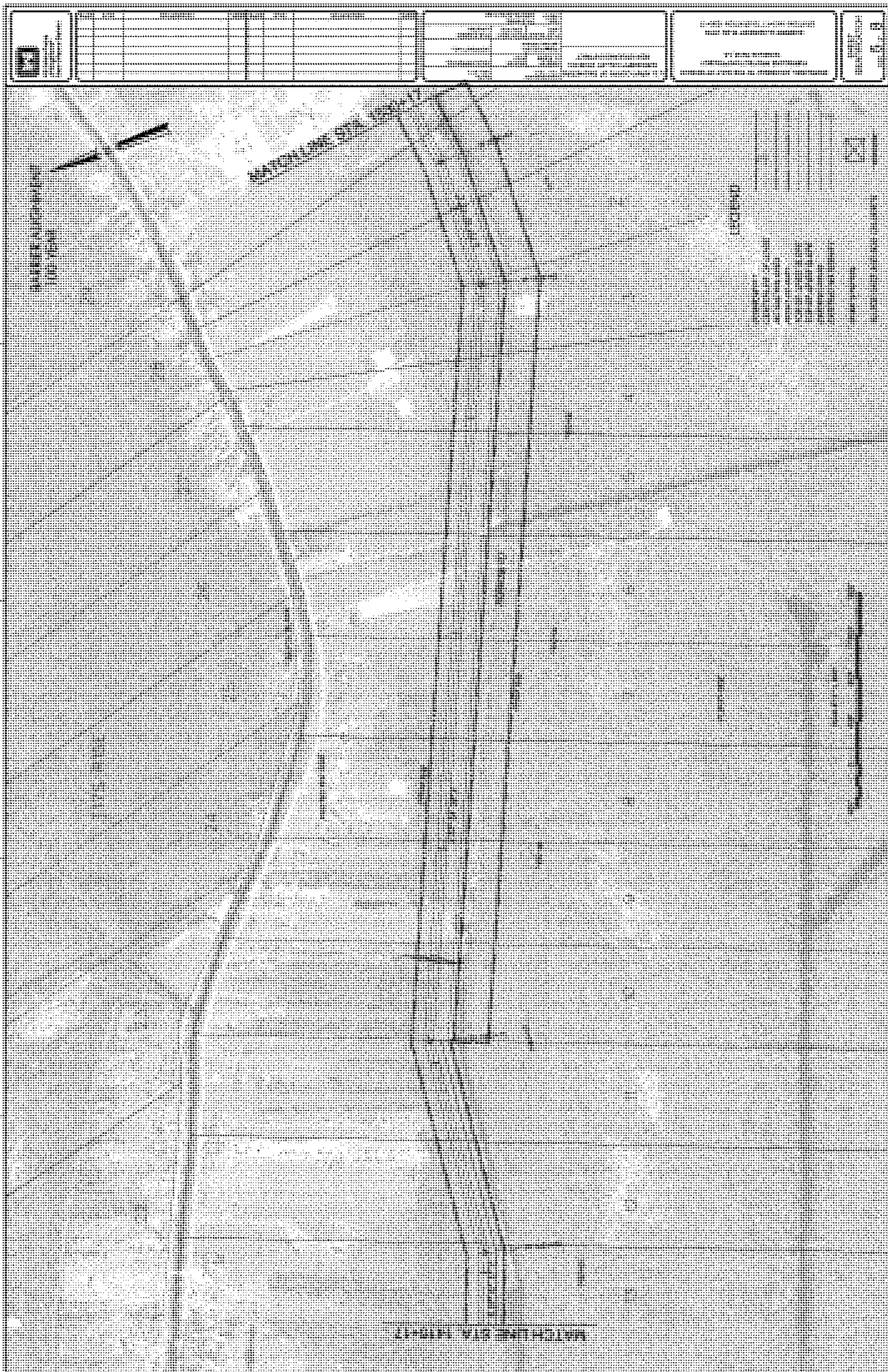


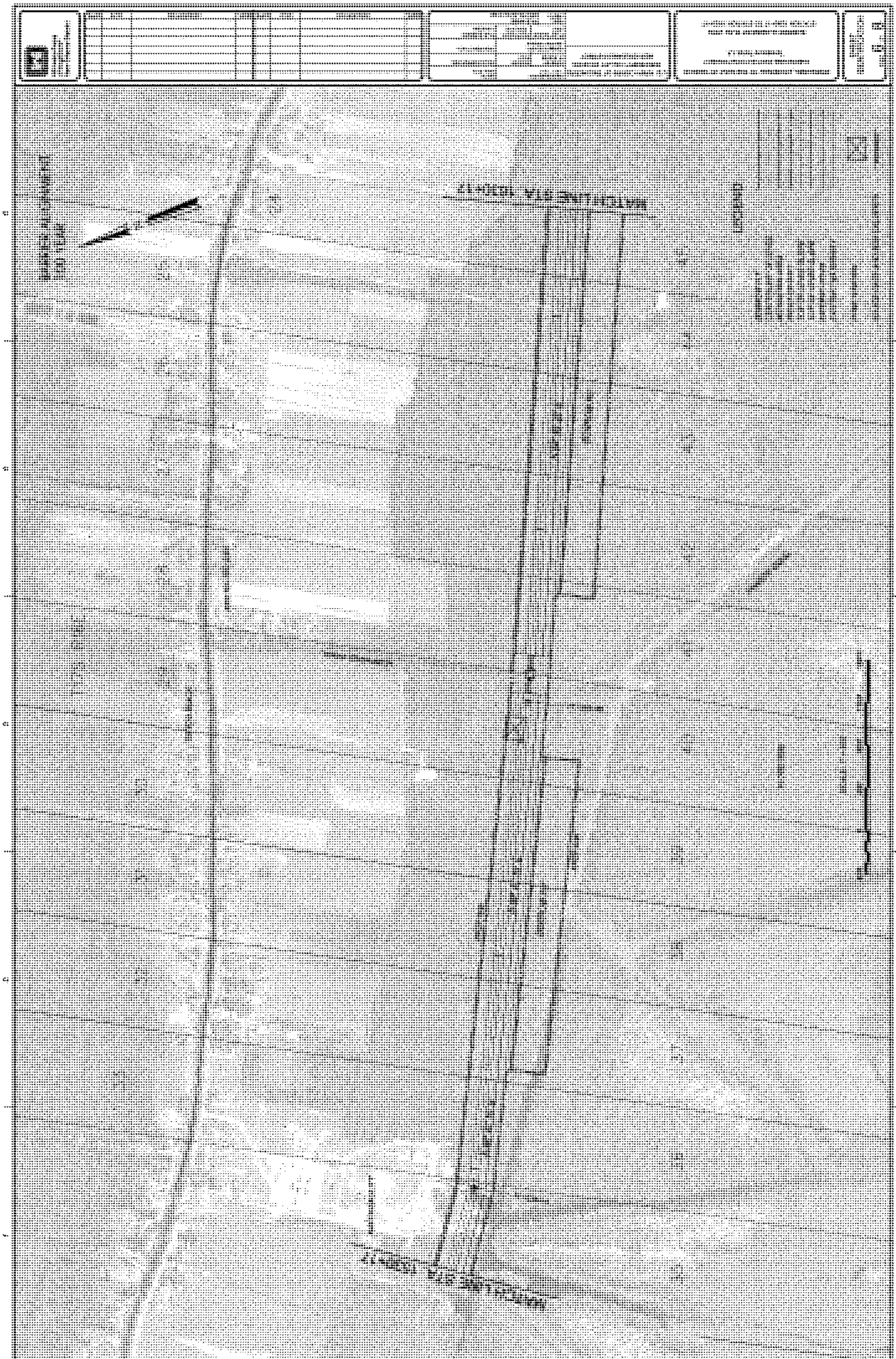


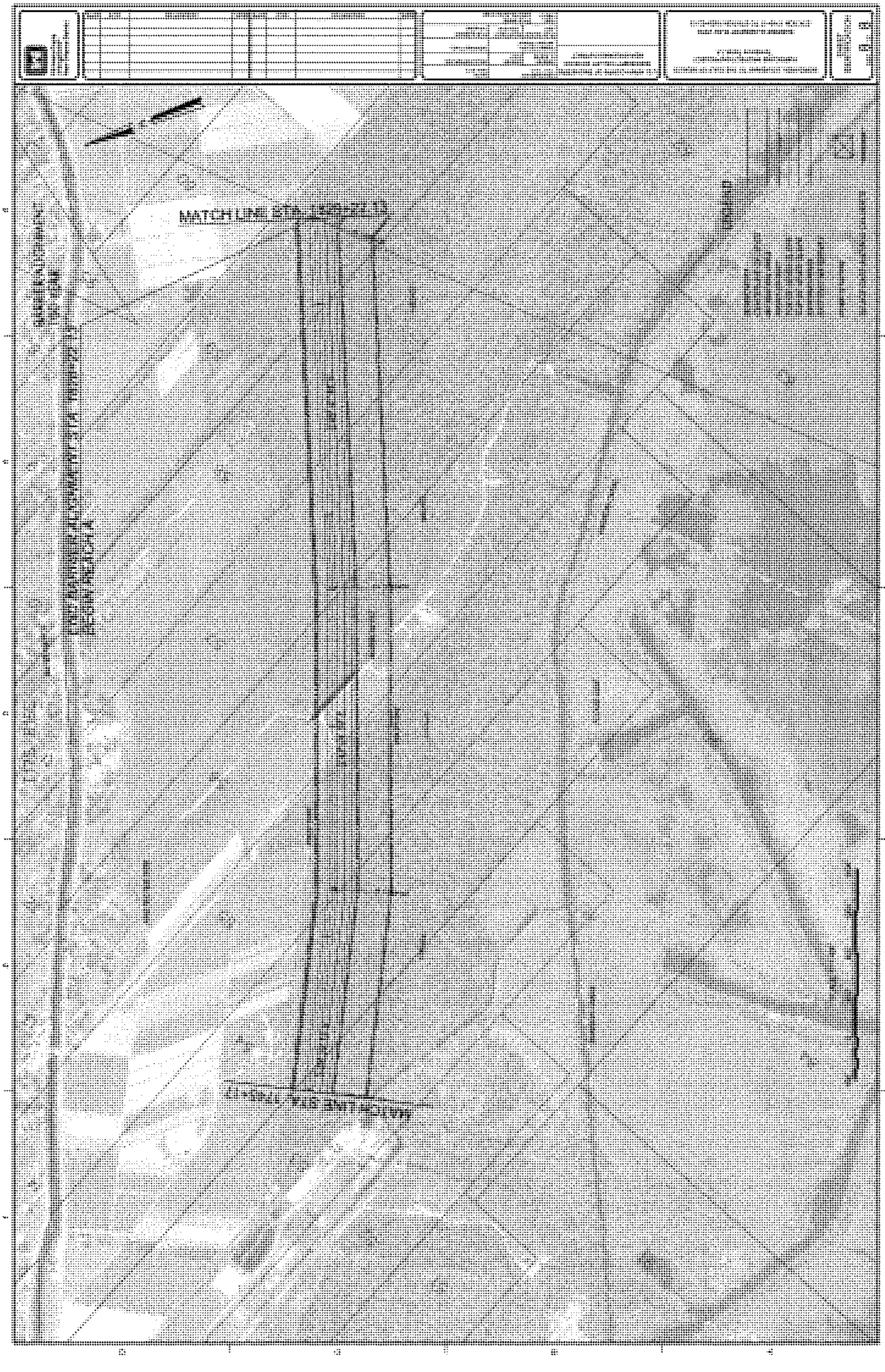


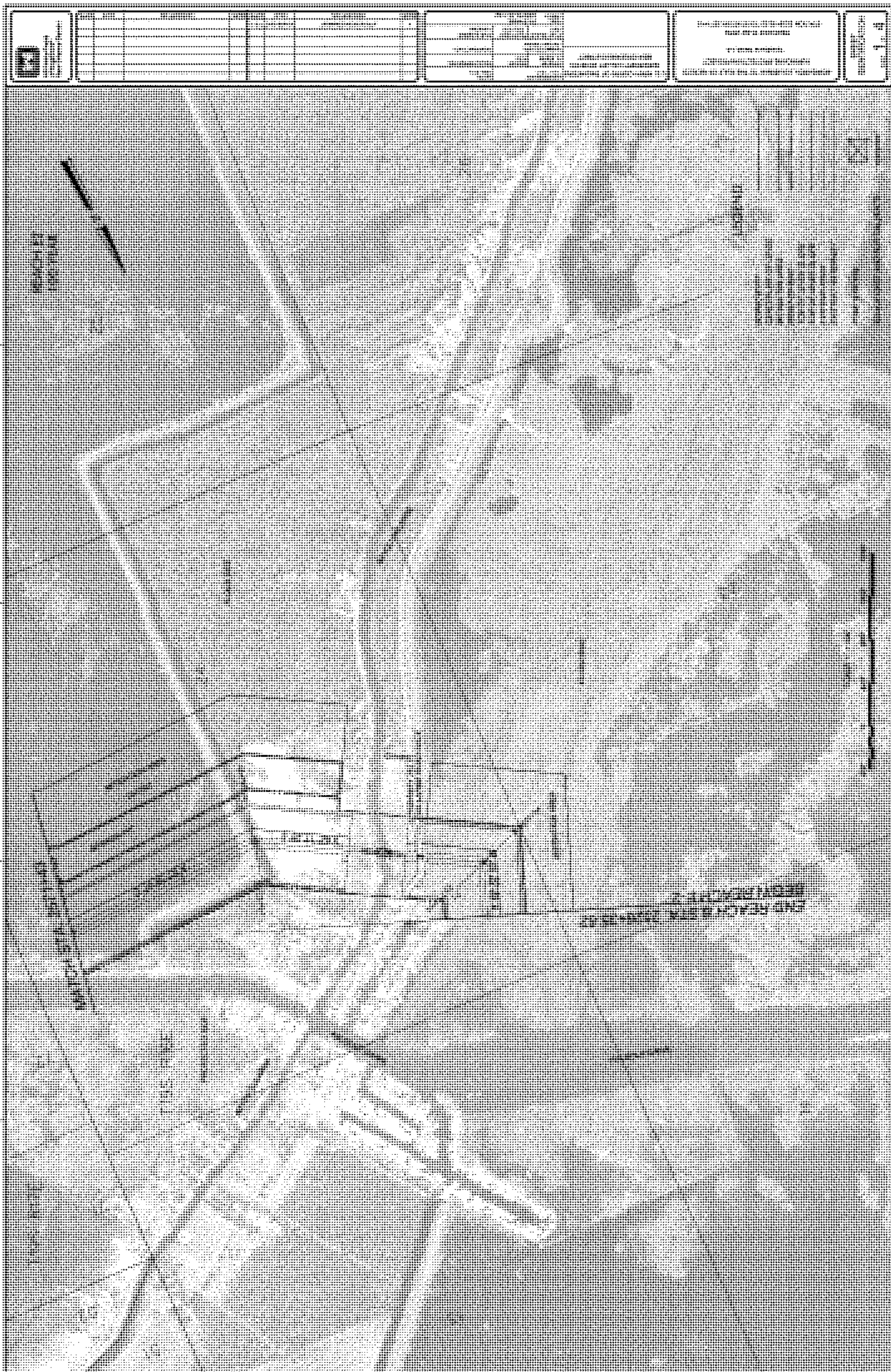


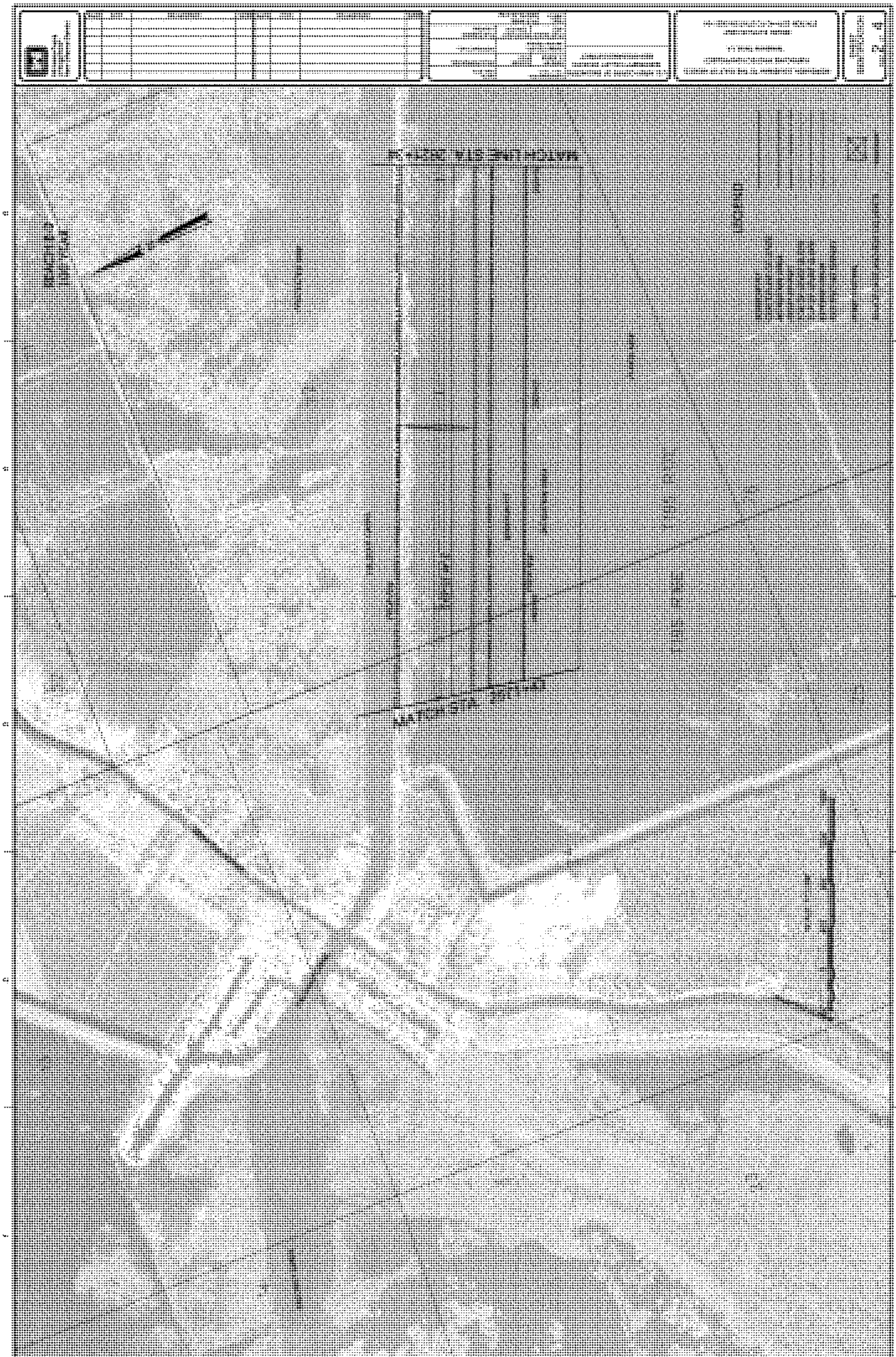


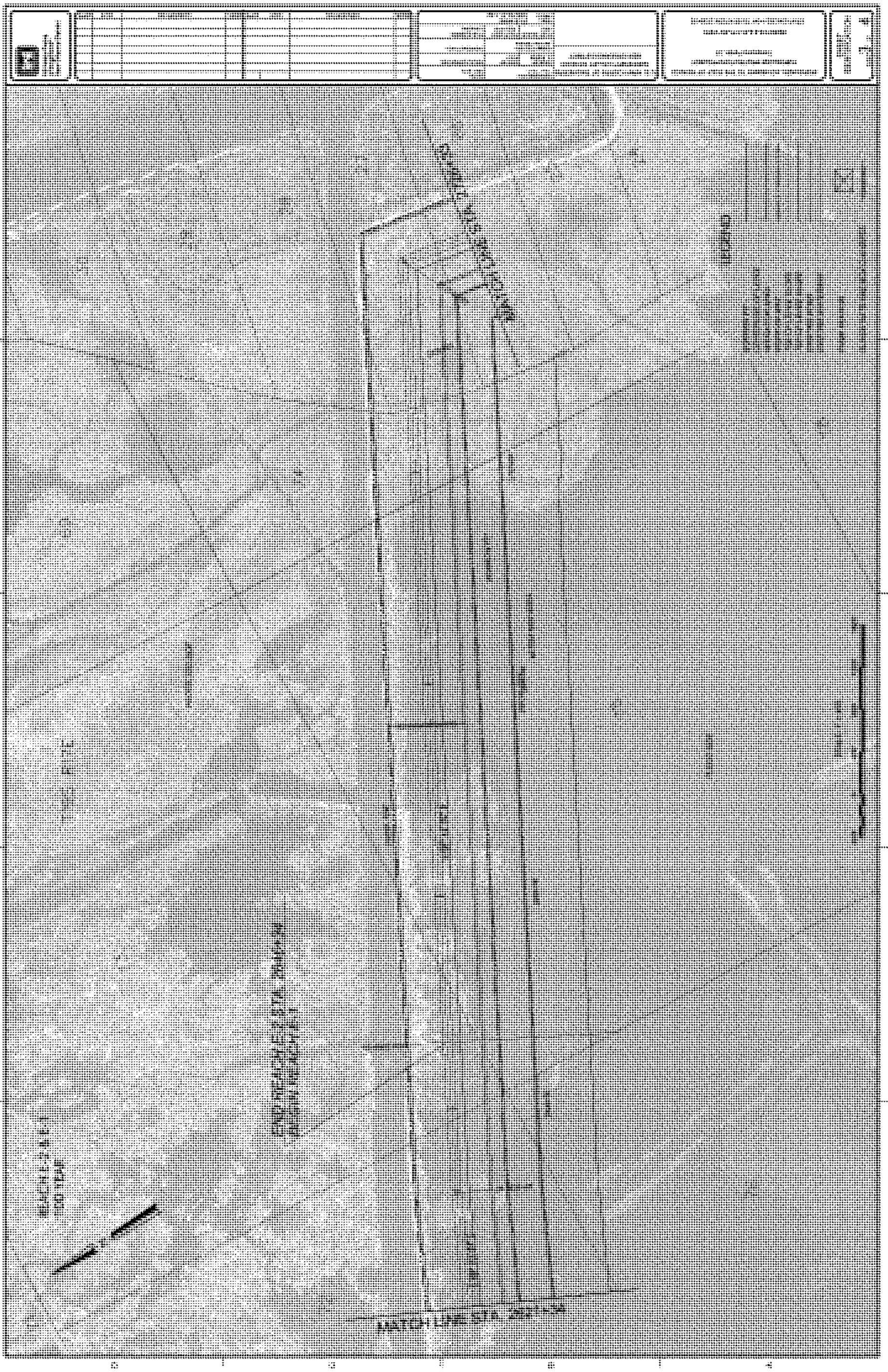


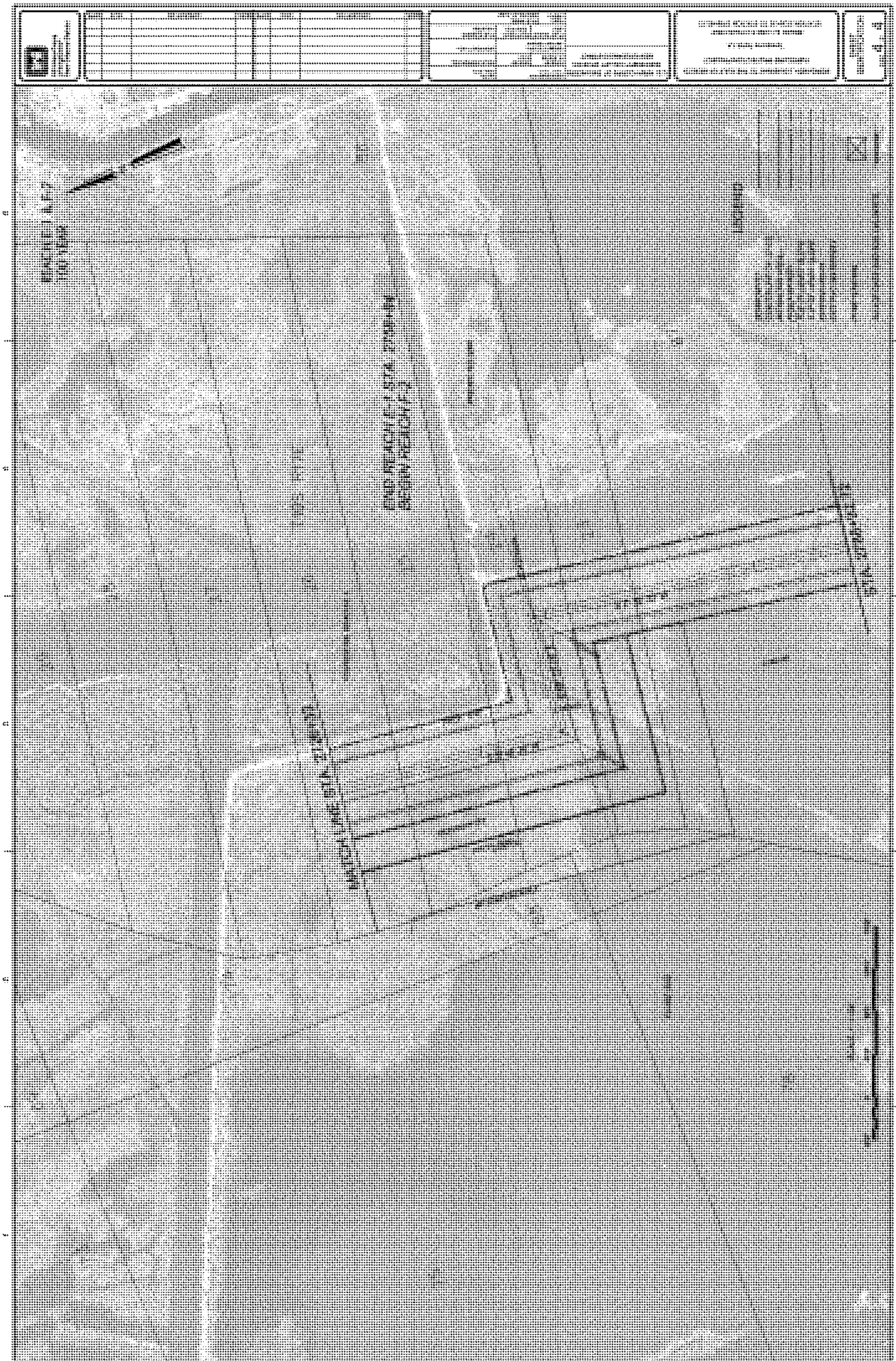


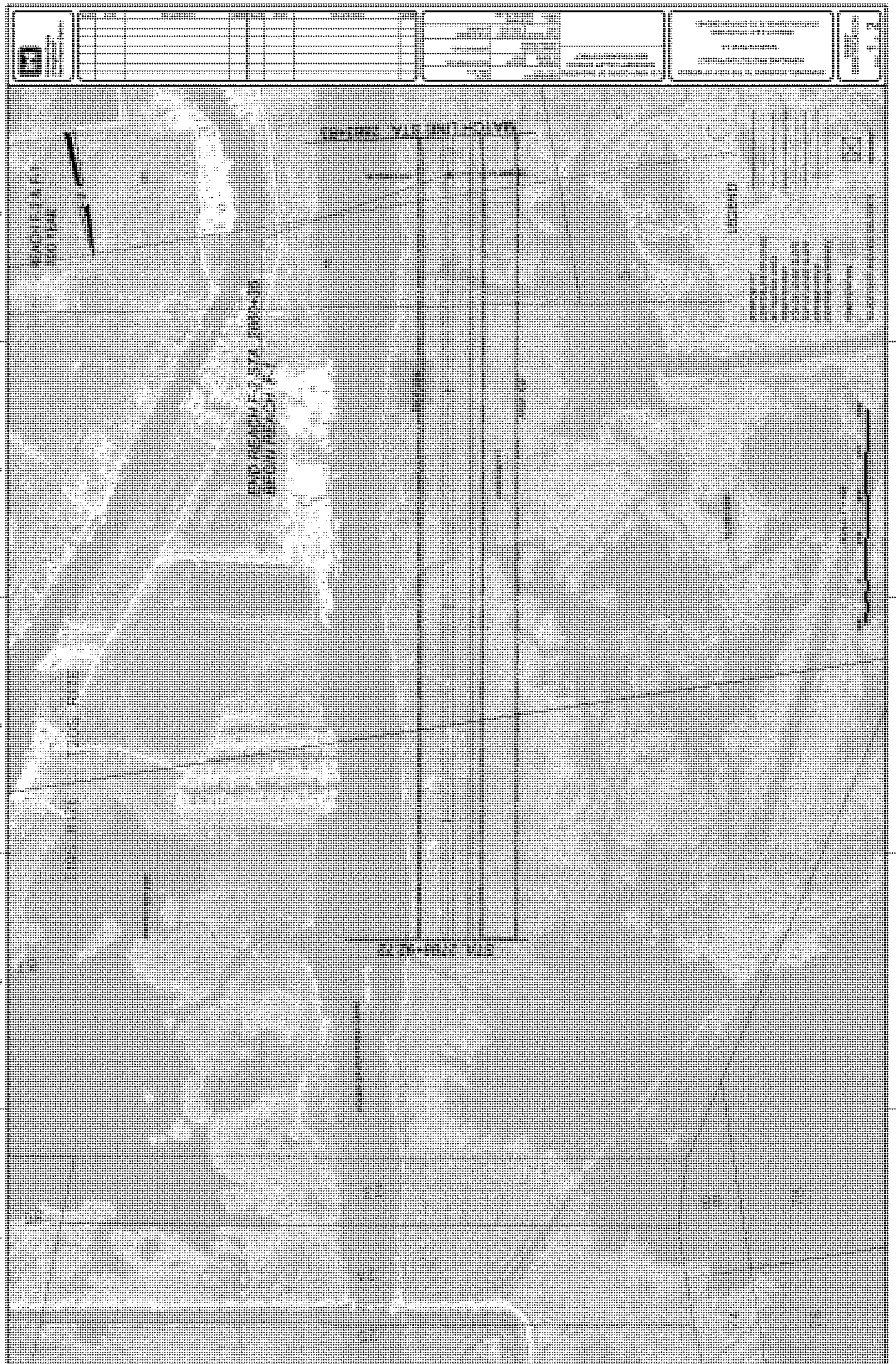


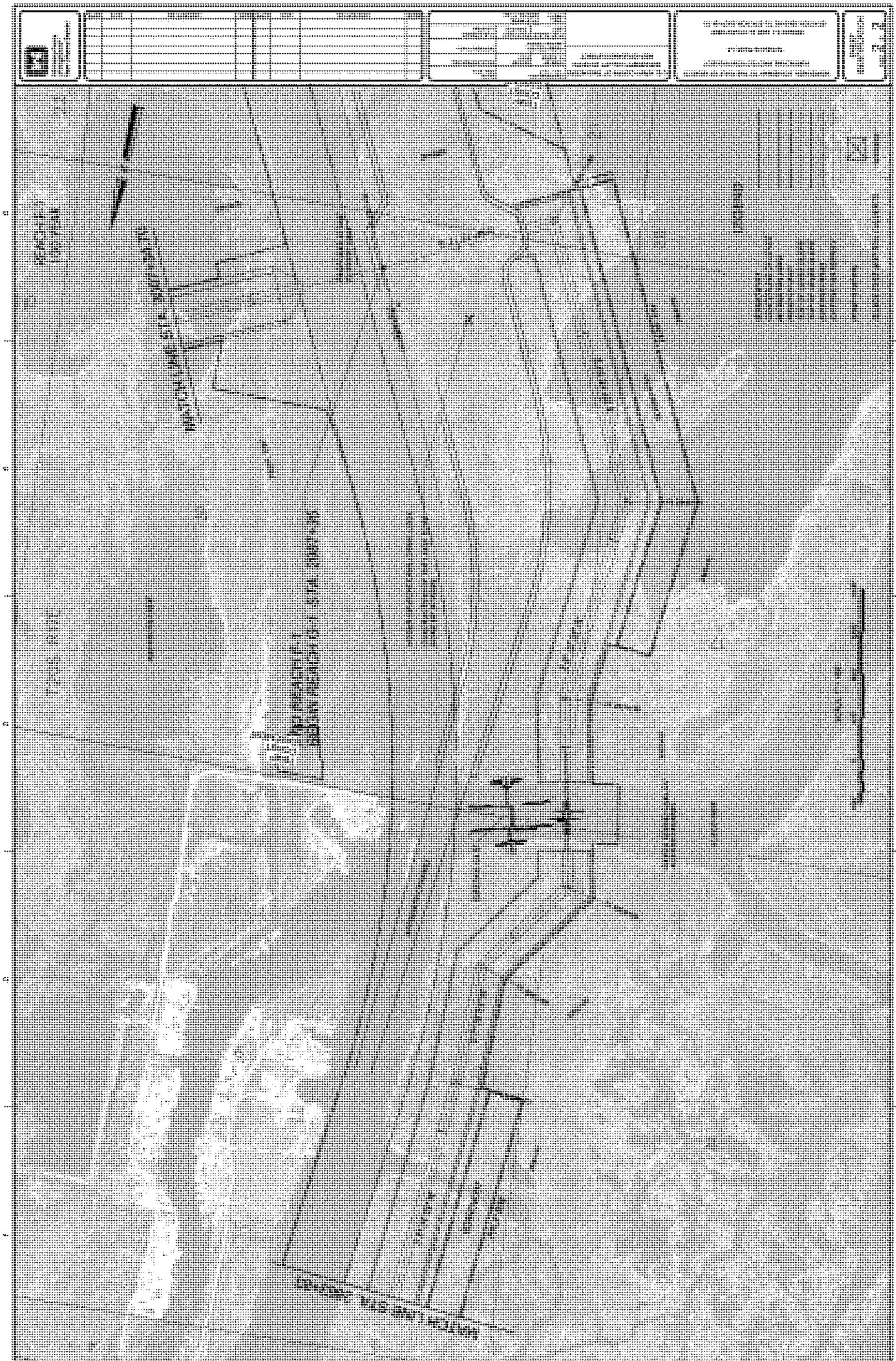


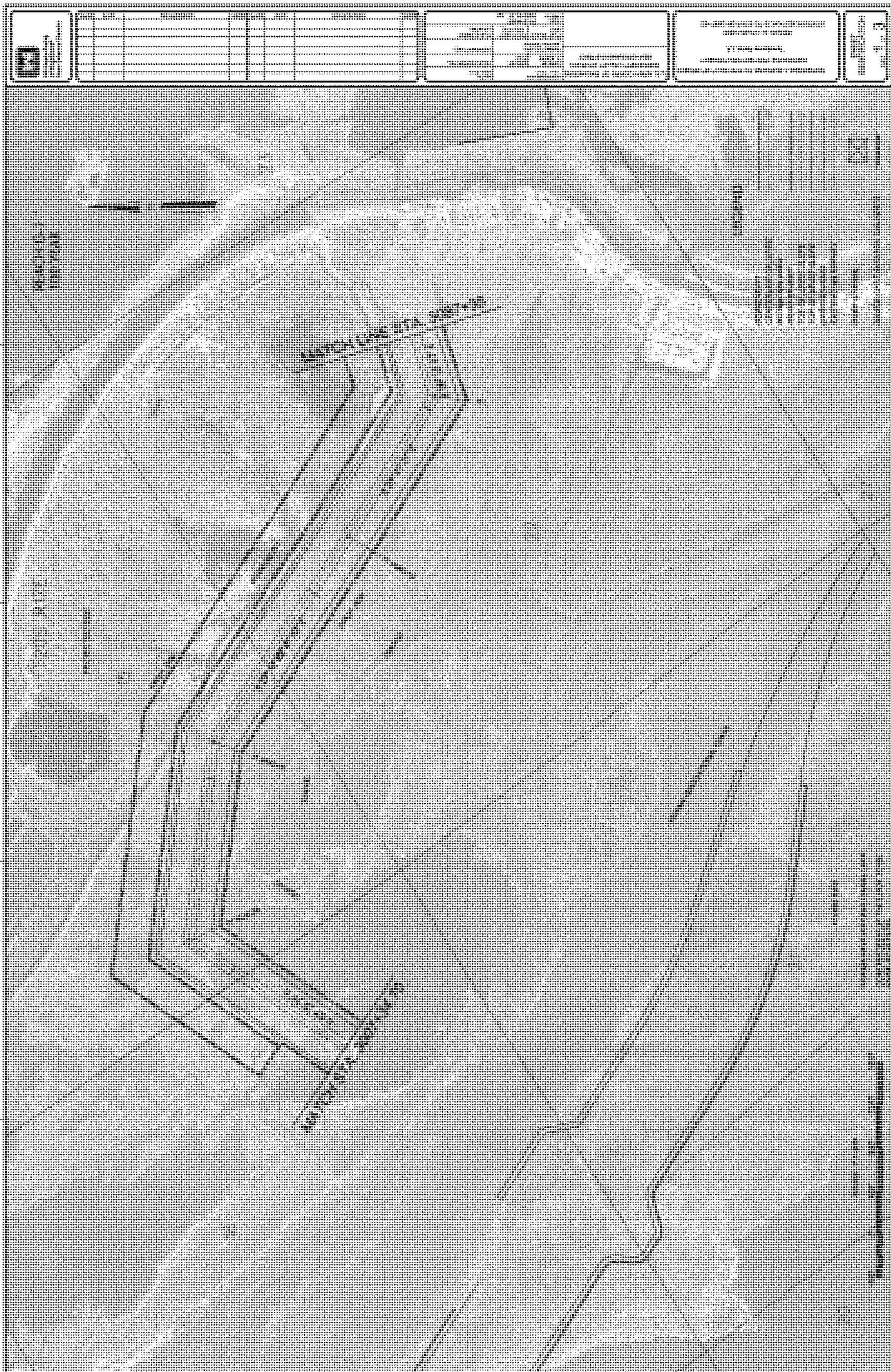


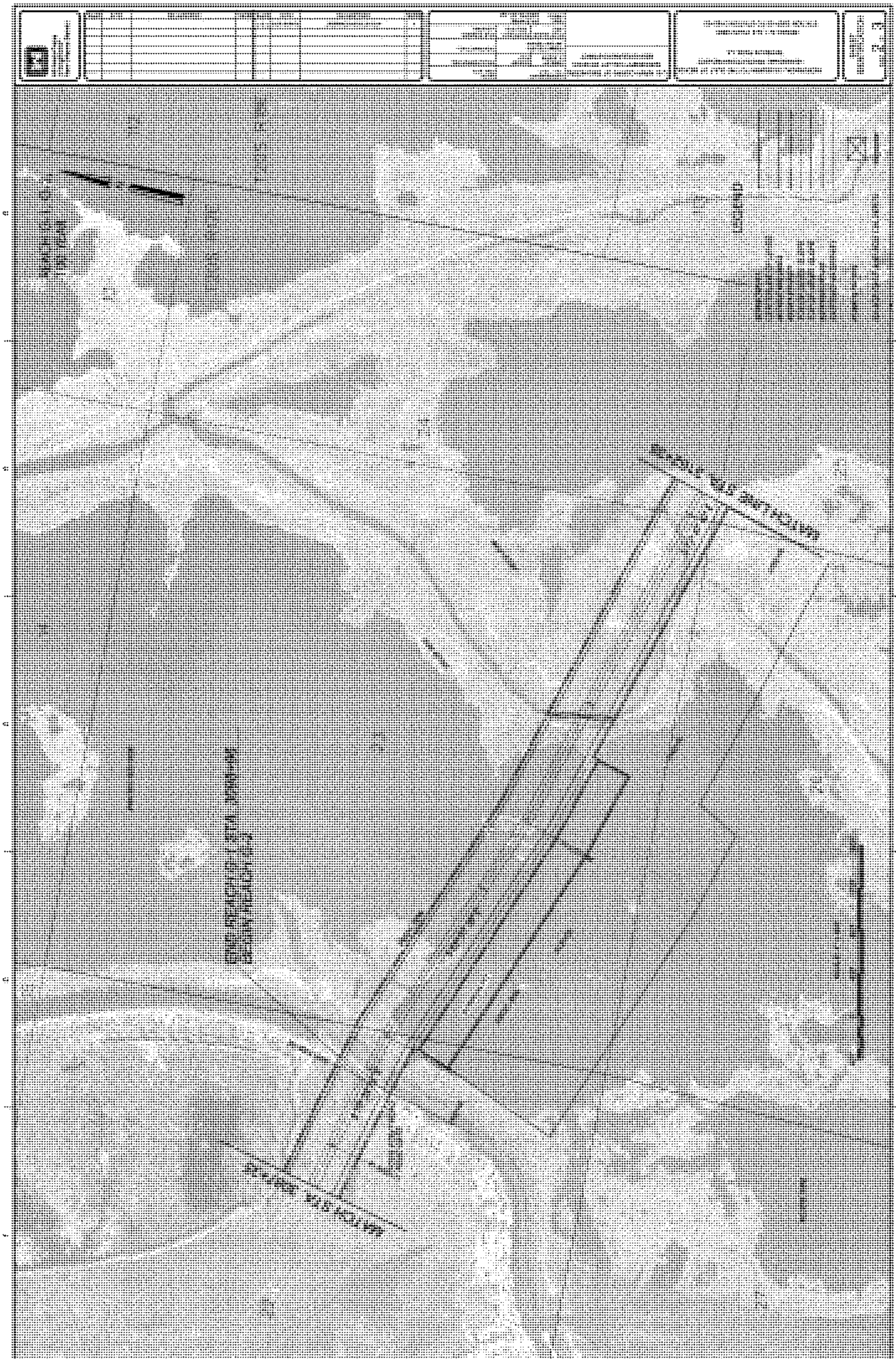


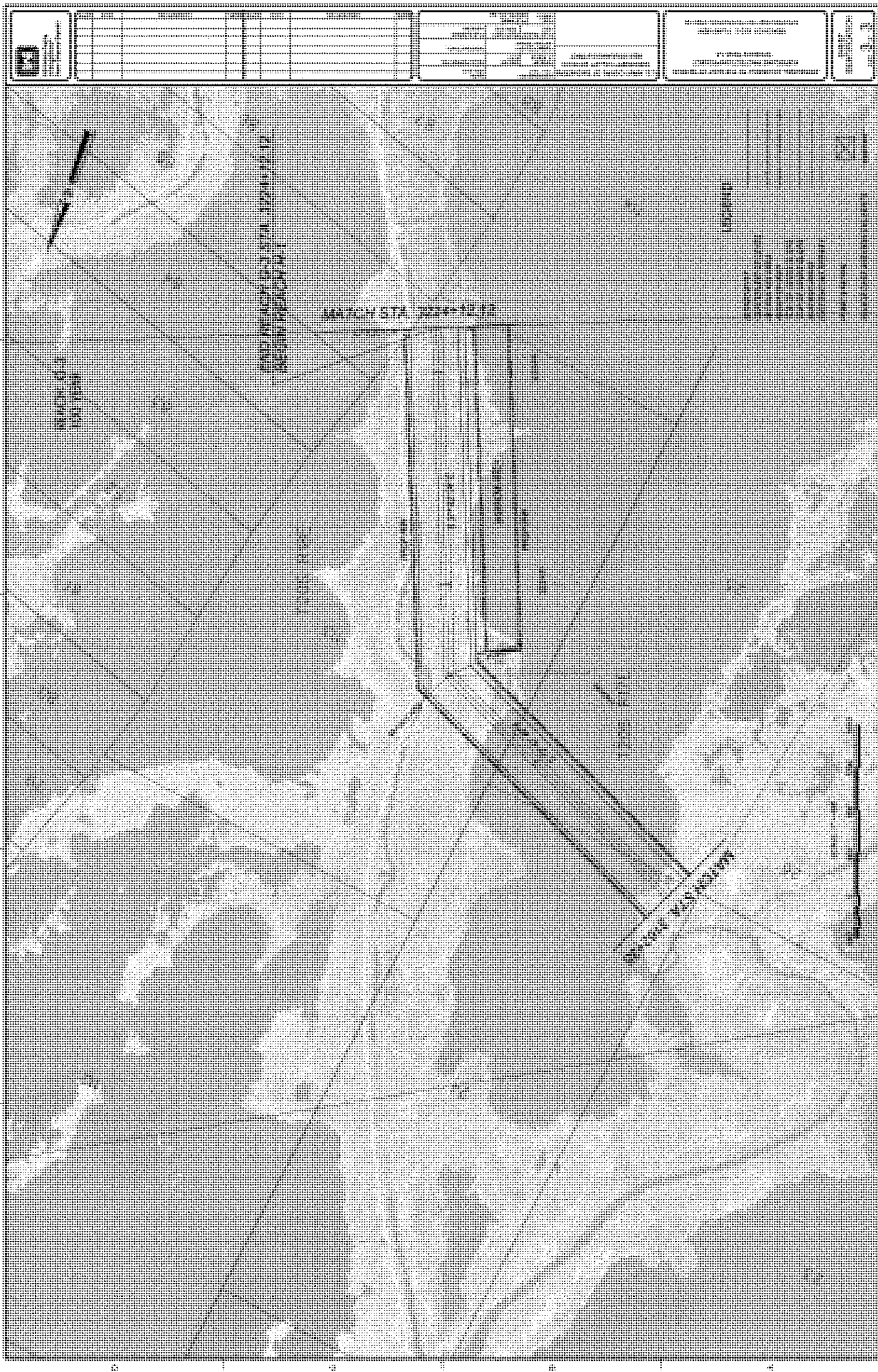


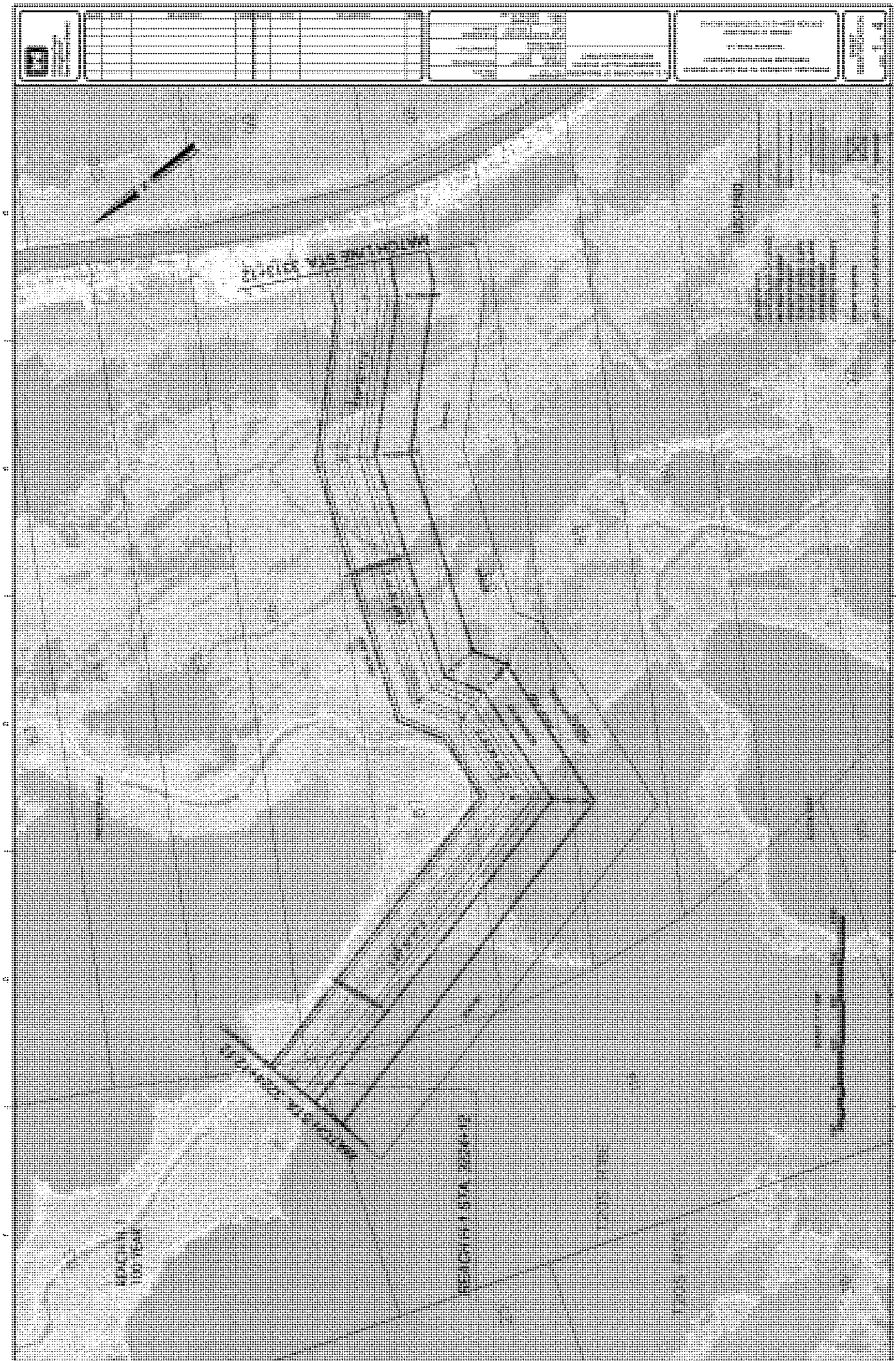


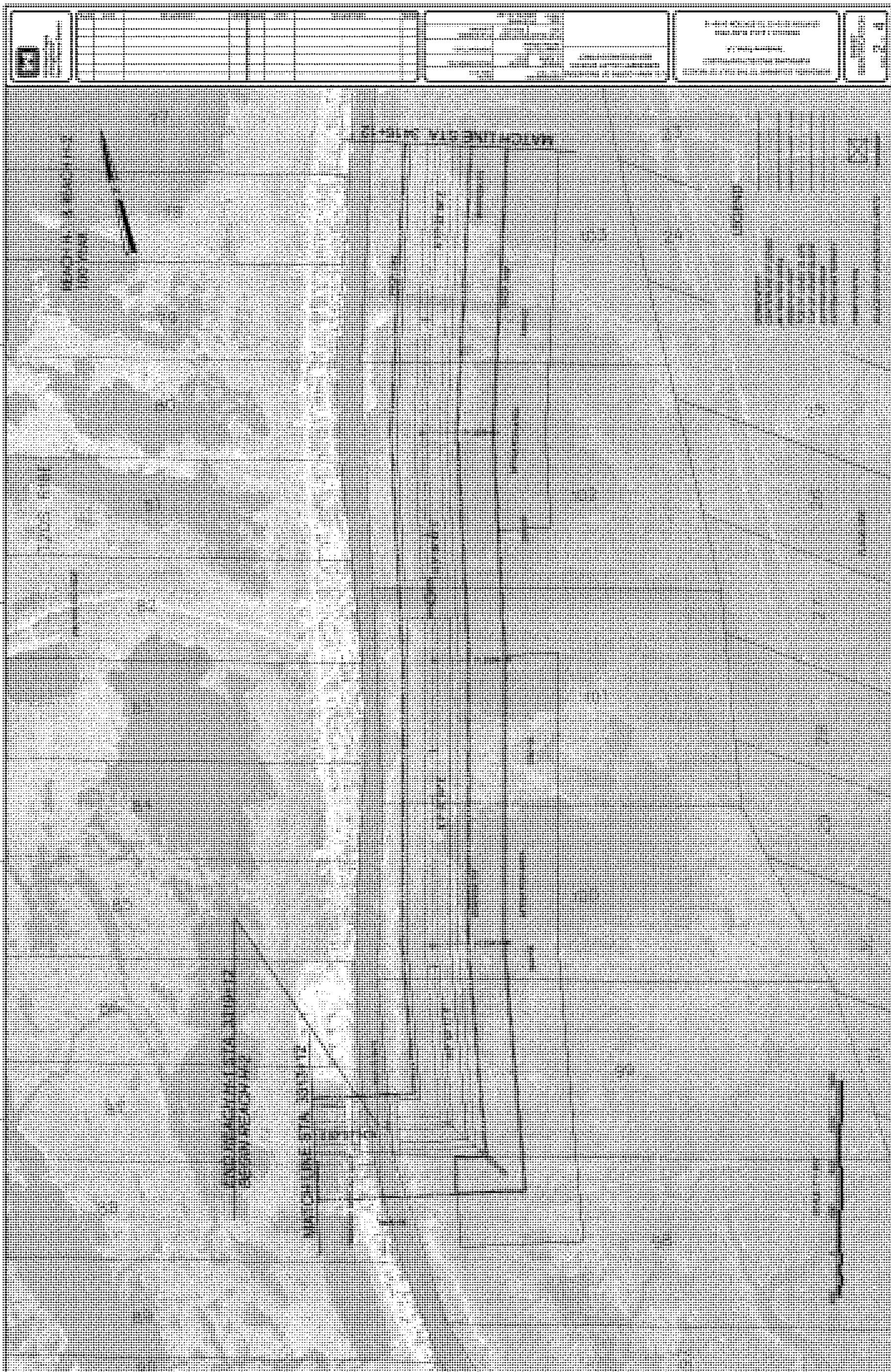


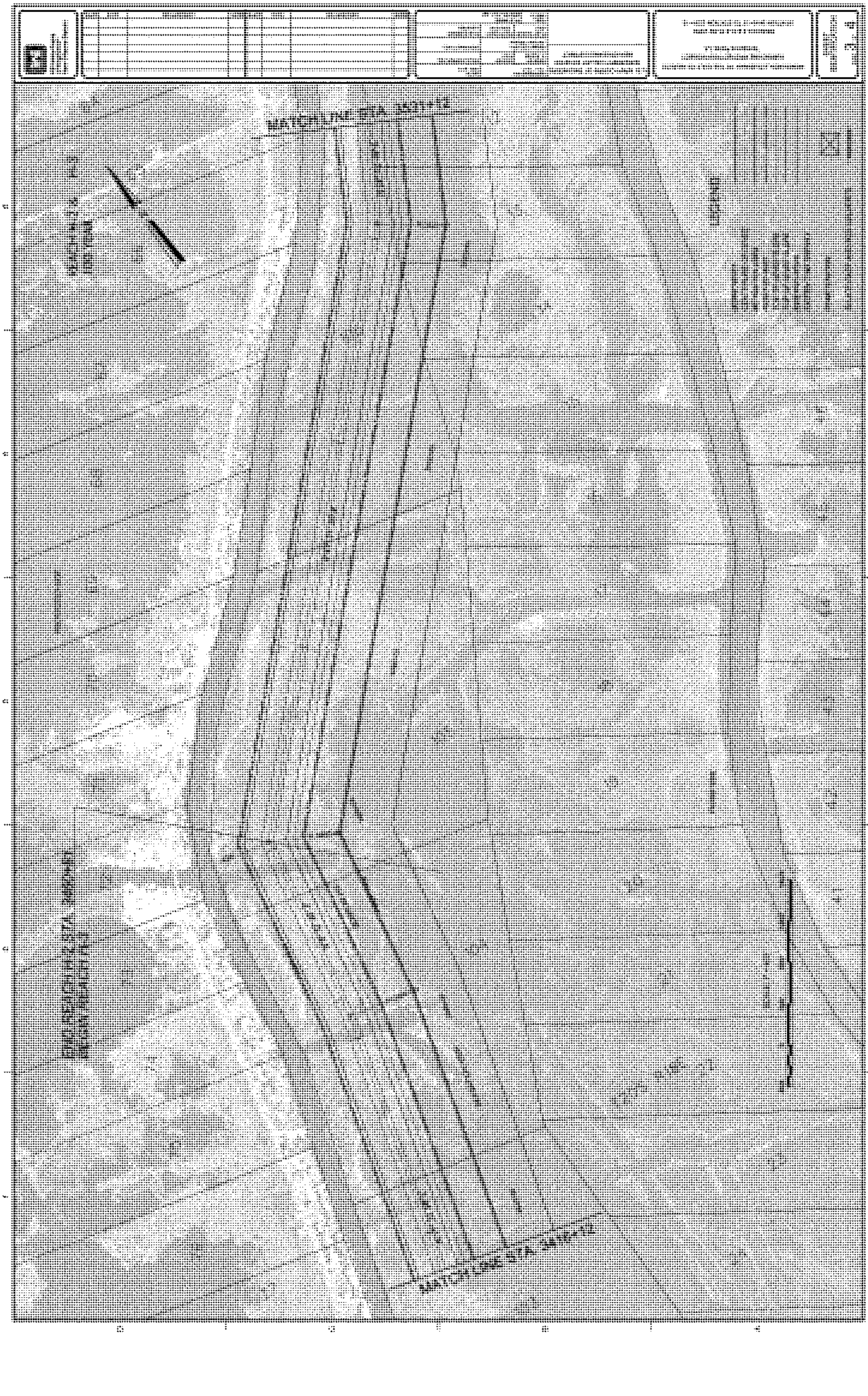


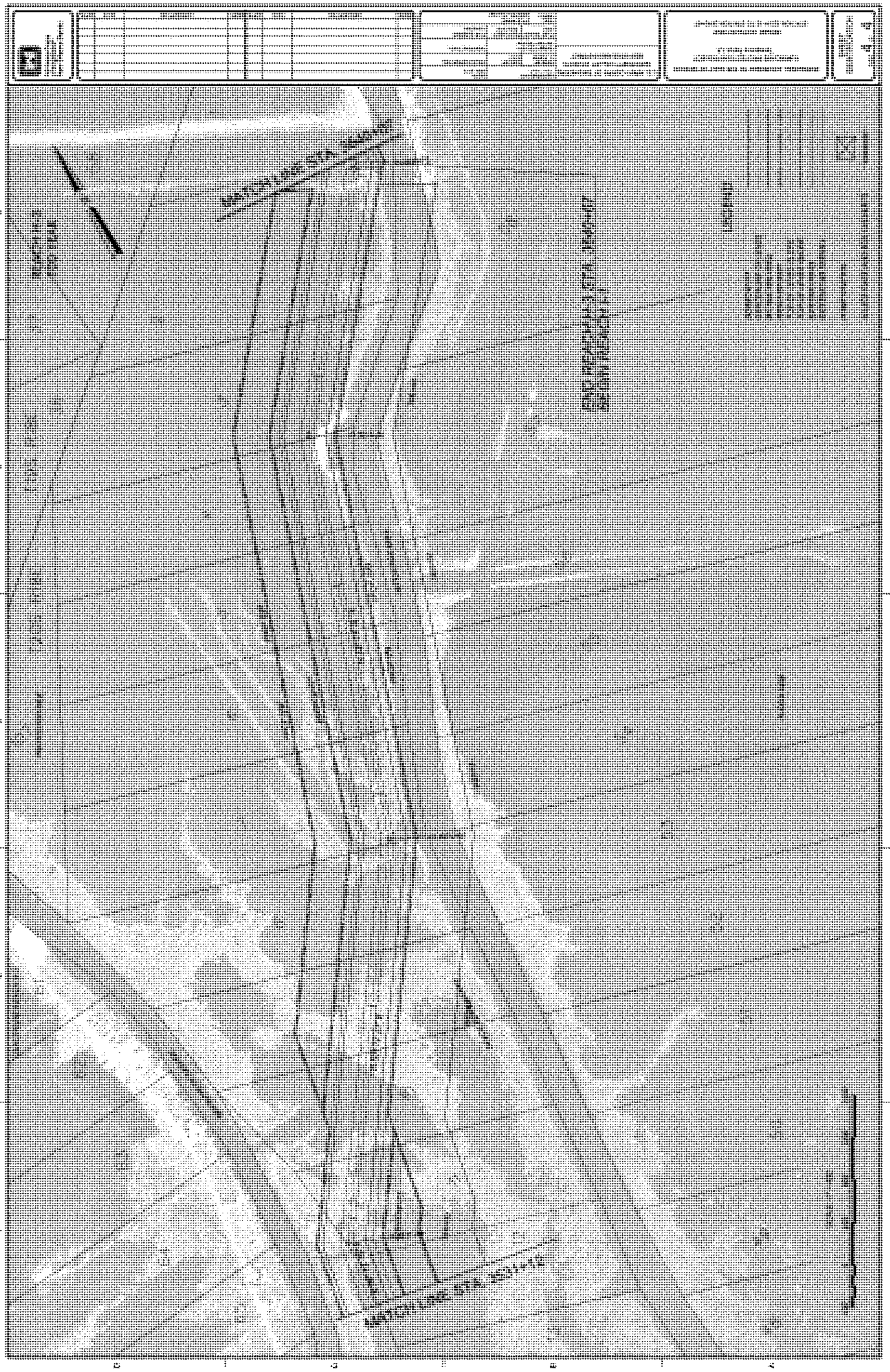


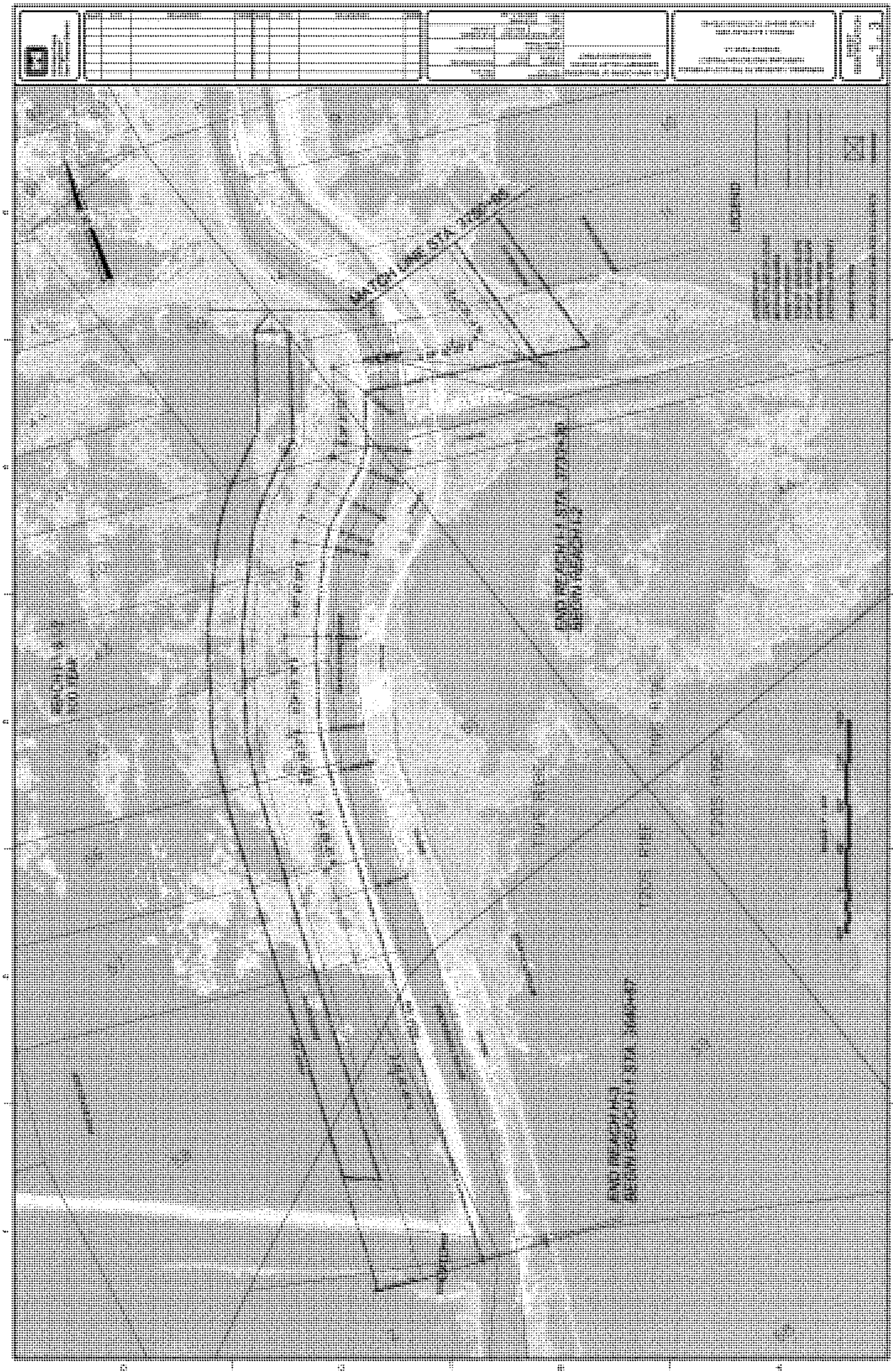


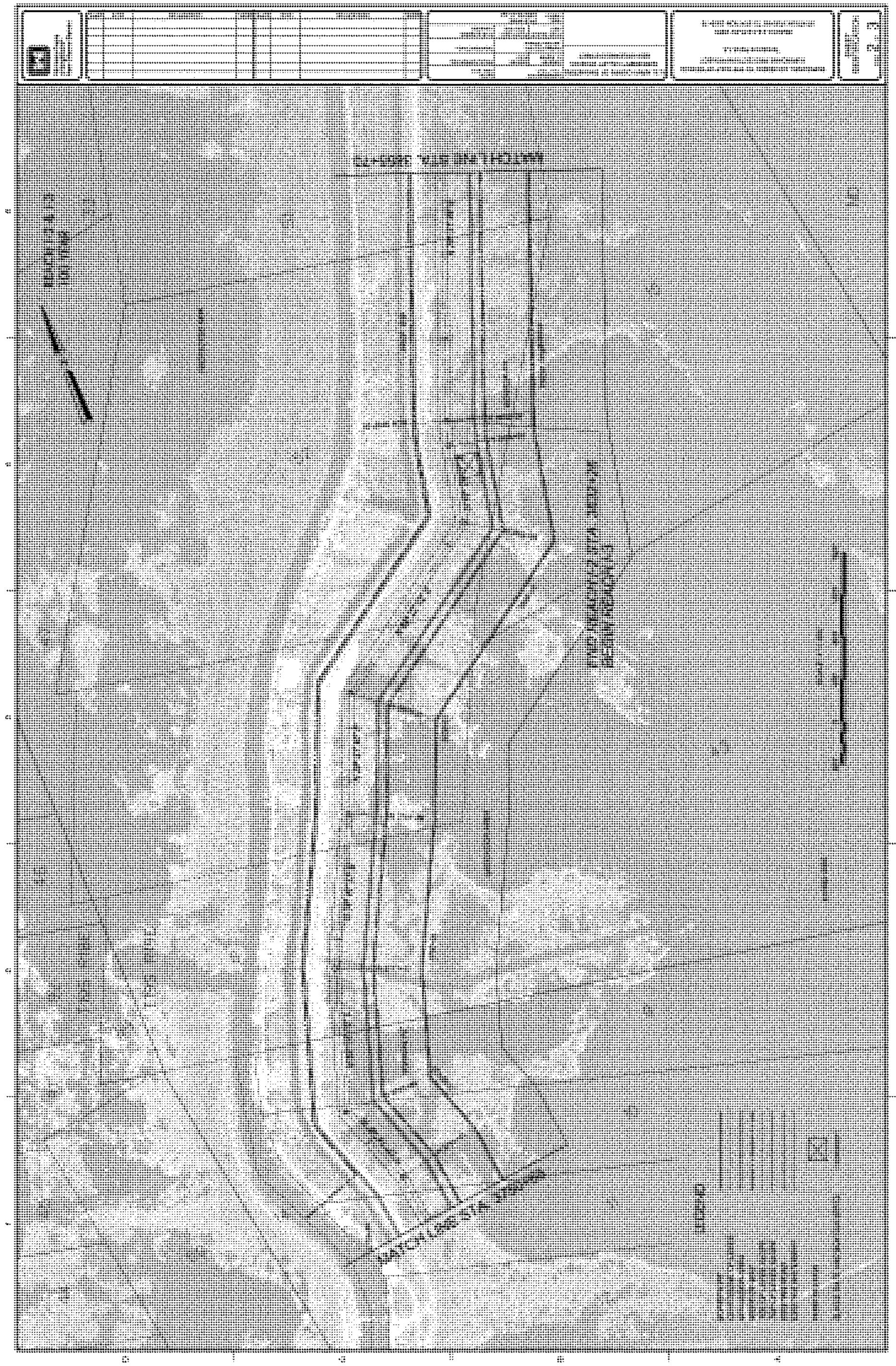


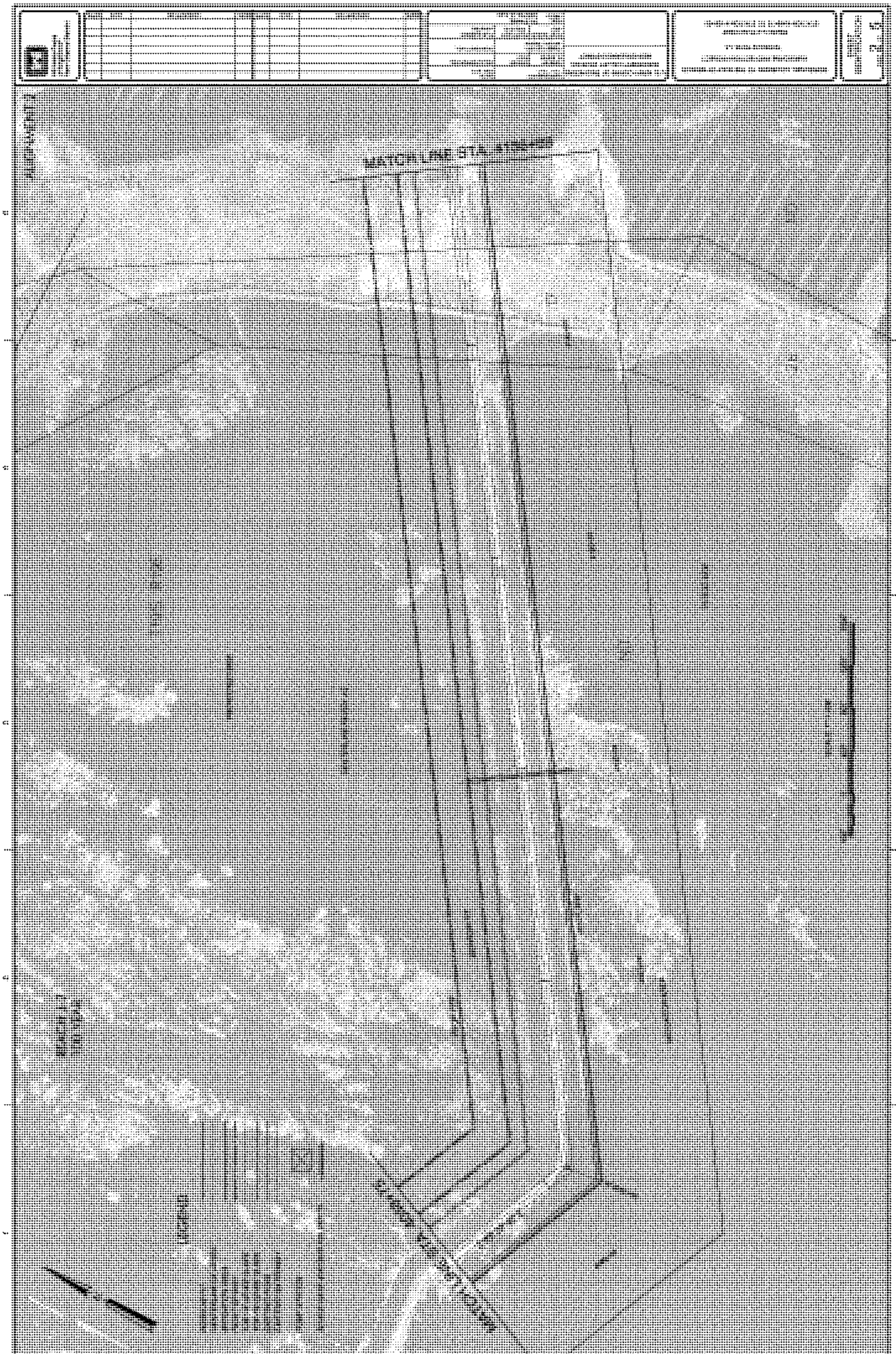


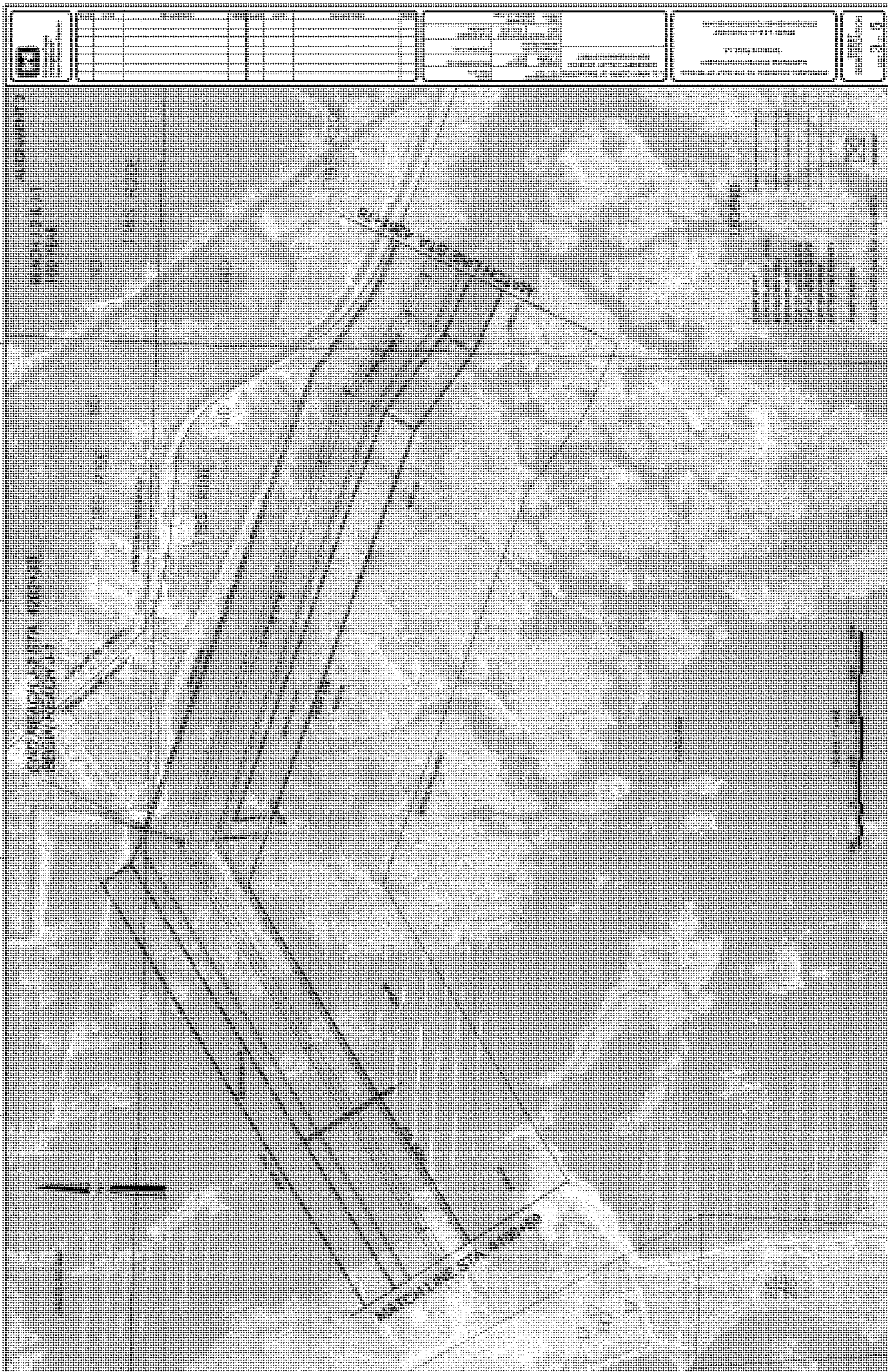


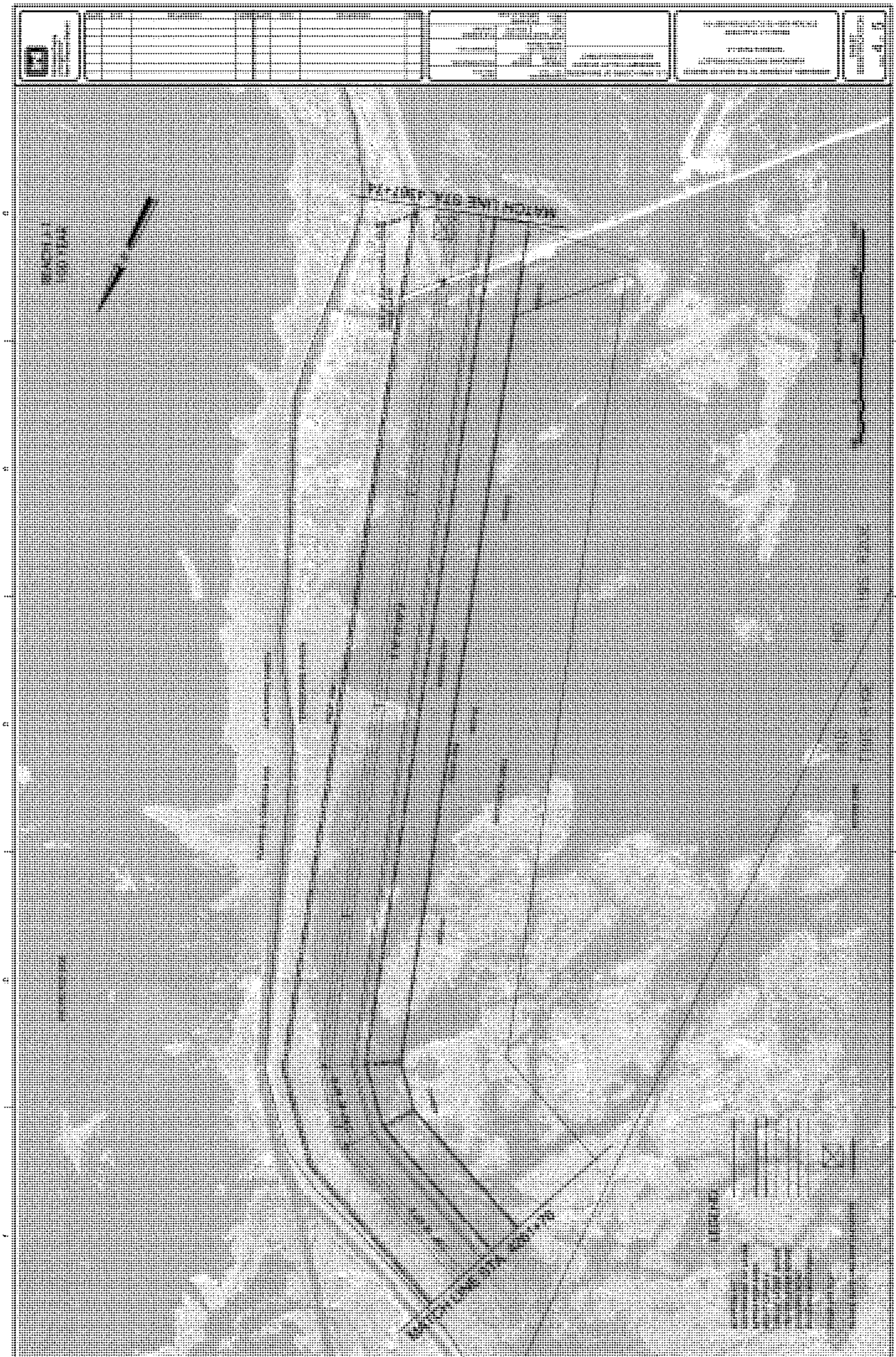


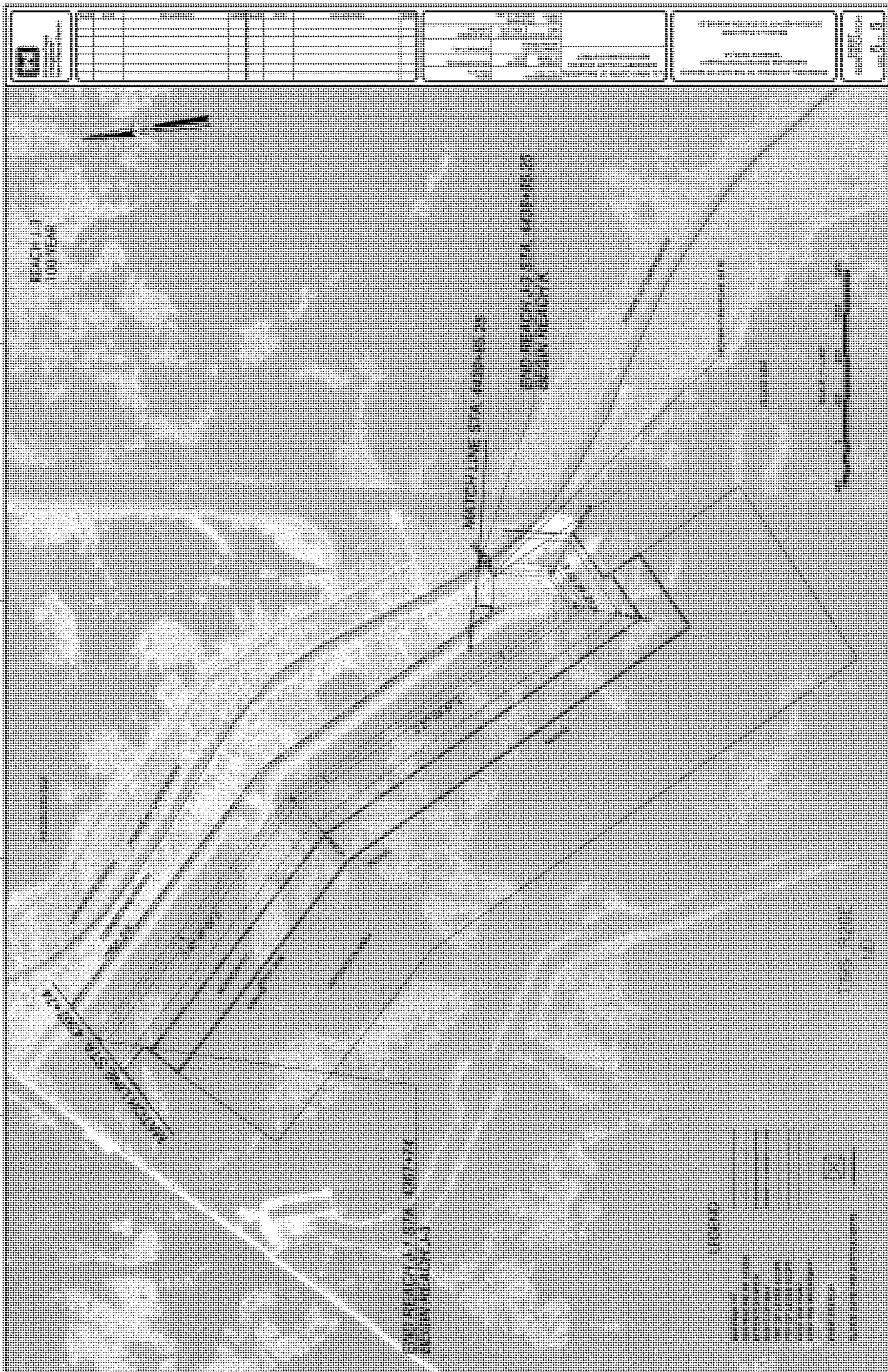


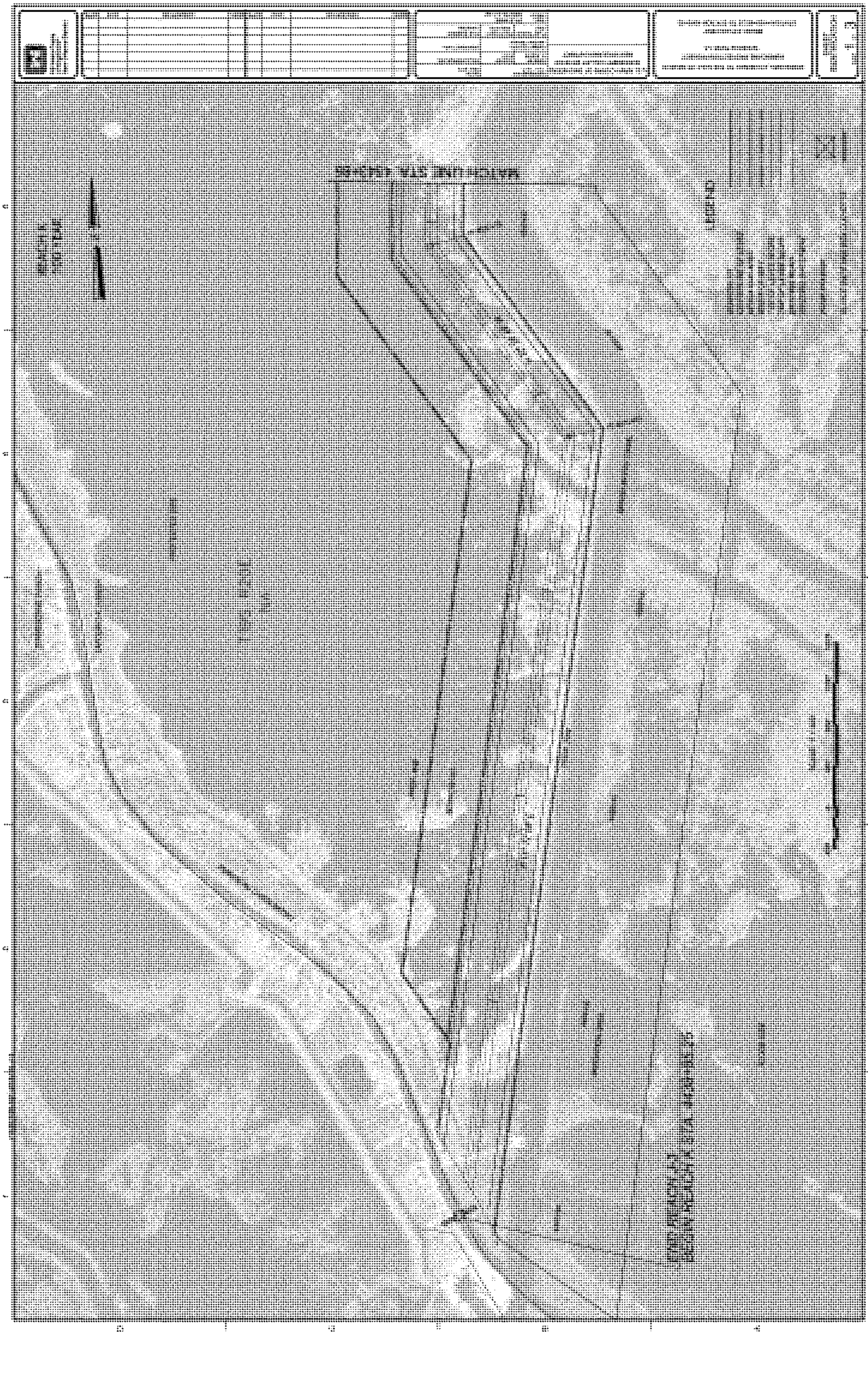


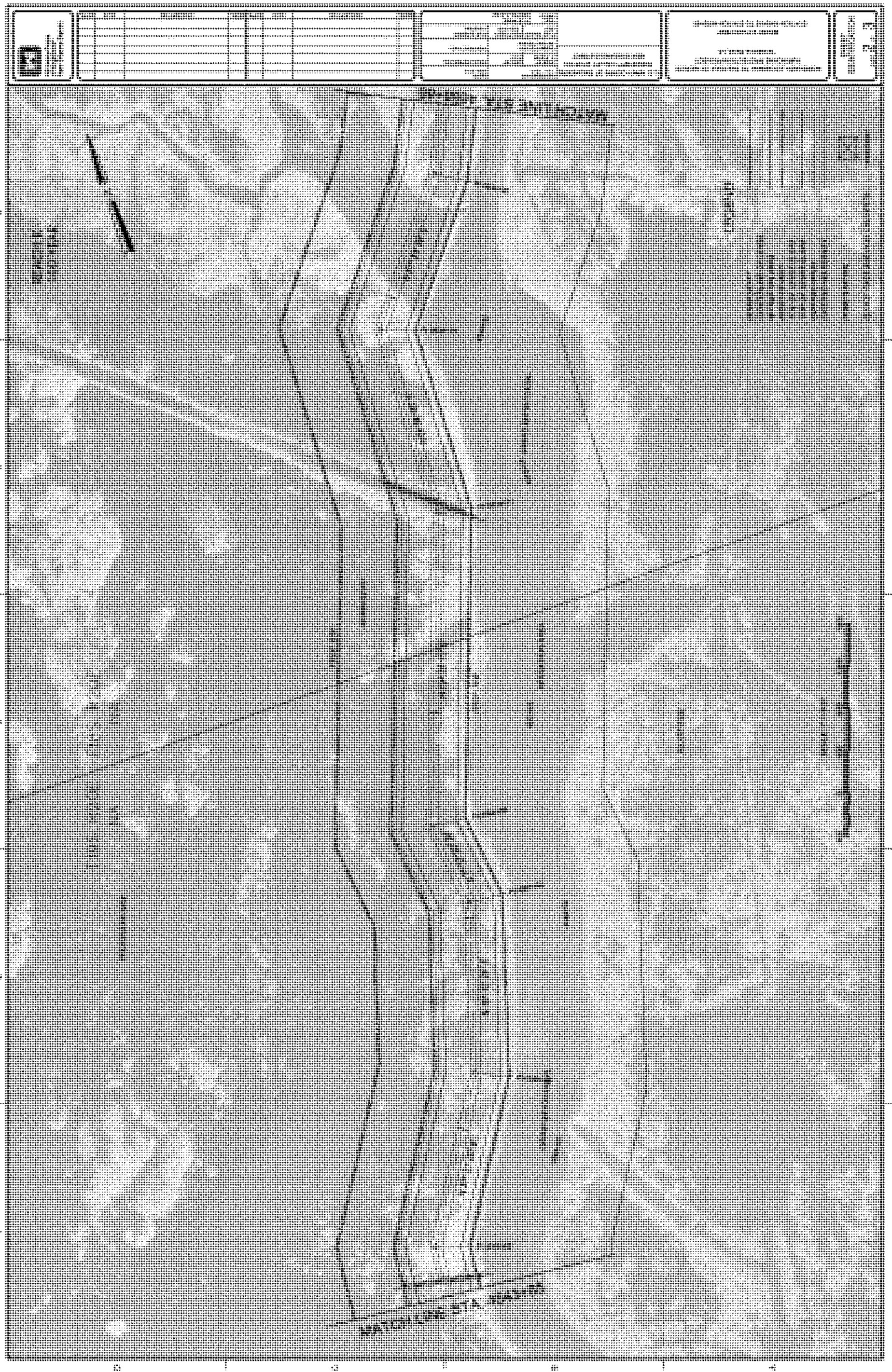


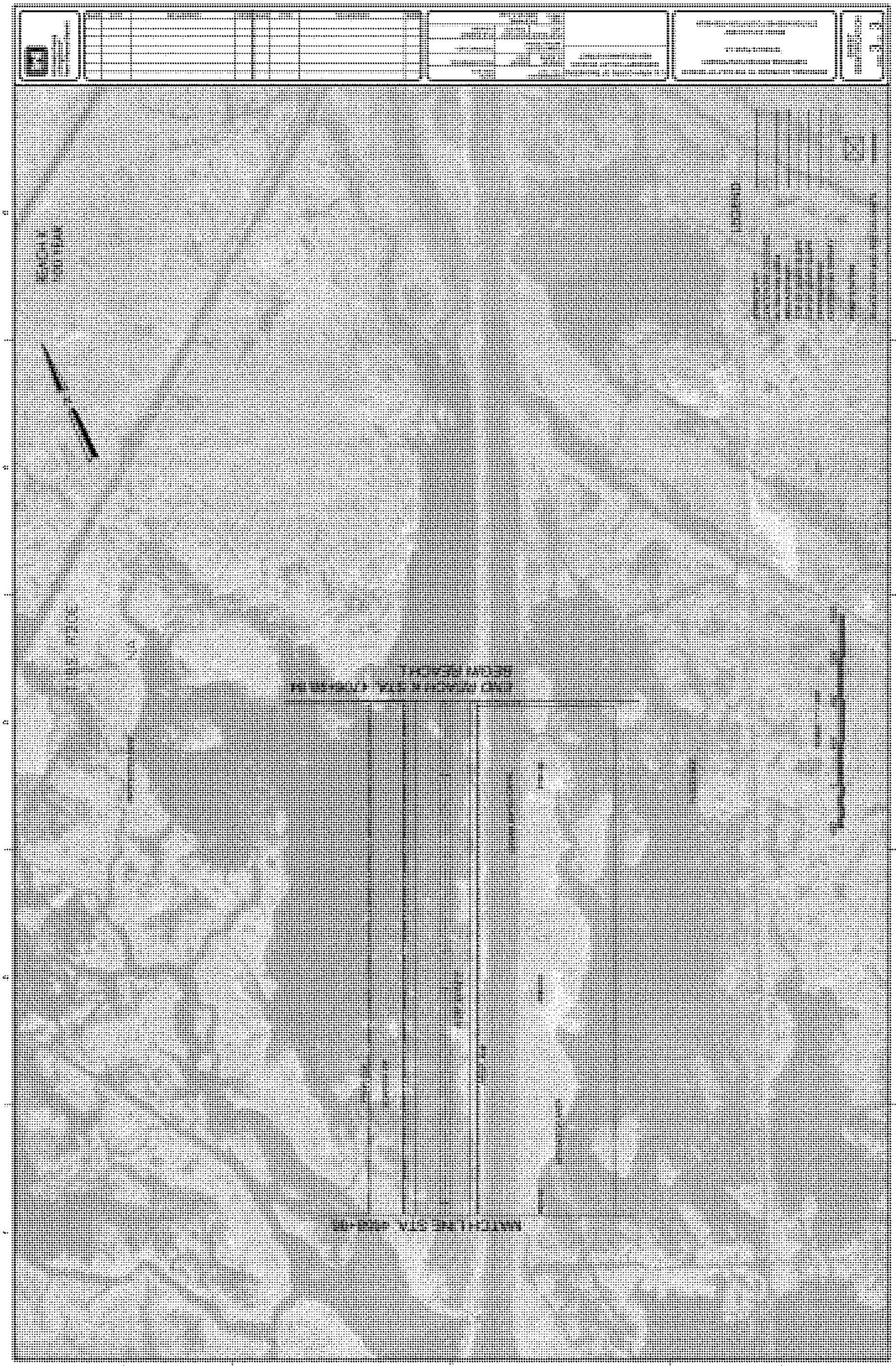


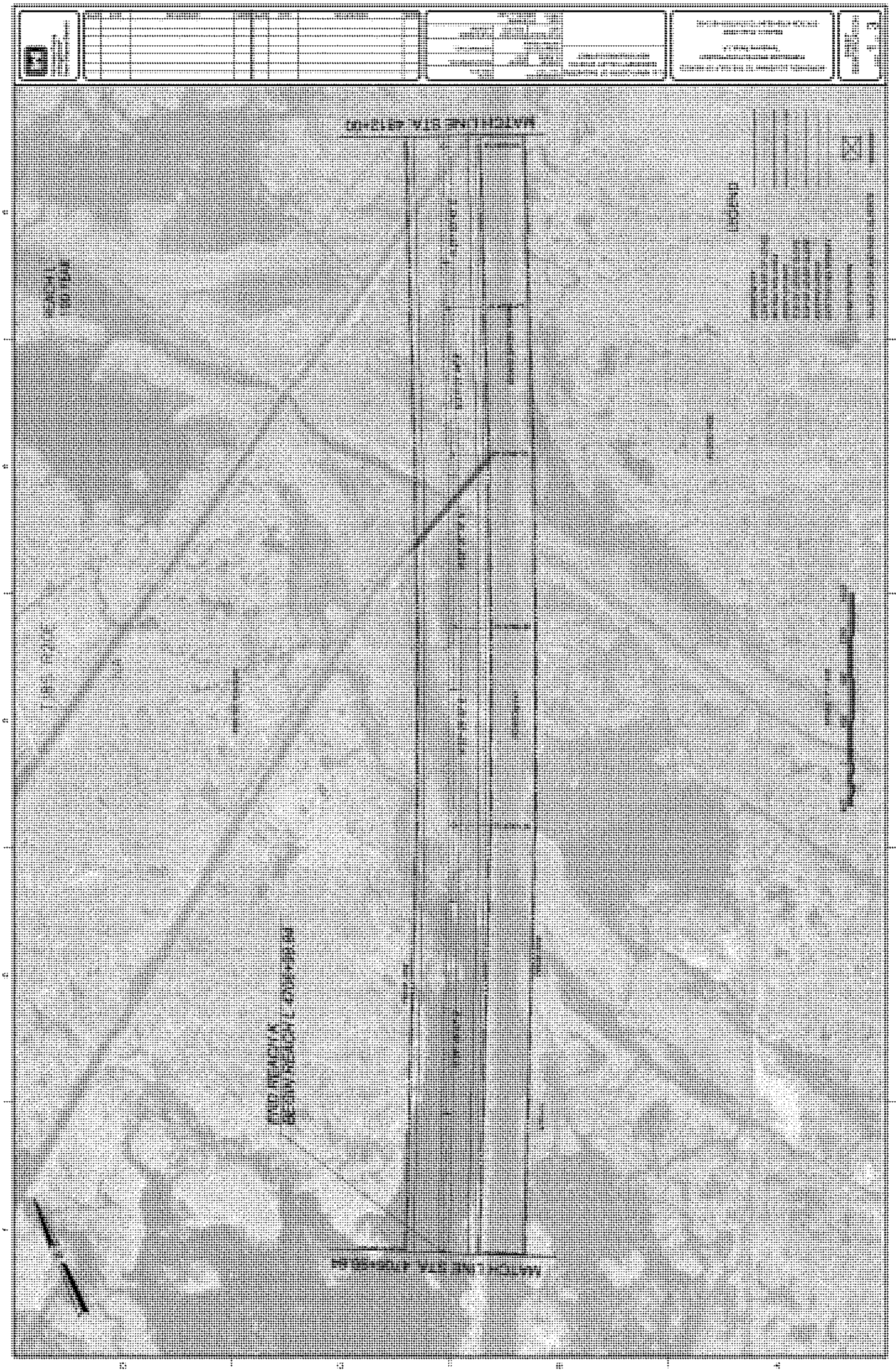


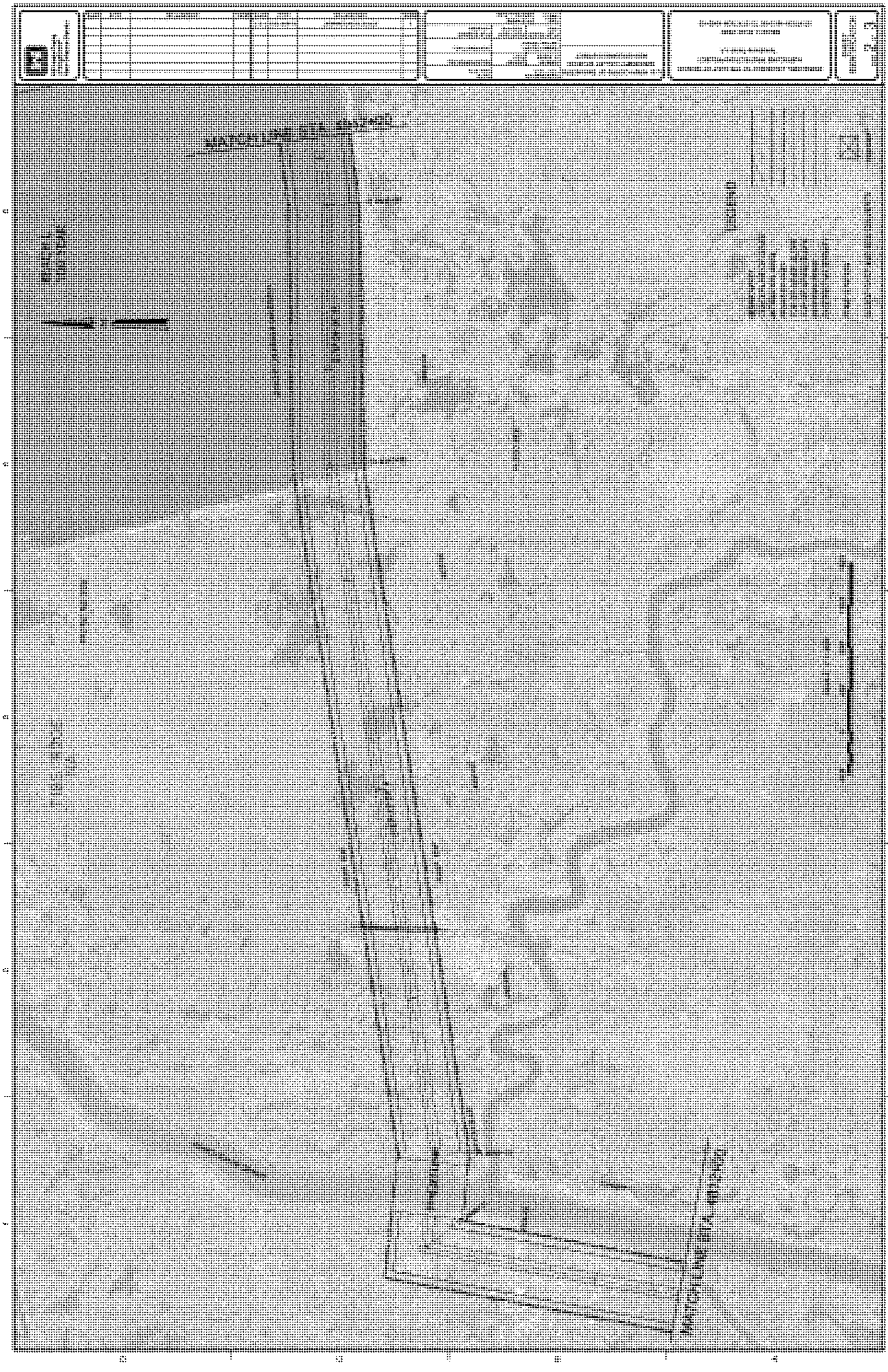


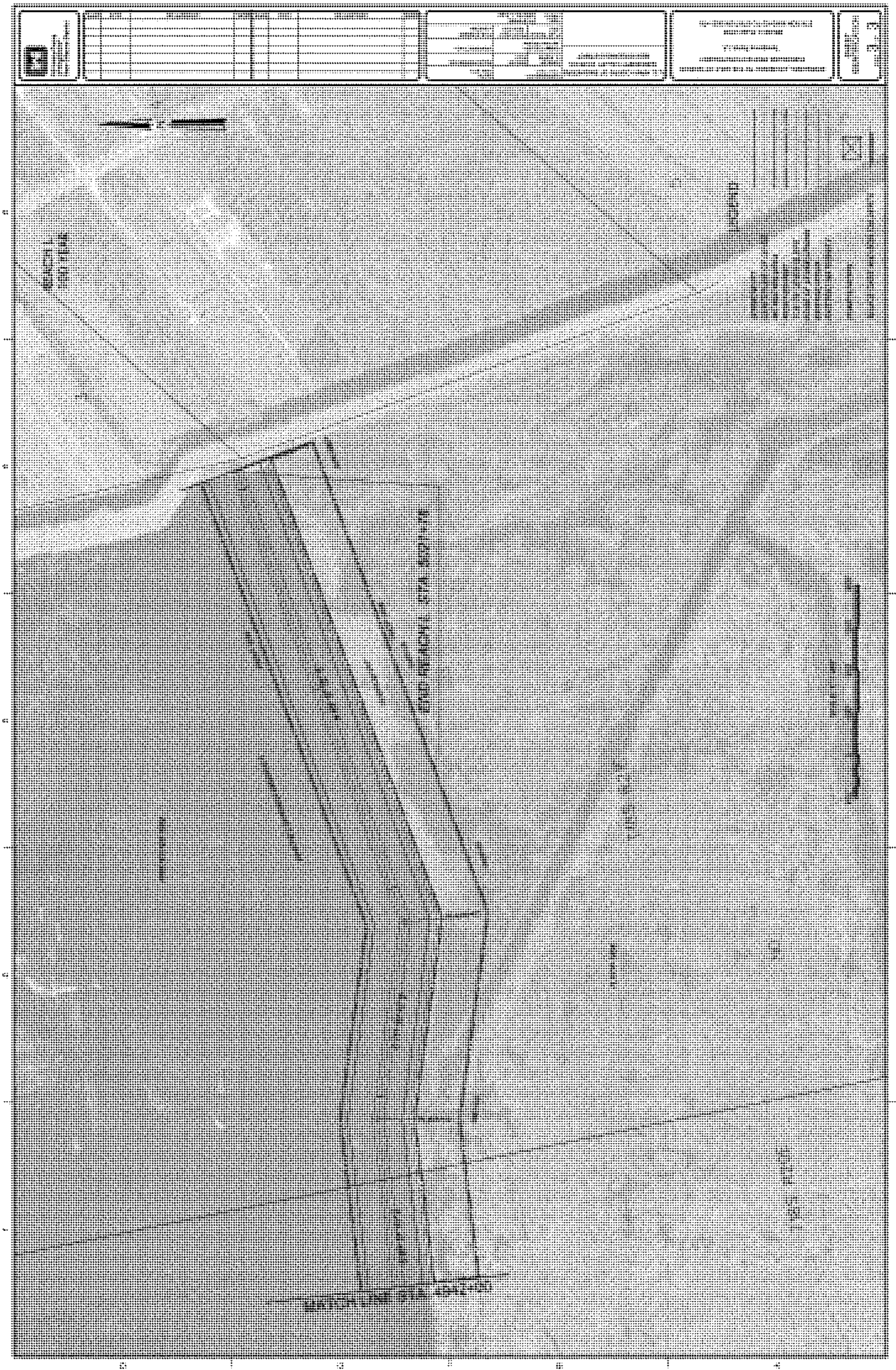


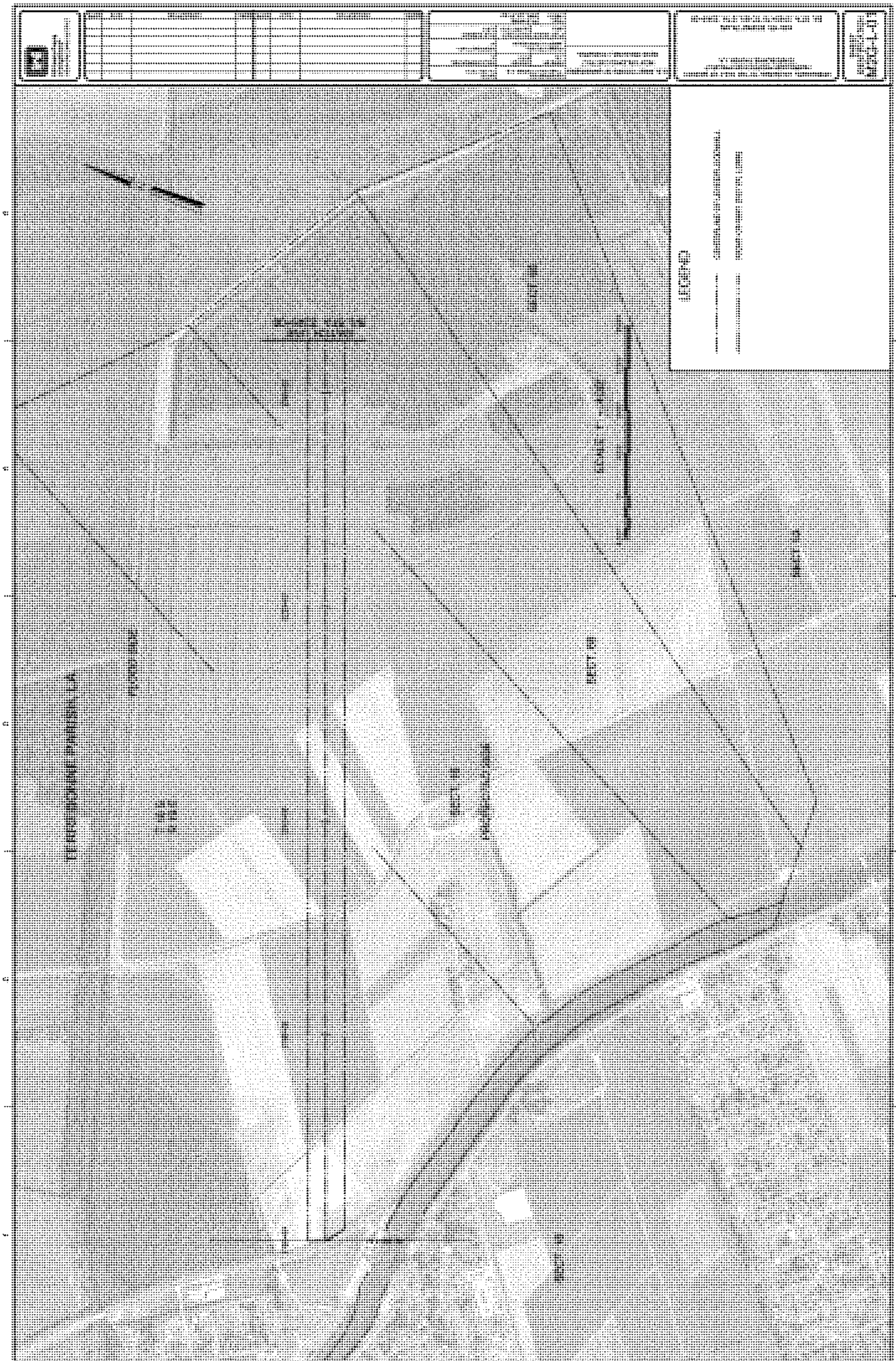


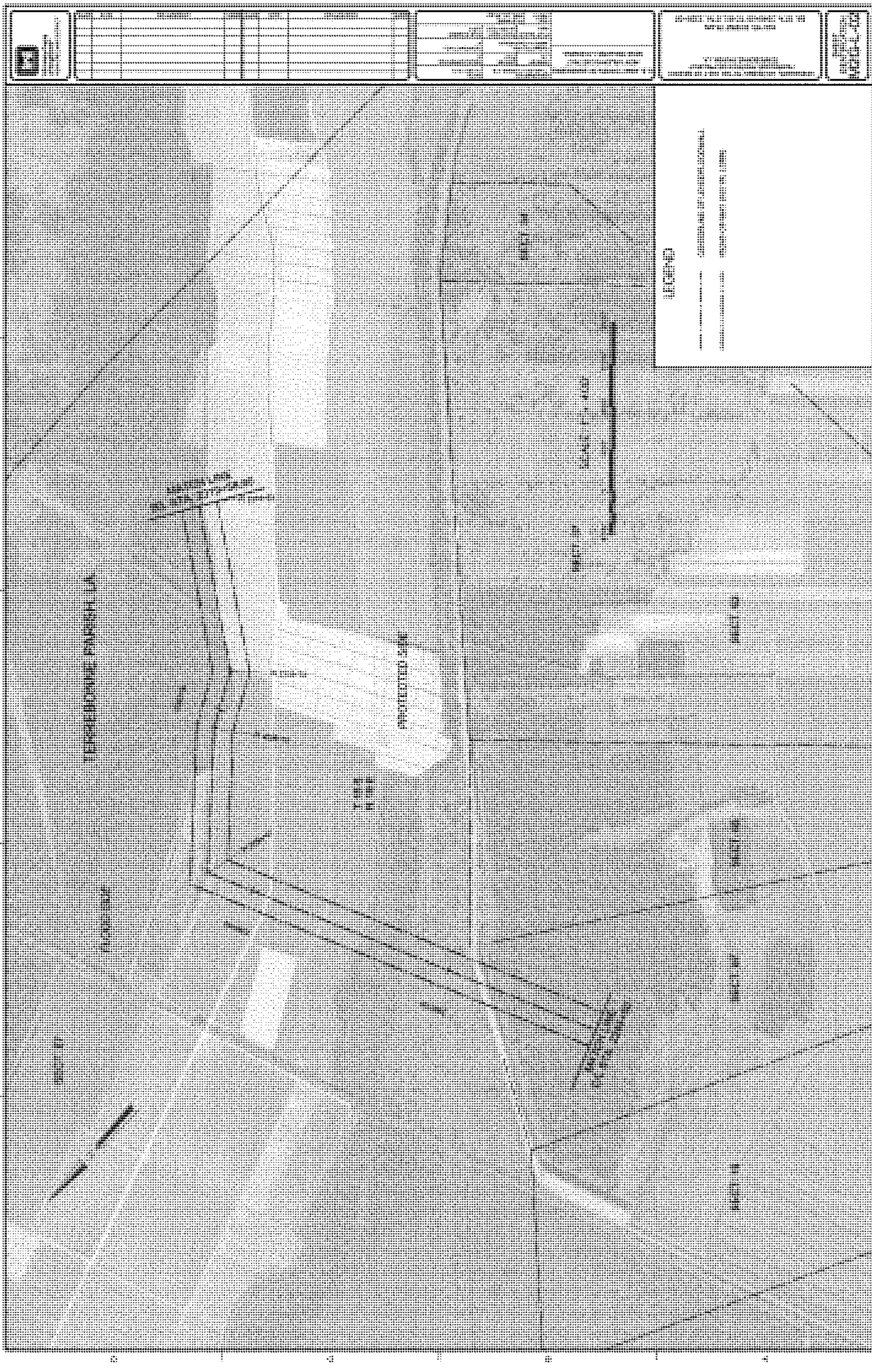


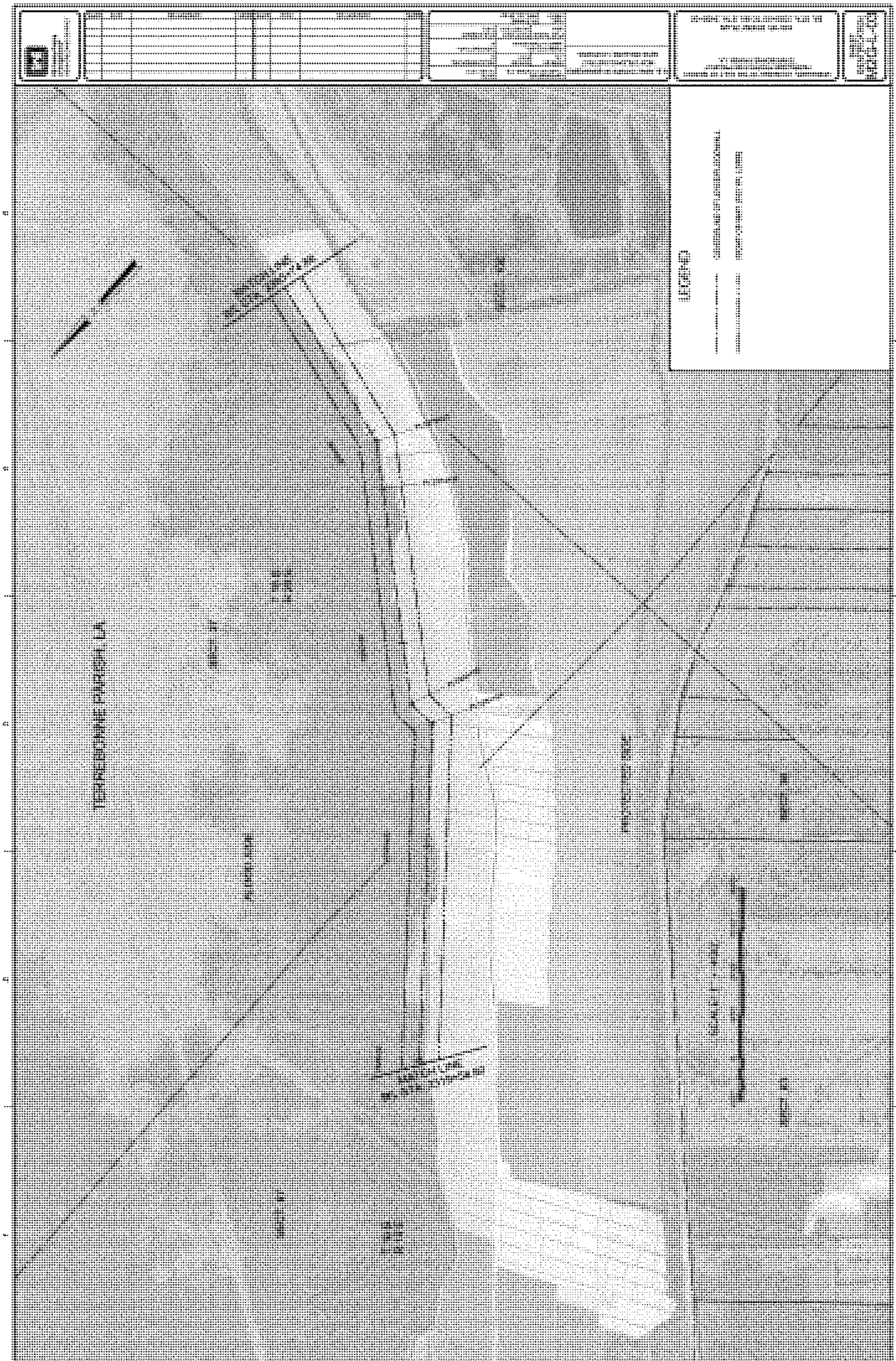


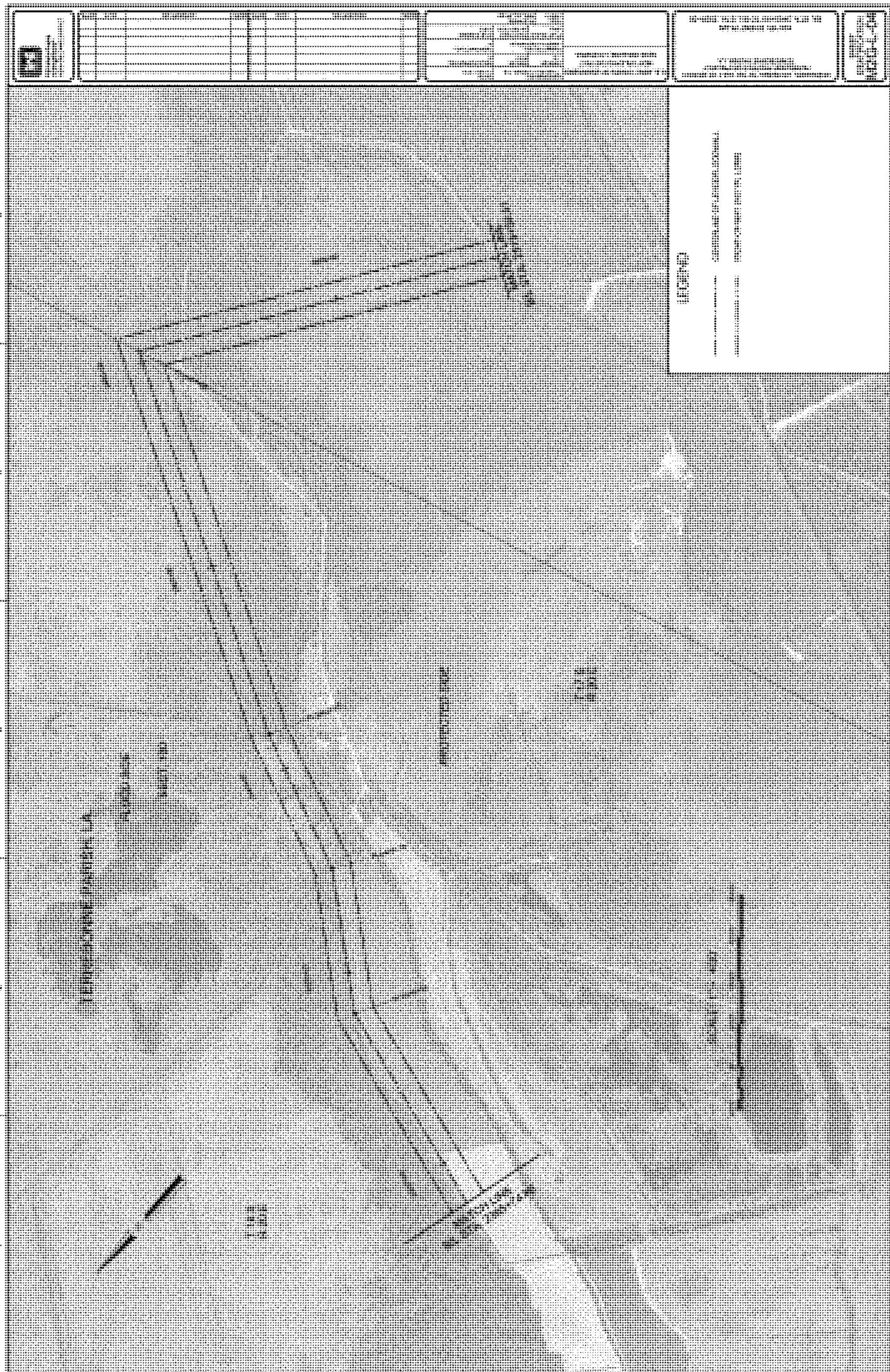


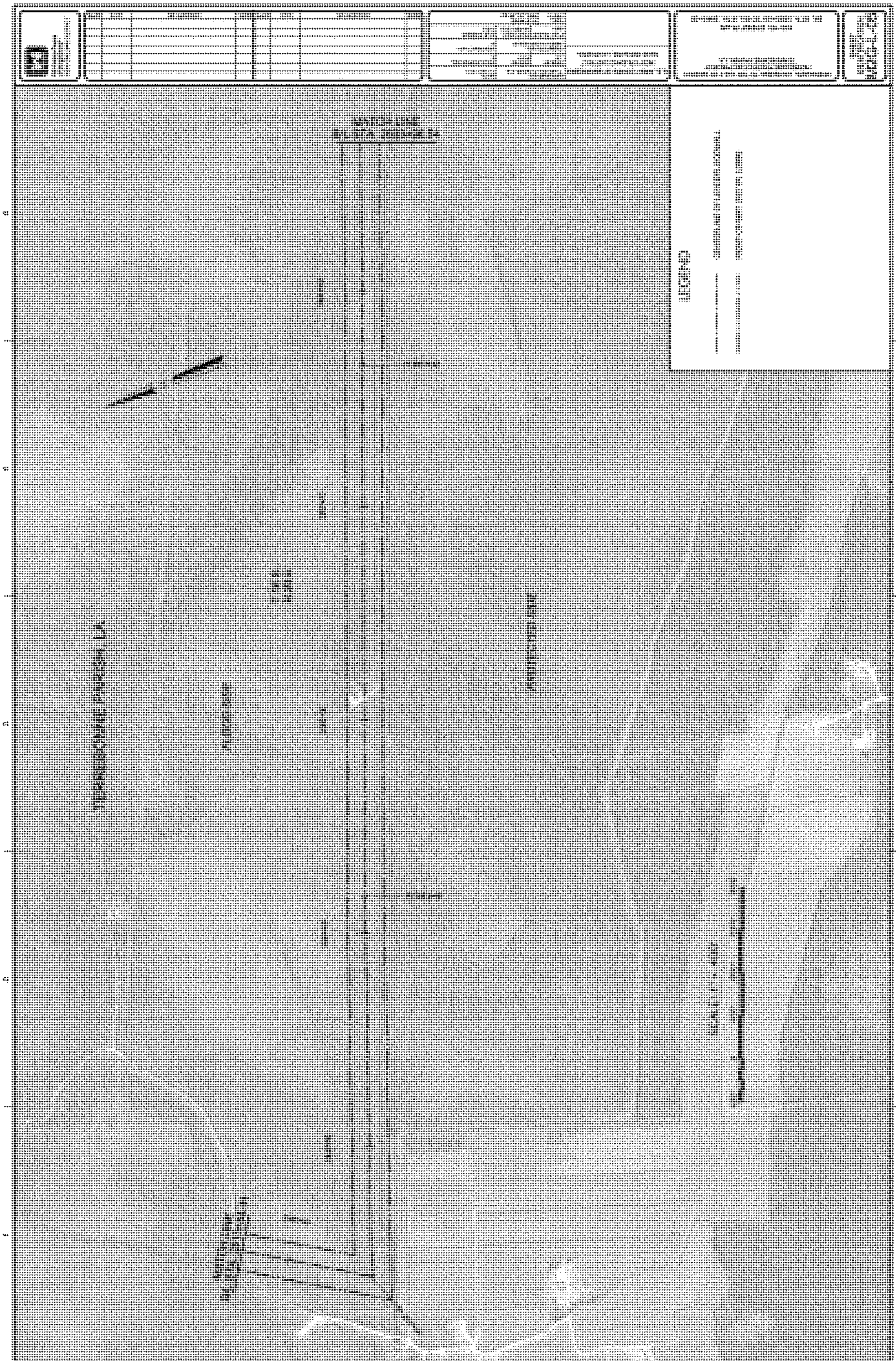


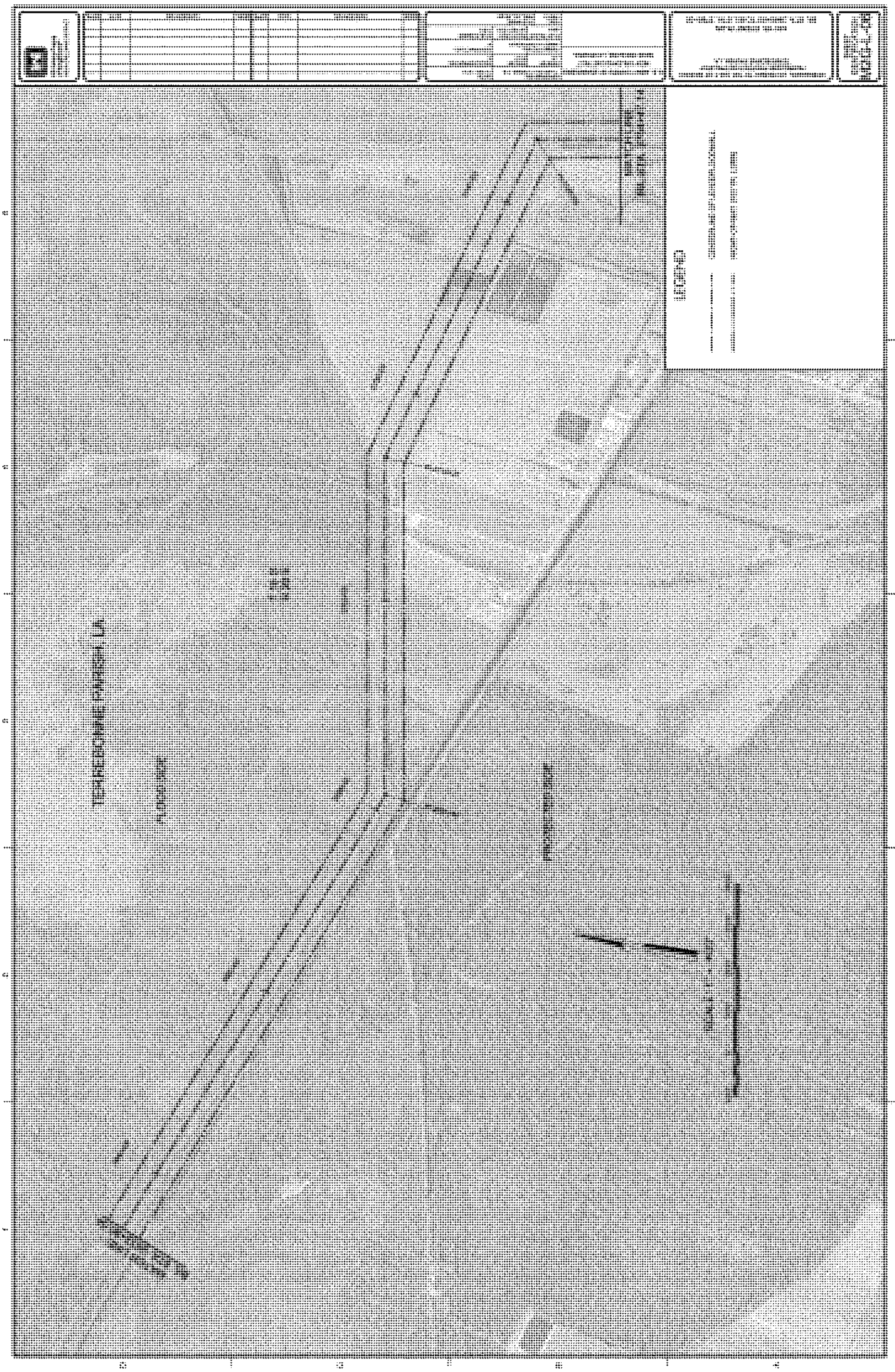


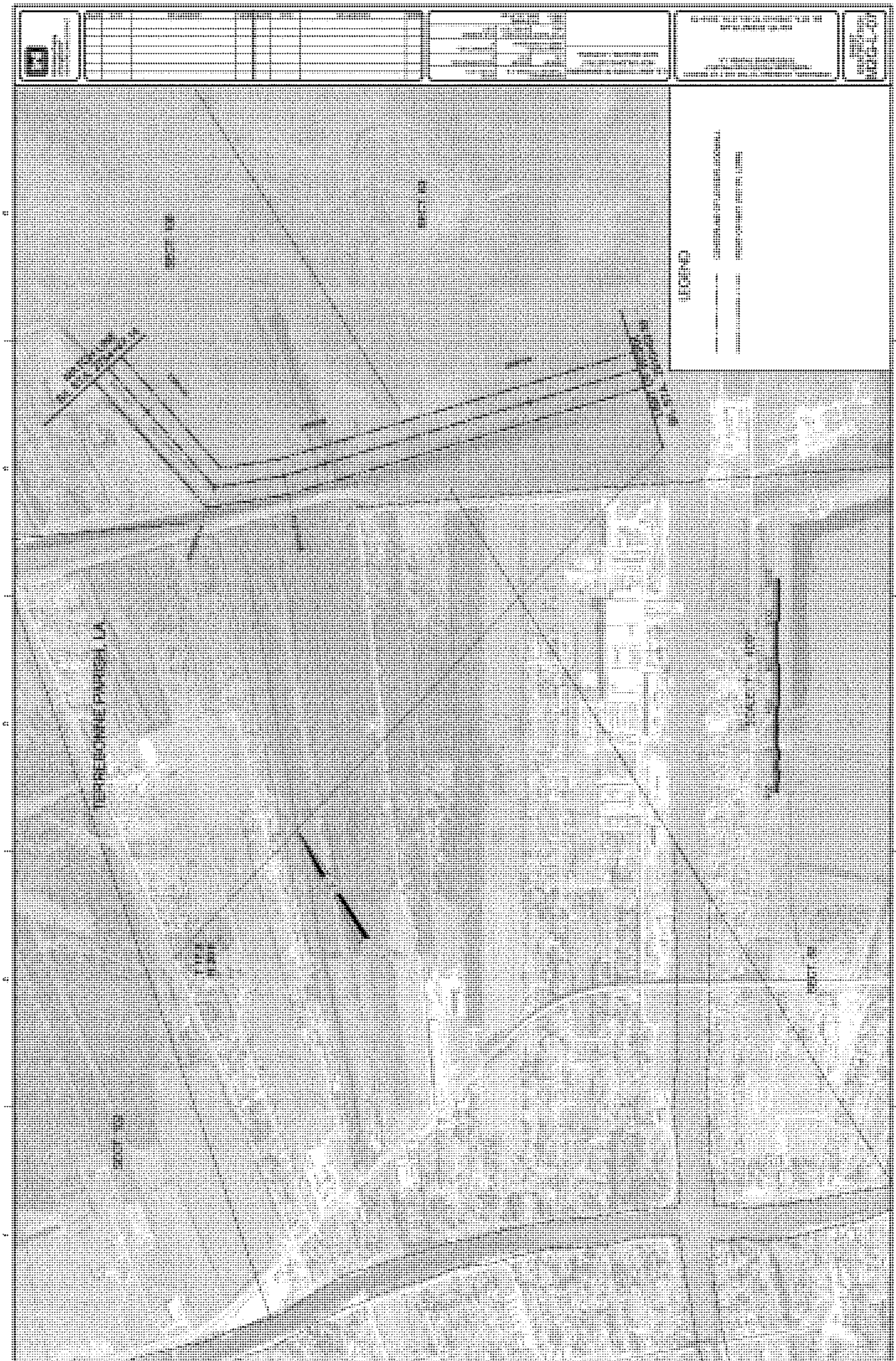


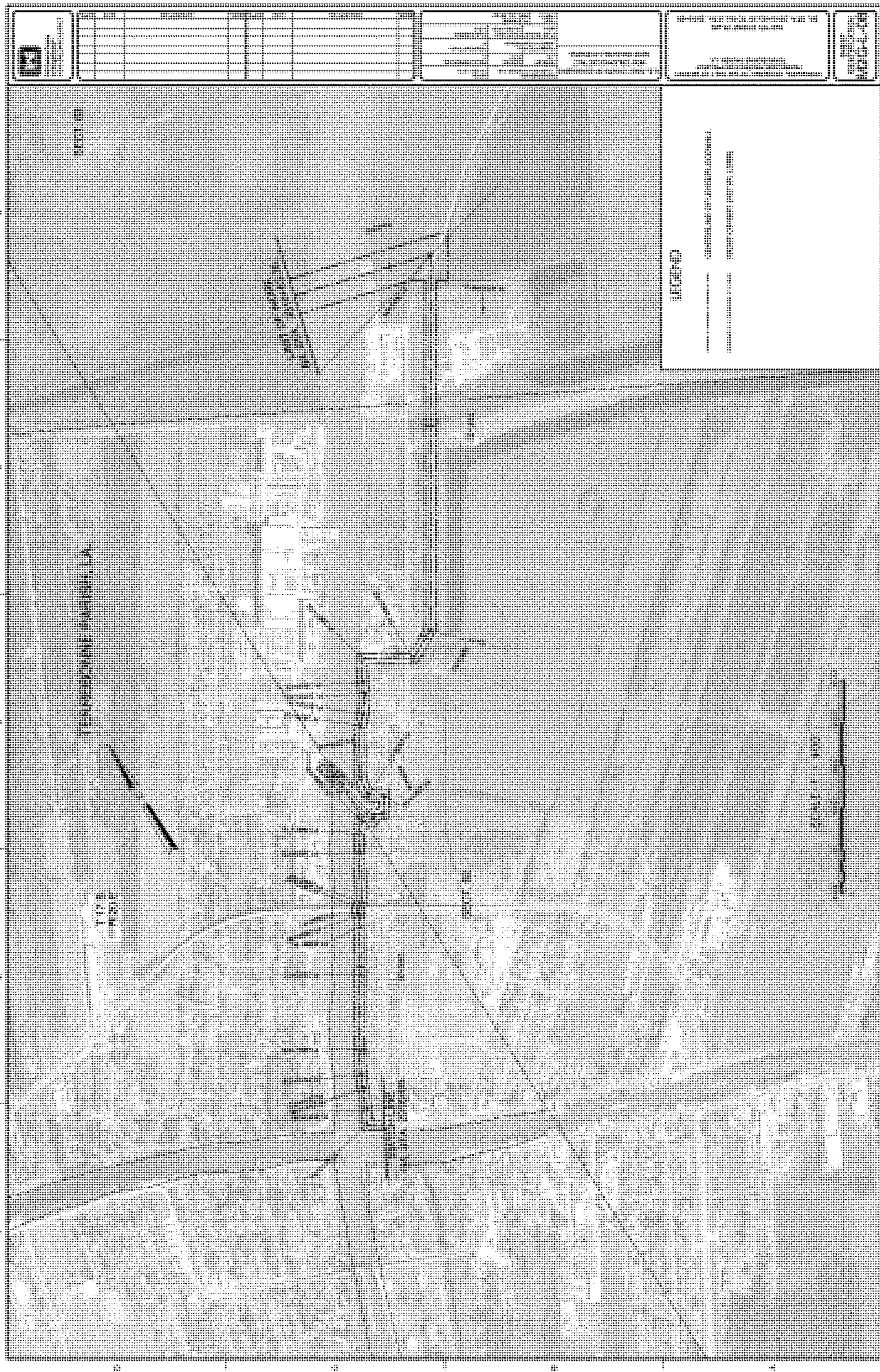


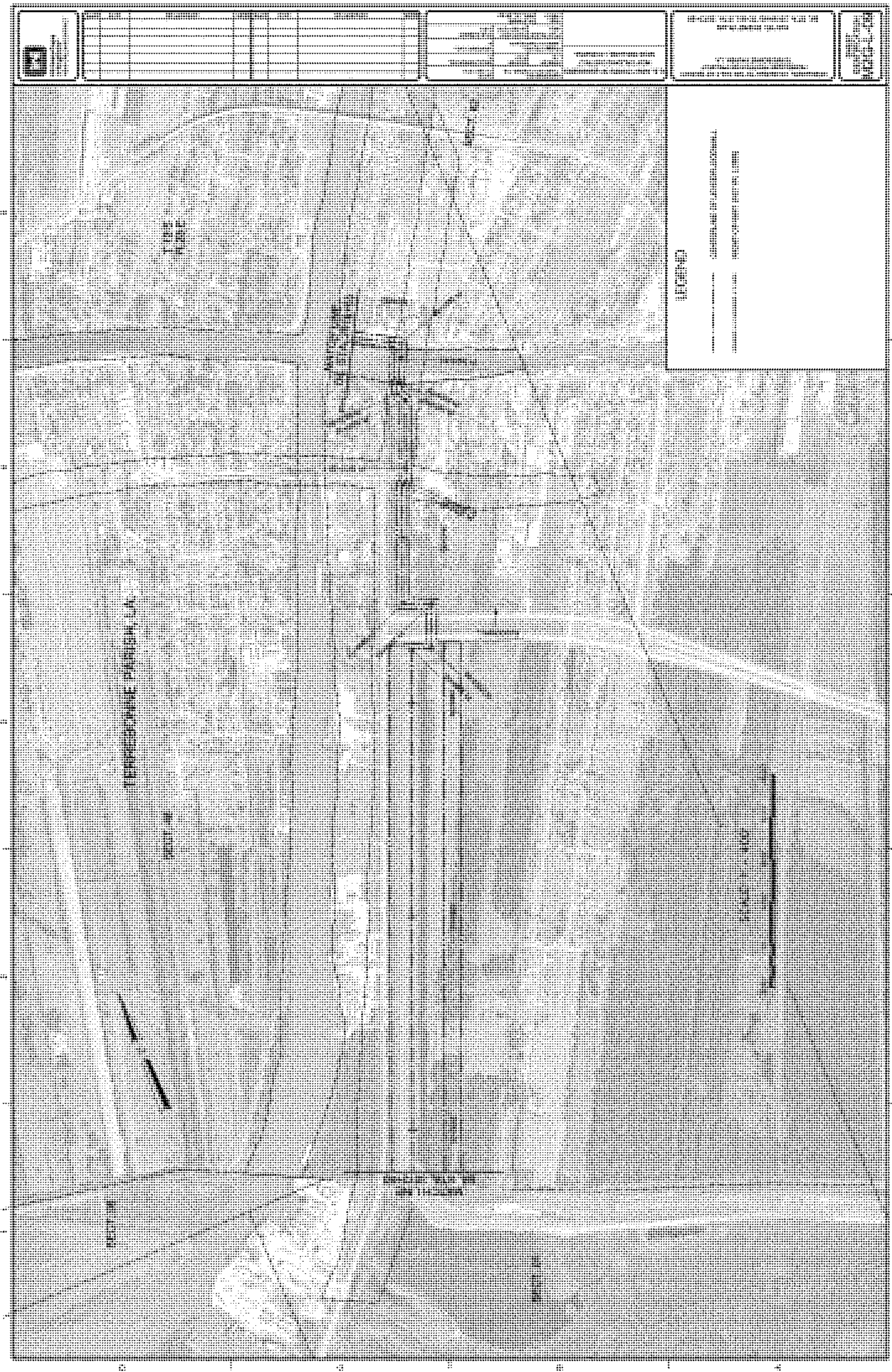


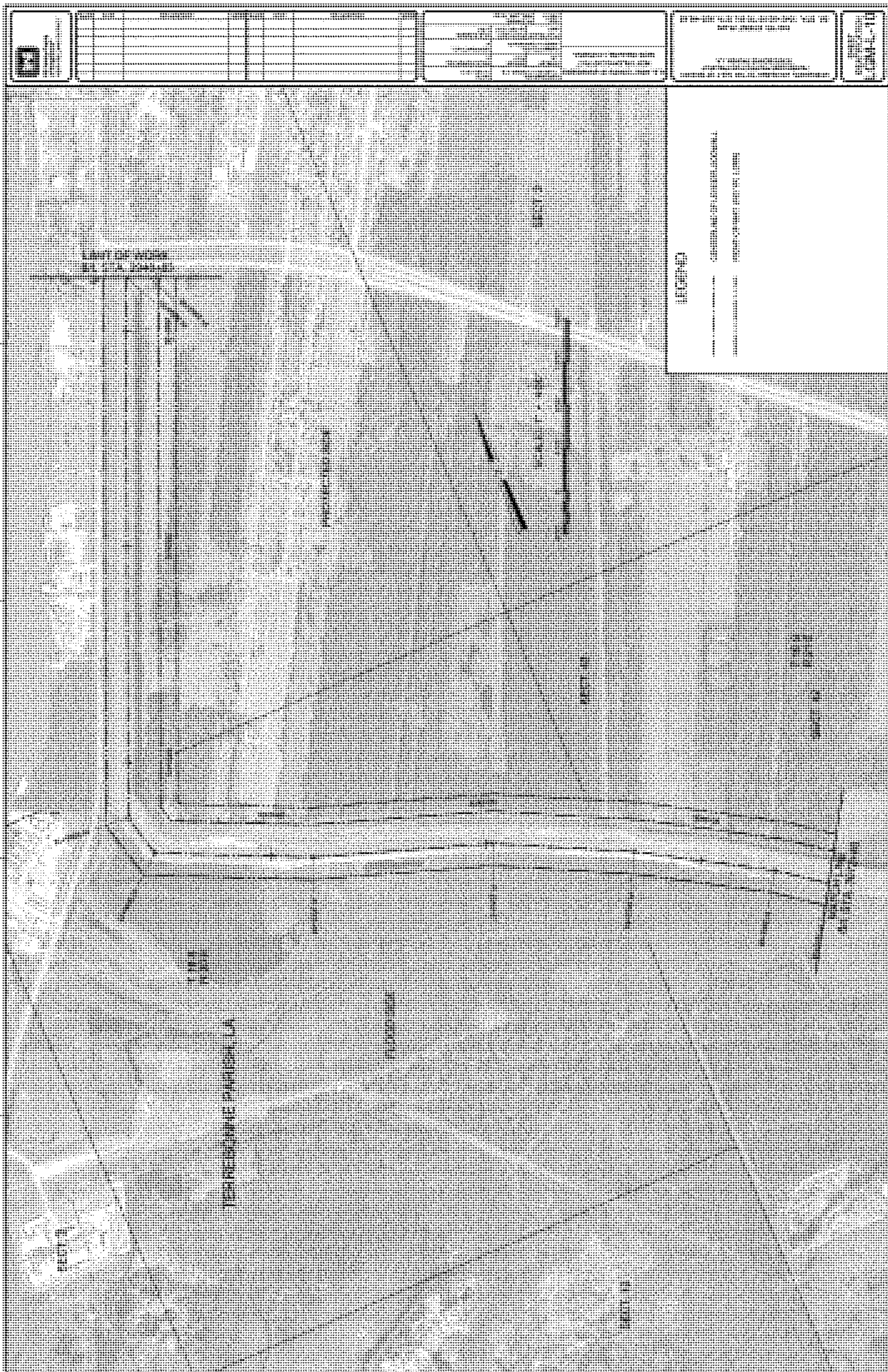

TERREBONNE PARISH, LA
PROTECTED SIDE
LEGEND

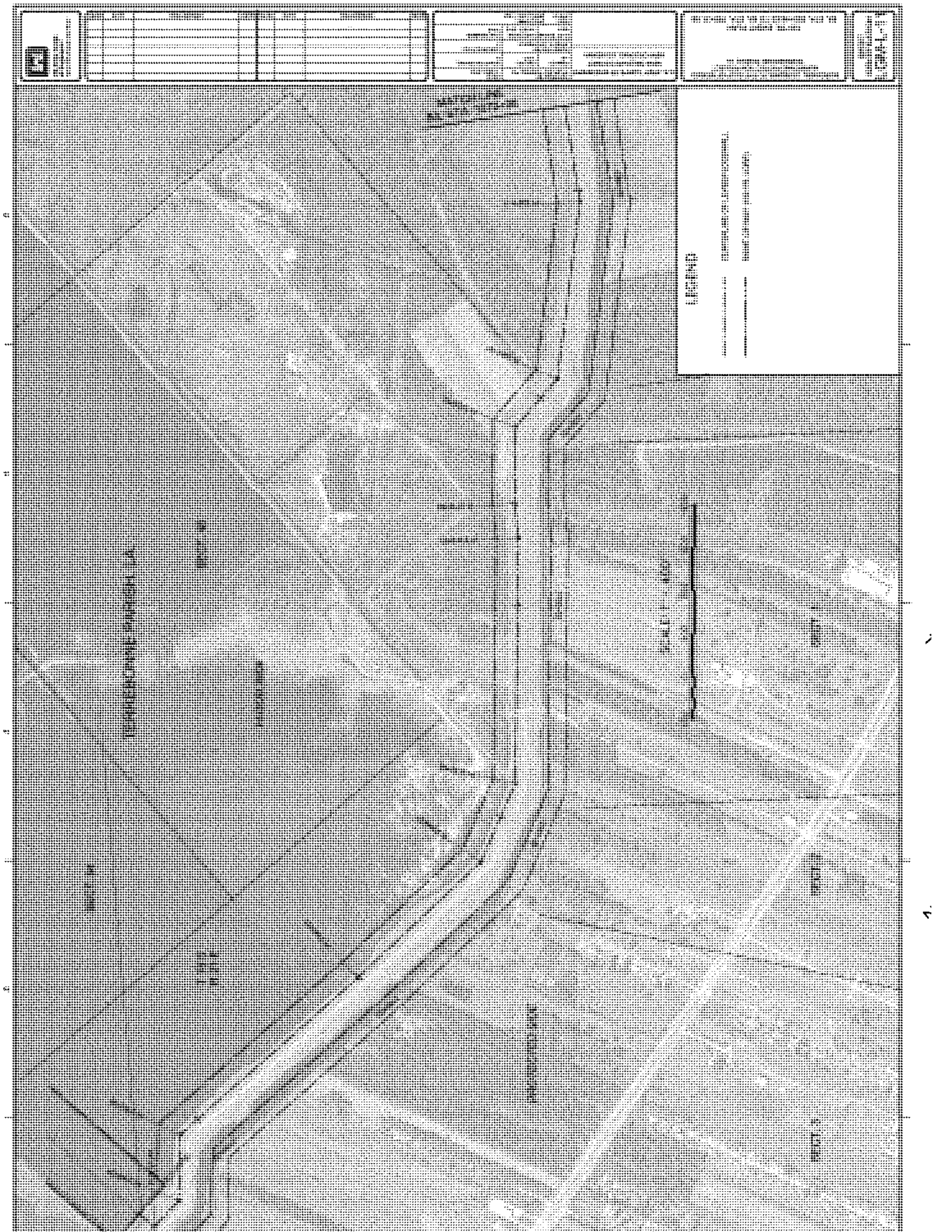

TERREBONNE PARISH, LA.
LEGEND

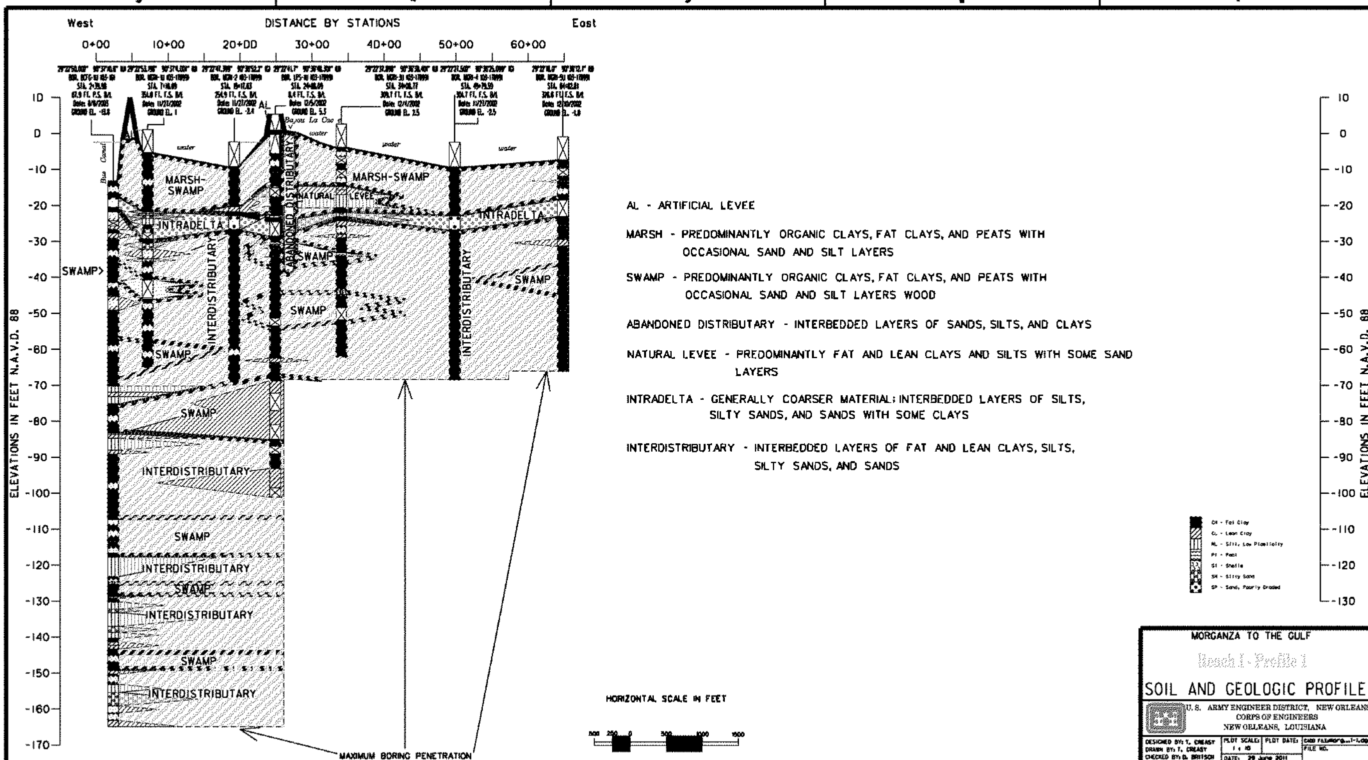


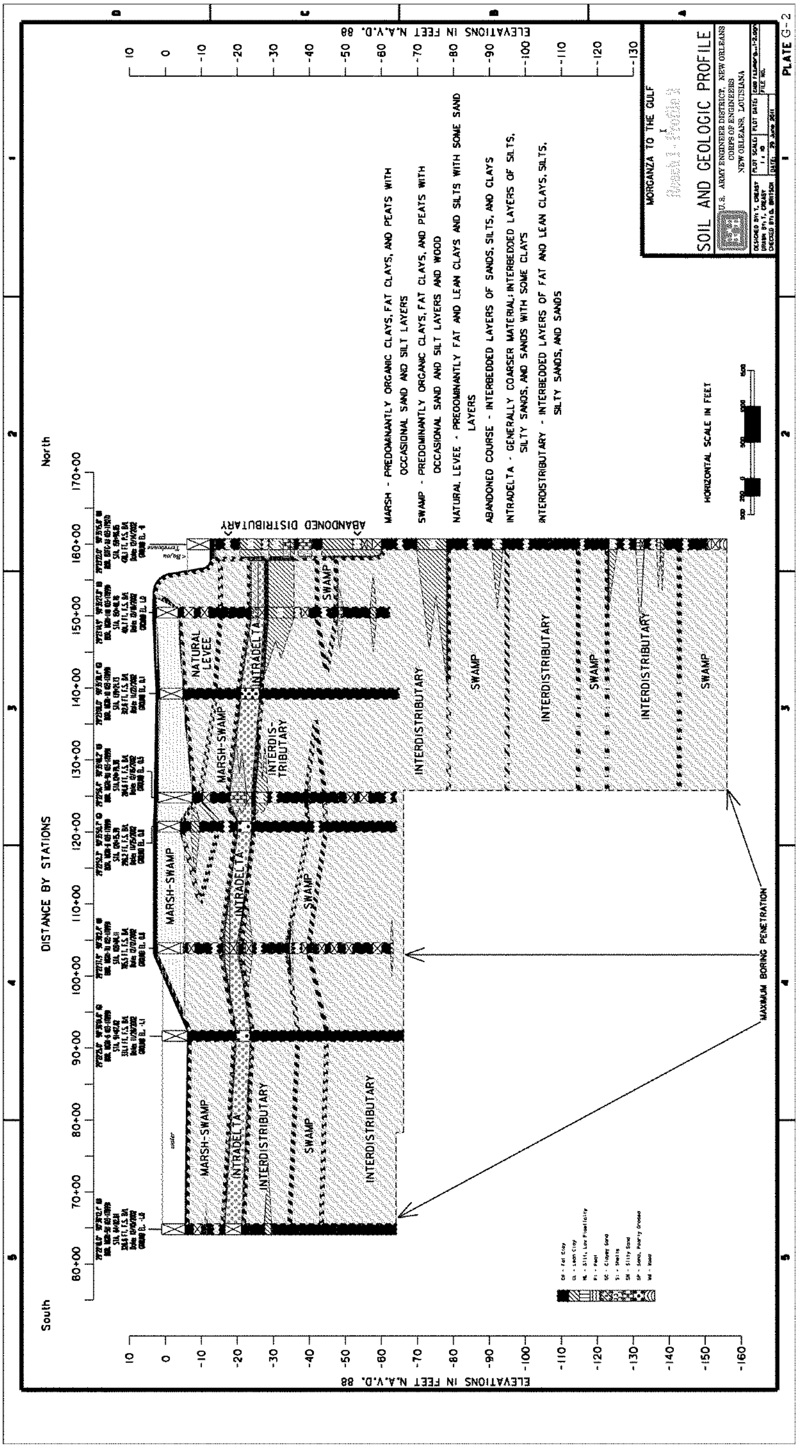



TERREBONNE PARISH, LA.






West
DISTANCE BY STATIONS
East
0+00
10+00
20+DD
30+00
40+00
50+00
60+00
ELEVATIONS IN FEET N.A.V.D. 88
MARSH-SWAMP
INTRADELTA
INTERDISTRIBUTARY
ABANDONED DISTRIBUTARY
NATURAL LEVEE
SWAMP
INTERDISTRIBUTARY
SWAMP>
AL
Bayou La Cao
water
MAXIMUM BORING PENETRATION
AL - ARTIFICIAL LEVEE
MARSH - PREDOMINANTLY ORGANIC CLAYS, FAT CLAYS, AND PEATS WITH OCCASIONAL SAND AND SILT LAYERS
SWAMP - PREDOMINANTLY ORGANIC CLAYS, FAT CLAYS, AND PEATS WITH OCCASIONAL SAND AND SILT LAYERS WOOD
ABANDONED DISTRIBUTARY - INTERBEDDED LAYERS OF SANDS, SILTS, AND CLAYS
NATURAL LEVEE - PREDOMINANTLY FAT AND LEAN CLAYS AND SILTS WITH SOME SAND LAYERS
INTRADELTA - GENERALLY COARSER MATERIAL; INTERBEDDED LAYERS OF SILTS, SILTY SANDS, AND SANDS WITH SOME CLAYS
INTERDISTRIBUTARY - INTERBEDDED LAYERS OF FAT AND LEAN CLAYS, SILTS, SILTY SANDS, AND SANDS
HORIZONTAL SCALE IN FEET
MORGANZA TO THE GULF
Reach I - Profile 1
SOIL AND GEOLOGIC PROFILE
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA
DATE: 29 June 2011
PLATE G-1


MORGANZA TO THE GULF
SOIL AND GEOLOGIC PROFILE
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA
PLATE G-2
DISTANCE BY STATIONS
South
North
ELEVATIONS IN FEET N.A.V.D. 88
MARSH - PREDOMINANTLY ORGANIC CLAYS, FAT CLAYS, AND PEATS WITH OCCASIONAL SAND AND SILT LAYERS
SWAMP - PREDOMINANTLY ORGANIC CLAYS, FAT CLAYS, AND PEATS WITH OCCASIONAL SAND AND SILT LAYERS AND WOOD
NATURAL LEVEE - PREDOMINANTLY FAT AND LEAN CLAYS AND SILTS WITH SOME SAND LAYERS
ABANDONED COURSE - INTERBEDDED LAYERS OF SANDS, SILTS, AND CLAYS
INTRADELTA - GENERALLY COARSER MATERIAL; INTERBEDDED LAYERS OF SILTS, SILTY SANDS, AND SANDS WITH SOME CLAYS
INTERDISTRIBUTARY - INTERBEDDED LAYERS OF FAT AND LEAN CLAYS, SILTS, SILTY SANDS, AND SANDS
HORIZONTAL SCALE IN FEET
MAXIMUM BORING PENETRATION
ABANDONED DISTRIBUTARY
MARSH-SWAMP
INTRADELTA
INTERDISTRIBUTARY
SWAMP
NATURAL LEVEE
INTERDIS-TRIBUTARY

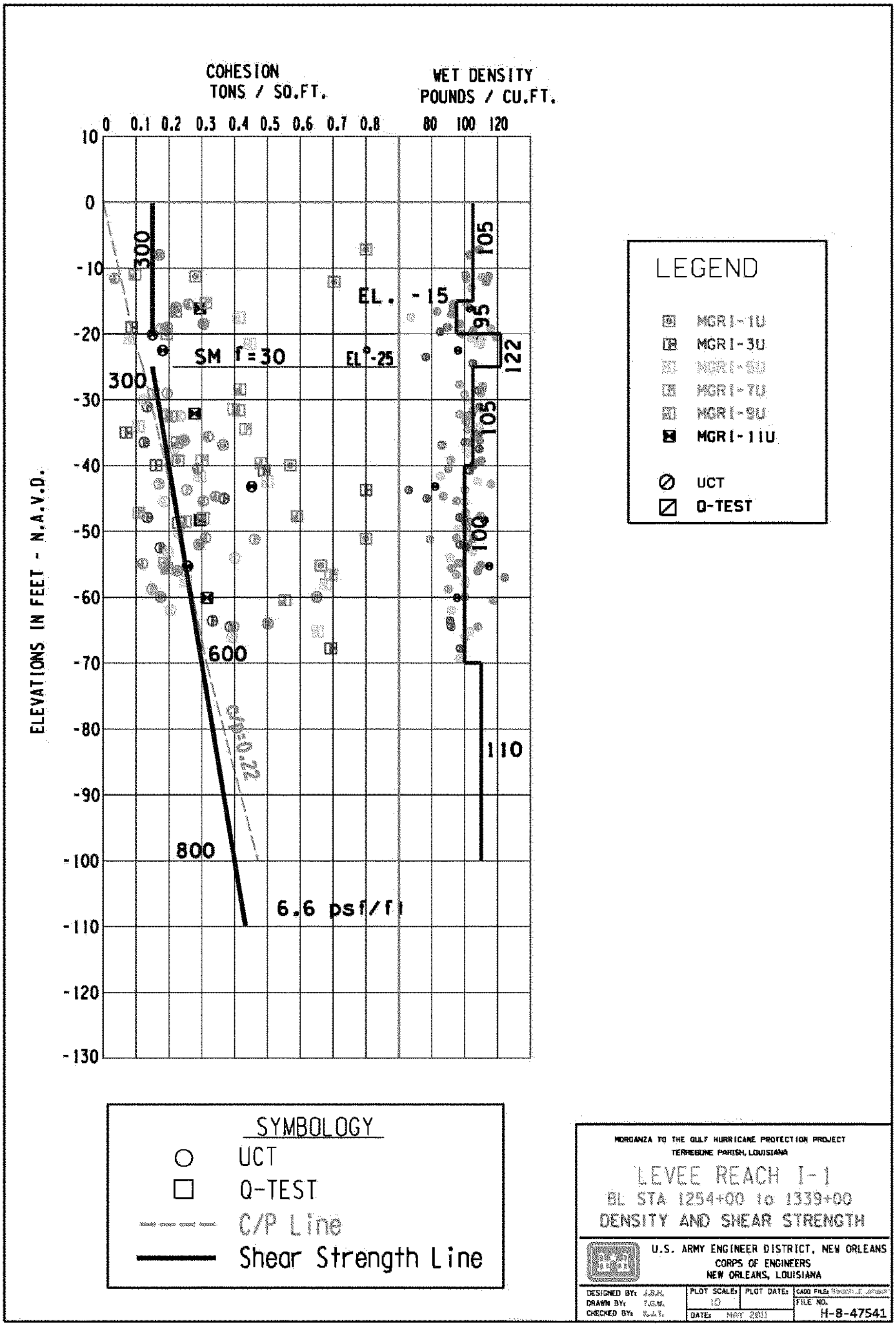
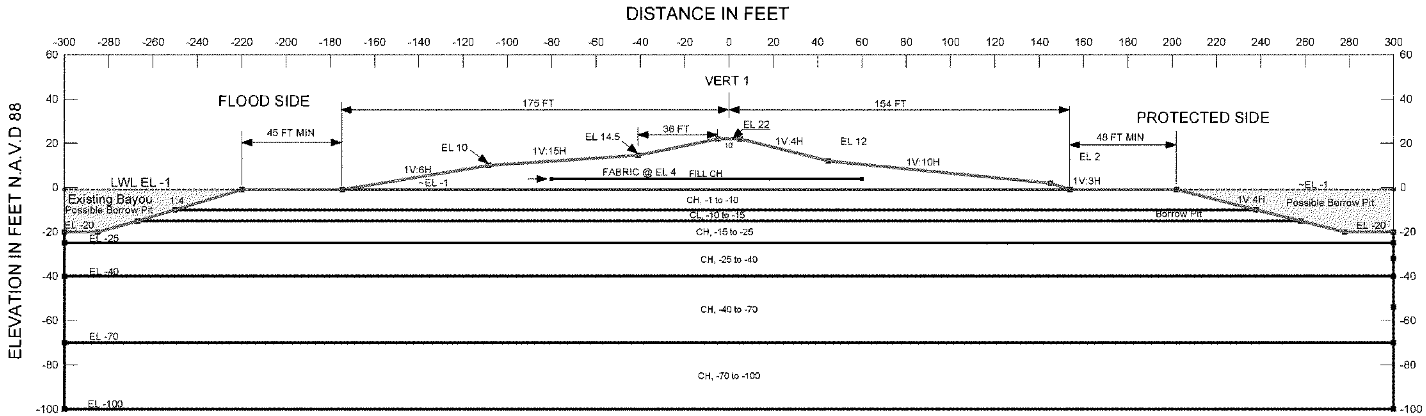

COHESION
TONS / SQ.FT.
WET DENSITY
POUNDS / CU.FT.
ELEVATIONS IN FEET - N.A.V.D.
EL. -15
SM f=30
EL -25
6.6 psf/ft
LEGEND
MGRI-1U
MGRI-3U
MGRI-5U
MGRI-7U
MGRI-9U
MGRI-11U
UCT
Q-TEST
SYMBOLOGY
UCT
Q-TEST
C/P Line
Shear Strength Line
MORGANZA TO THE GULF HURRICANE PROTECTION PROJECT
TERREBONNE PARISH, LOUISIANA
LEVEE REACH I-1
BL STA 1254+00 to 1339+00
DENSITY AND SHEAR STRENGTH
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA
H-8-47541
MAY 2011

PLATE G-3




Assumes increase in C/L strengths to EL -25 due to previous lifts

CLASSIFICATION STRATIFICATION
SHEAR STRENGTHS AND UNIT WEIGHTS OF THE SOIL WERE BASED ON THE RESULTS OF UNDISTURBED BORINGS AND CPT DATA. SEE BOTH BORING AND CPT DATA PLATES.

SHEAR STRENGTHS BETWEEN VERTICALS WERE ASSUMED TO VARY LINEARLY BETWEEN THE VALUES INDICATED FOR THESE LOCATIONS.

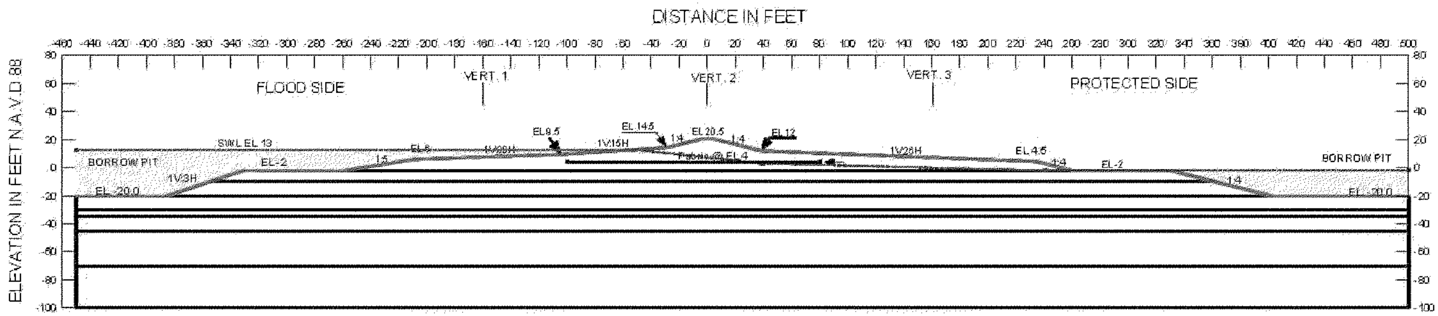
Morganza to the Gulf
Levee Reach A & Barrier Alignment
Terrebonne Parish, Louisiana

**LWL**
**100-Yr Protection (Base Year plus Overbuild)**
**NonCircular Analysis - Around Fabric Into Borrow Pit**
**Includes:**
**Optimization & Tension Crack**

US Army Corps of Engineers
New Orleans District

MORGANZA TO THE GULF
Levee Reach A and Barrier Alignment
100 YR LORR
Base Year Conditions w/Overbuild
Floodside and Protected Side Analyses
Fabric Reinforced Earthen Section
TERREBONNE PARISH, LOUISIANA

FIGURE A_LWL-5




NOTE: BORROW PIT TO BE EXCAVATED IN-THE-WET.

180 FT of 1800 lbs/in Reinforced Fabric
100 FT Floodside of C/L
80 FT Protected Side of C/L

Assumes increase in C/L strengths due to previous lifts

Morganza to the Gulf
Levee Reach B
Terrebonne Parish, Louisiana

CLASSIFICATION STRATIFICATION
SHEAR STRENGTHS AND UNIT WEIGHTS OF THE SOIL WERE BASED ON THE RESULTS OF UNDISTURBED BORINGS AND CPT DATA. SEE BOTH BORING AND CPT DATA PLATES.

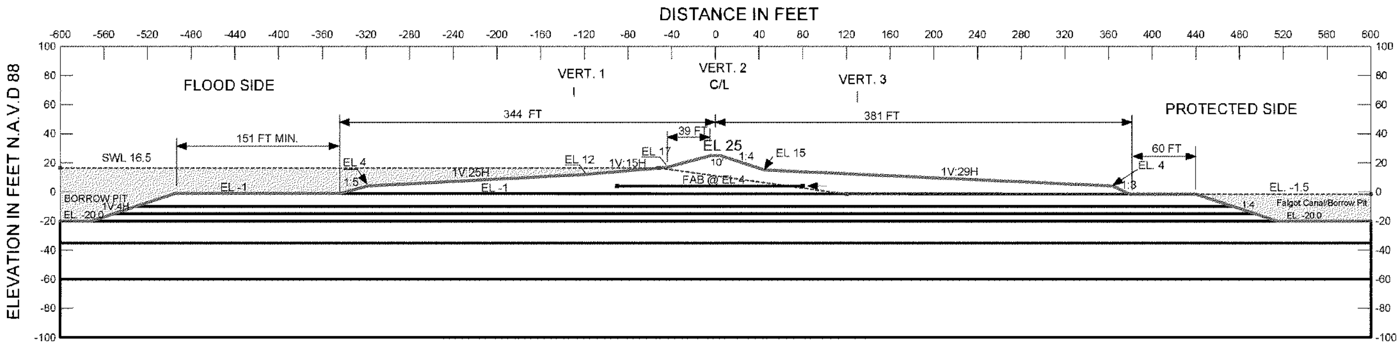
SHEAR STRENGTHS BETWEEN VERTICALS WERE ASSUMED TO VARY LINEARLY BETWEEN THE VALUES INDICATED FOR THESE LOCATIONS

**SWL**
**100-Yr Protection (Base Year plus Overbuild)**
**Circular Analysis - Thru Fabric into Borrow Pit**
**Includes:**
**Optimization & Tension Crack**

**US Army Corps of Engineers**
New Orleans District

MORGANZA TO THE GULF
Levee Reach B, 100 YR LORR
Base Year Conditions w/Overbuild
Floodside and Protected Side Analyses
Fabric Reinforced Earthen Section
TERREBONNE PARISH, LOUISIANA

FIGURE B_SWL-3




NOTE: BORROW PIT TO BE EXCAVATED IN-THE-WET.

Assumes increase in C/L strengths due to previous lifts

170 Feet Length of 1600 lbs/in Reinforced Geotextile laid at EL 4
From C/L Levee, offset 90 ft to Floodside and 80 ft to Protected Side

CLASSIFICATION STRATIFICATION SHEAR STRENGTHS AND UNIT WEIGHTS OF THE SOIL WERE BASED ON THE RESULTS OF UNDISTURBED BORINGS AND CPT DATA. SEE BOTH BORING AND CPT DATA PLATES.

SHEAR STRENGTHS BETWEEN VERTICALS WERE ASSUMED TO VARY LINEARLY BETWEEN THE VALUES INDICATED FOR THESE LOCATIONS.

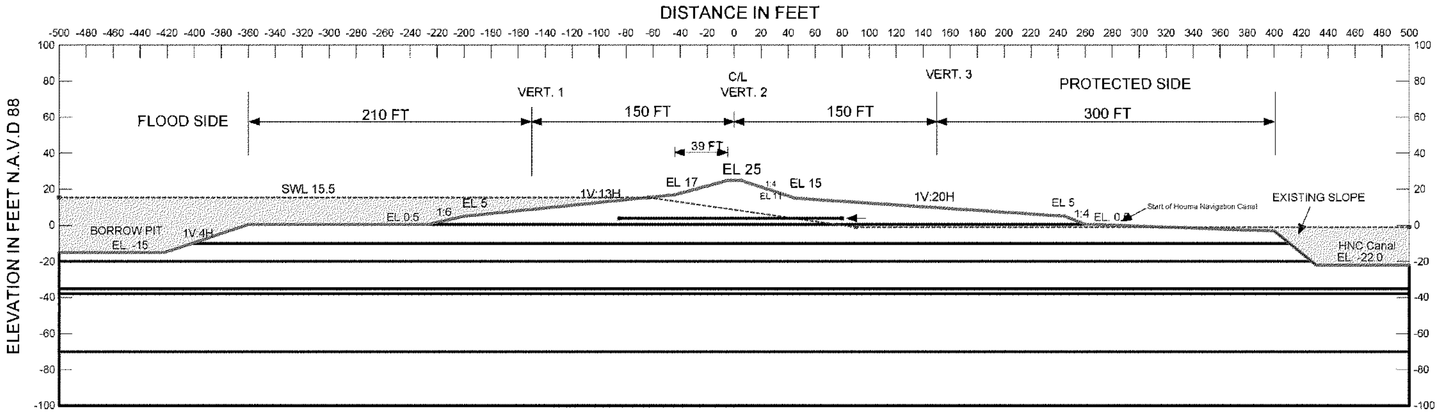
Morganza to the Gulf
Levee Reach E
Terrebonne Parish, Louisiana

**LWL**
**100-Yr Protection (Base Year plus Overbuild)**
**NonCircular Analysis - Thru Fabric into Borrow Pit**
**Includes:**
**Optimization & Tension Crack**

MORGANZA TO THE GULF
Levee Reach E, 100 YR LORR
Base Year Conditions w/Overbuild
Floodside and Protected Side Analyses
Fabric Reinforced Earthen Section
TERREBONNE PARISH, LOUISIANA

FIGURE E_SWL-6

US Army Corps of Engineers
New Orleans District




NOTE: BORROW PIT TO BE EXCAVATED IN-THE-WET

165 Feet Length of 1950 lbs/in Reinforced Geotextile laid at EL 4
From C/L Levee, offset 85 ft to Floodside and 80 ft to Protected Side

* Floodside borrow pit not recommended to presence of near surface silts and sands (pervious strata)

CLASSIFICATION STRATIFICATION
SHEAR STRENGTHS AND UNIT WEIGHTS OF THE SOIL WERE BASED ON THE RESULTS OF UNDISTURBED BORINGS AND CPT DATA. SEE BOTH BORING AND CPT DATA PLATES.

SHEAR STRENGTHS BETWEEN VERTICALS WERE ASSUMED TO VARY LINEARLY BETWEEN THE VALUES INDICATED FOR THESE LOCATIONS.

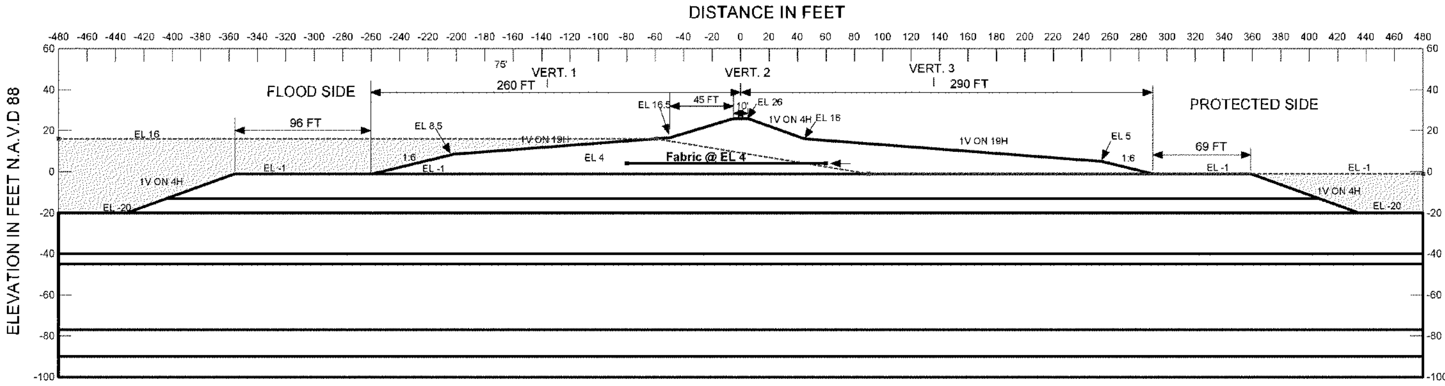
Morganza to the Gulf
Levee Reach F
Terrebonne Parish, Louisiana

**SWL**
**100-Yr Protection (Base Year plus Overbuild)**
**Circular Analysis - Around Fabric into Berm**
**Includes:**
**Optimization & Tension Crack**

MORGANZA TO THE GULF
Levee Reach F, 100 YR LORR
Base Year Conditions w/Overbuild
Floodside and Protected Side Analyses
Fabric Reinforced Earthen Section
TERREBONNE PARISH, LOUISIANA

US Army Corps of Engineers
New Orleans District

FIGURE F_SWL-4




NOTE: BORROW PIT TO BE EXCAVATED IN-THE-WET

* Floodside borrow pit not recommended to presence of near surface silts and sands (pervious strata)

140 FT of 2000 lbs/in Reinforced Fabric
80 FT Floodside of C/L
60 FT Protected Side of C/L

CLASSIFICATION STRATIFICATION
SHEAR STRENGTHS AND UNIT WEIGHTS OF THE SOIL WERE BASED ON THE RESULTS OF UNDISTURBED BORINGS AND CPT DATA. SEE BOTH BORING AND CPT DATA PLATES.

SHEAR STRENGTHS BETWEEN VERTICALS WERE ASSUMED TO VARY LINEARLY BETWEEN THE VALUES INDICATED FOR THESE LOCATIONS.

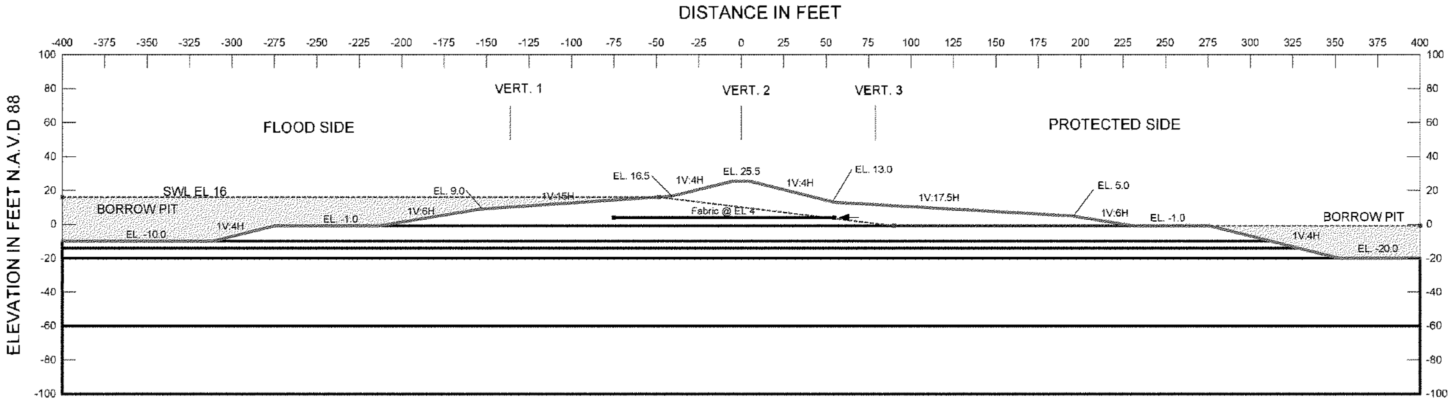
Morganza to the Gulf
Levee Reach G
Terrebonne Parish, Louisiana

**SWL**
**100-Yr Protection (Base Year plus Overbuild)**
**Circular Analysis - Thru Fabric into Borrow Pit**
**Includes:**
**Optimization & Tension Crack**

MORGANZA TO THE GULF
Levee Reach G, 100 YR LORR
Base Year Conditions w/Overbuild
Floodside and Protected Side Analyses
Fabric Reinforced Earthen Section
TERREBONNE PARISH, LOUISIANA

US Army Corps of Engineers
New Orleans District

FIGURE G_SWL-1




NOTE: BORROW PIT TO BE EXCAVATED IN-THE-WET.

130 FT of 1550 lbs/in Reinforced Fabric
75 FT Floodside of C/L
55 FT Protected Side of C/L

Assumes increase in C/L strengths due to previous lifts

CLASSIFICATION STRATIFICATION SHEAR STRENGTHS AND UNIT WEIGHTS OF THE SOIL WERE BASED ON THE RESULTS OF UNDISTURBED BORINGS AND CPT DATA. SEE BOTH BORING AND CPT DATA PLATES.

SHEAR STRENGTHS BETWEEN VERTICALS WERE ASSUMED TO VARY LINEARLY BETWEEN THE VALUES INDICATED FOR THESE LOCATIONS.

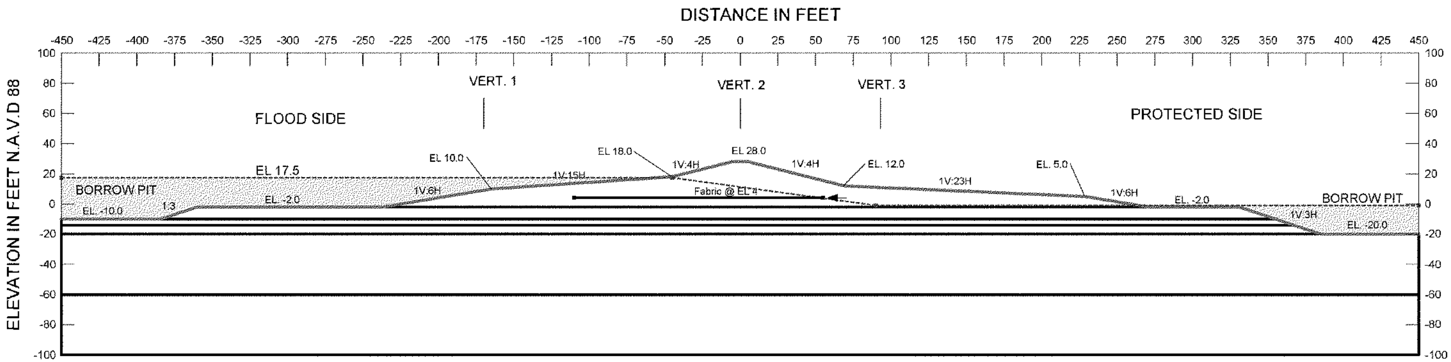
Morganza to the Gulf
Levee Reach H1
Terrebonne Parish, Louisiana

**SWL**
**100-Yr Protection (Base Year plus Overbuild)**
**Circular Analysis - Around Fabric into Borrow Pit**
**Includes:**
**Optimization & Tension Crack**

US Army Corps of Engineers
New Orleans District

MORGANZA TO THE GULF
Levee Reach H1, 100 YR LORR
Base Year Conditions w/Overbuild
Floodside and Protected Side Analyses
Fabric Reinforced Earthen Section
TERREBONNE PARISH, LOUISIANA

FIGURE H1_SWL-2




NOTE: BORROW PIT TO BE EXCAVATED IN-THE-WET.

165 FT of 1600 lbs/in Reinforced Fabric
110 FT Floodside of C/L, 55 FT Protected Side of C/L

Assumes increase in C/L strengths due to previous lifts

CLASSIFICATION STRATIFICATION SHEAR STRENGTHS AND UNIT WEIGHTS OF THE SOIL WERE BASED ON THE RESULTS OF UNDISTURBED BORINGS AND CPT DATA. SEE BOTH BORING AND CPT DATA PLATES.

SHEAR STRENGTHS BETWEEN VERTICALS WERE ASSUMED TO VARY LINEARLY BETWEEN THE VALUES INDICATED FOR THESE LOCATIONS.

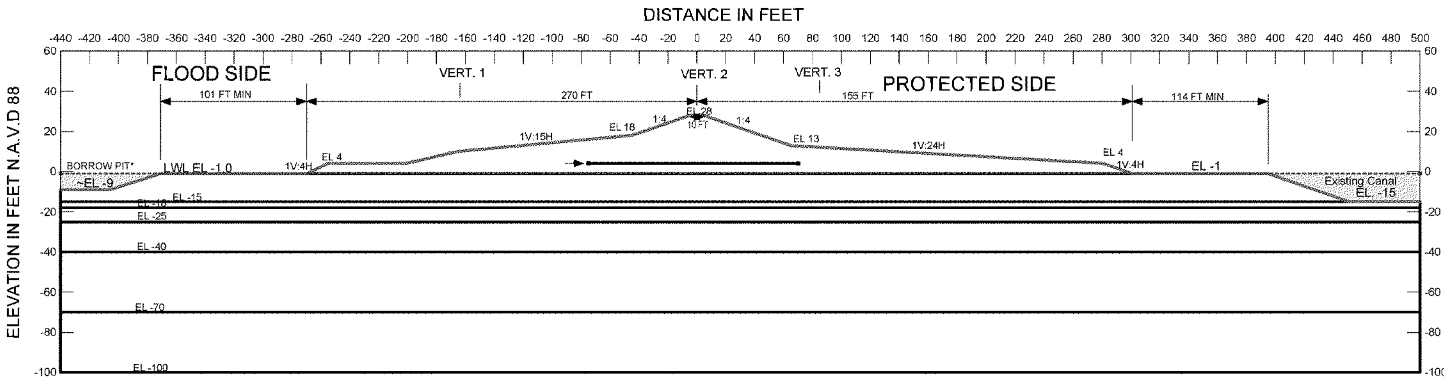
Morganza to the Gulf
Levee Reach H2 & H3
Terrebonne Parish, Louisiana

**SWL**
**100-Yr Protection (Base Year plus Overbuild)**
**NonCircular Analysis - Thru Fabric into Borrow Pit**
**Includes:**
**Optimization & Tension Crack**

US Army Corps of Engineers
New Orleans District

MORGANZA TO THE GULF
Levee Reach H2 & H3, 100 YR LORR
Base Year Conditions w/Overbuild
Floodside and Protected Side Analyses
Fabric Reinforced Earthen Section
TERREBONNE PARISH, LOUISIANA

FIGURE H2_SWL-5




* Floodside borrow pit not recommended due to presence of near surface silts and sands (pervious strata)

Assumes increase in C/L strengths to EL -70 due to previous lifts

NOTE: BORROW PIT TO BE EXCAVATED IN-THE-WET.

145 Feet Length of 1900 lbs/in Reinforced Geotextile laid at EL 4
From C/L Levee, offset 75 ft to Floodside and 70 ft to Protected Side

CLASSIFICATION STRATIFICATION
SHEAR STRENGTHS AND UNIT WEIGHTS OF THE SOIL WERE BASED ON THE RESULTS OF UNDISTURBED BORINGS AND CPT DATA. SEE BOTH BORING AND CPT DATA PLATES.

SHEAR STRENGTHS BETWEEN VERTICALS WERE ASSUMED TO VARY LINEARLY BETWEEN THE VALUES INDICATED FOR THESE LOCATIONS.

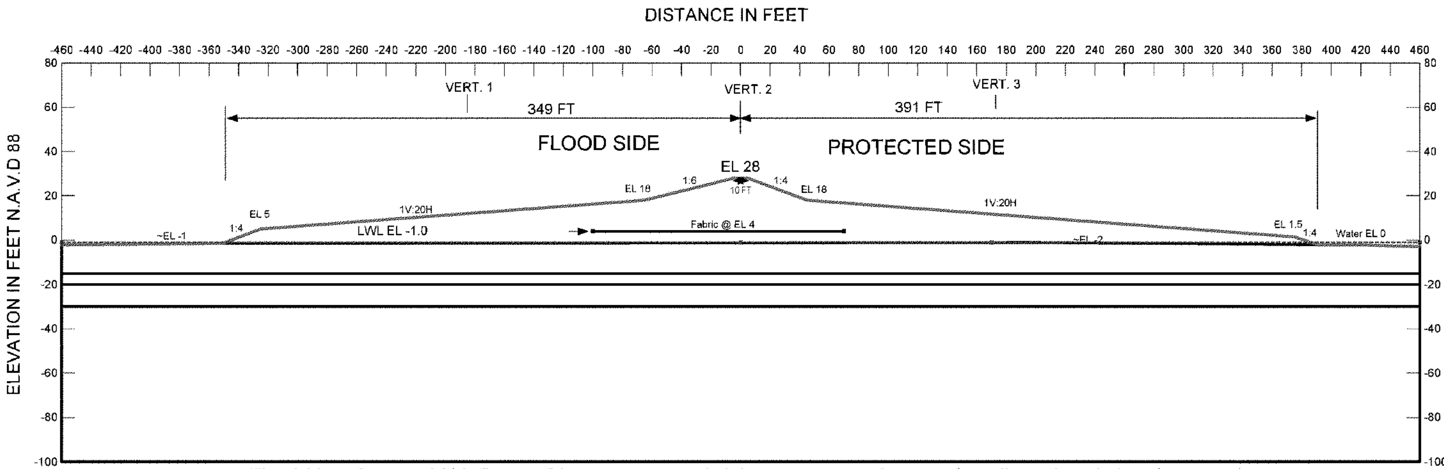
Morganza to the Gulf
Levee Reach I
Terrebonne Parish, Louisiana

**LWL**
**100-Yr Protection (Base Year plus Overbuild)**
**Circular Analysis - Around Fabric into Borrow Pit**
**Includes:**
**Optimization & Tension Crack**

MORGANZA TO THE GULF
Levee Reach I, 100 YR LORR
Base Year Conditions w/Overbuild
Floodside and Protected Side Analyses
Fabric Reinforced Earthen Section
TERREBONNE PARISH, LOUISIANA

US Army Corps of Engineers
New Orleans District

FIGURE I_LWL-3




Floodside or Protected Side Borrow Pits not recommended due to presence of near surface silts and sands (pervious strata)

Assumes increase in C/L strengths to EL -30 due to previous lifts

170 Feet Length of 2000 lbs/in Reinforced Geotextile laid at EL 4
From C/L Levee, offset 100 ft to Floodside and 70 ft to Protected Side

CLASSIFICATION STRATIFICATION
SHEAR STRENGTHS AND UNIT WEIGHTS OF THE SOIL WERE BASED ON THE RESULTS OF UNDISTURBED BORINGS AND CPT DATA. SEE BOTH BORING AND CPT DATA PLATES.

SHEAR STRENGTHS BETWEEN VERTICALS WERE ASSUMED TO VARY LINEARLY BETWEEN THE VALUES INDICATED FOR THESE LOCATIONS.

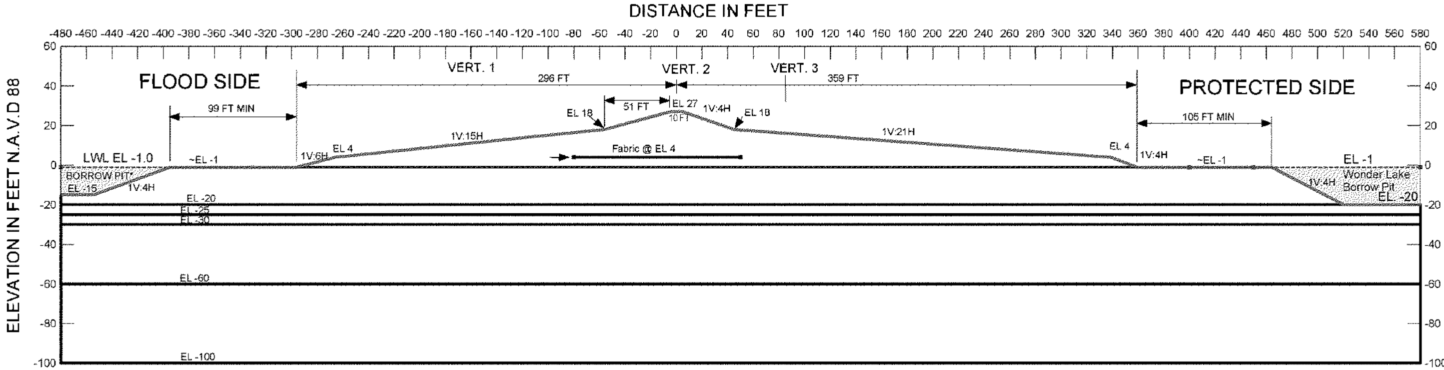
Morganza to the Gulf
Levee Reach J3
Terrebonne Parish, Louisiana

**LWL**
**100-Yr Protection (Base Year plus Overbuild)**
**Circular Analysis - Around Fabric into Berm**
**Includes:**
**Optimization & Tension Crack**

MORGANZA TO THE GULF
Levee Reach J-3, 100 YR LORR
Base Year Conditions w/Overbuild
Floodside and Protected Side Analyses
Fabric Reinforced Earthen Section
TERREBONNE PARISH, LOUISIANA

US Army Corps of Engineers
New Orleans District

FIGURE J3_LWL-2




NOTE: BORROW PIT TO BE EXCAVATED IN-THE-WET.

Assumes increase in C/L strengths to EL -60 due to previous lifts

* Limit Floodside borrow pit depth due to presence of near surface silts and sands (pervious strata)

Borrow Pit Availability
Borrow Land Aquisition
Borrow Pit Quantities
Environmental and Mitigation Issues
are not Geotechnical Responsibilities

130 Feet Length of 1500 lbs/in Reinforced Geotextile laid at EL 4
80 Feet Floodside of C/L
50 Feet Protected Side of C/L

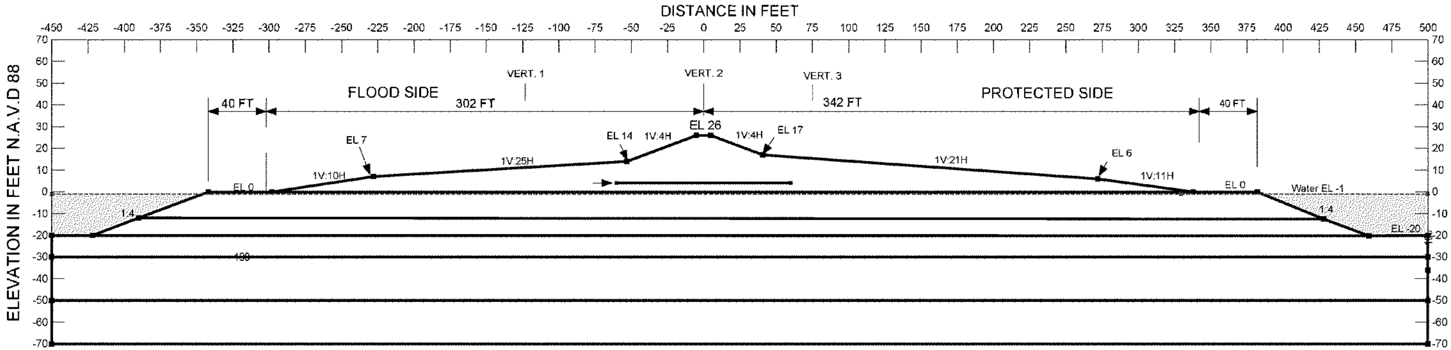
LWL Case
Block Analysis - Into Berm Through Fabric
Includes:
Optimization & Tension Crack

US Army Corps of Engineers
New Orleans District

# Analysis for 100 Yr LORR (with Overbuild) Lift Levee Reach J

MORGANZA TO THE GULF
Levee Reach J, 100 YR LORR (With Overbuild)
Floodside and Protected Side Analyses
Earthen Section With Fabic
TERREBONNE PARISH, LOUISIANA

PLATE




NOTE: BORROW PIT TO BE EXCAVATED IN-THE-WET.

Assumes increase in C/L strengths due to previous lifts

120 Feet Length of 1700 lbs/in Reinforced Geotextile laid at EL 4
From C/L Levee, offset 60 ft to Floodside and 60 ft to Protected Side

Morganza to the Gulf
Levee Reach K&L
Terrebonne Parish, Louisiana

GENERAL NOTES:
CLASSIFICATION STRATIFICATION
SHEAR STRENGTHS AND UNIT WEIGHTS OF THE SOIL WERE BASED ON THE RESULTS OF UNDISTURBED BORINGS AND CPT DATA. SEE BOTH BORING AND CPT DATA PLATES.

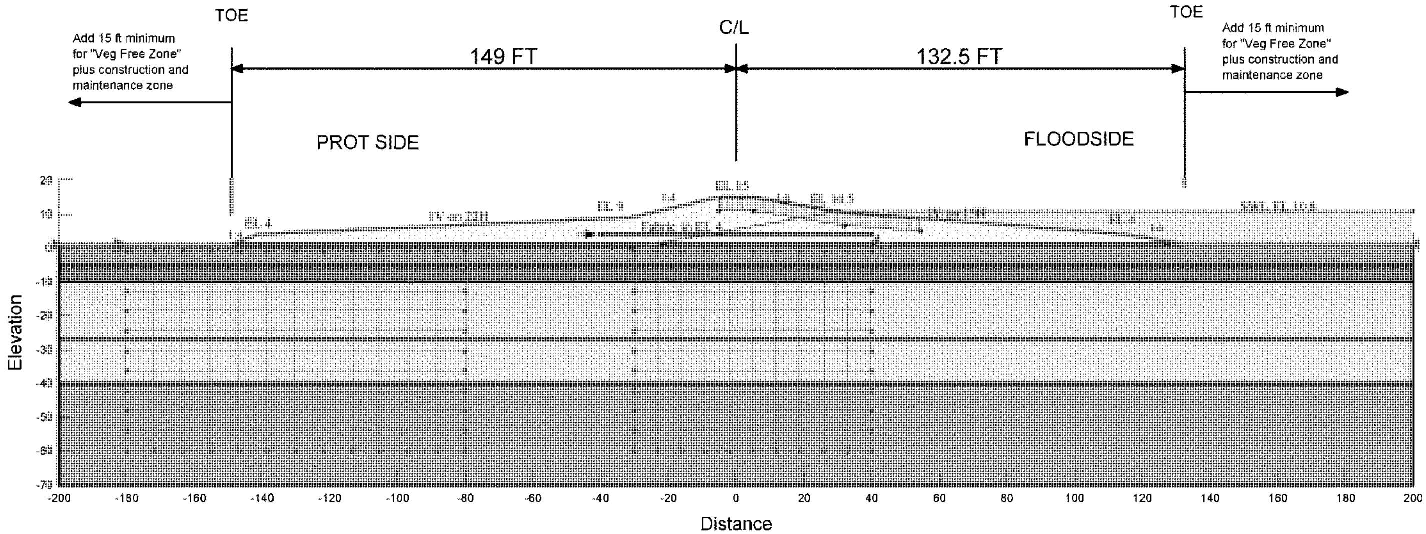
SHEAR STRENGTHS BETWEEN VERTICALS WERE ASSUMED TO VARY LINEARLY BETWEEN THE VALUES INDICATED FOR THESE LOCATIONS.

**LWL**
**35-Yr Protection (Base Year plus Overbuild)**
**NonCircular Analysis - Into Berm**
**Includes:**
**Optimization & Tension Crack**

MORGANZA TO THE GULF
Levee Reach K&L, 100 YR LORR
Base Year Conditions w/Overbuild
Floodside and Protected Side Analyses
Fabric Reinforced Earthen Section
TERREBONNE PARISH, LOUISIANA

US Army Corps of Engineers
New Orleans District

FIGURE KL_LWL-5



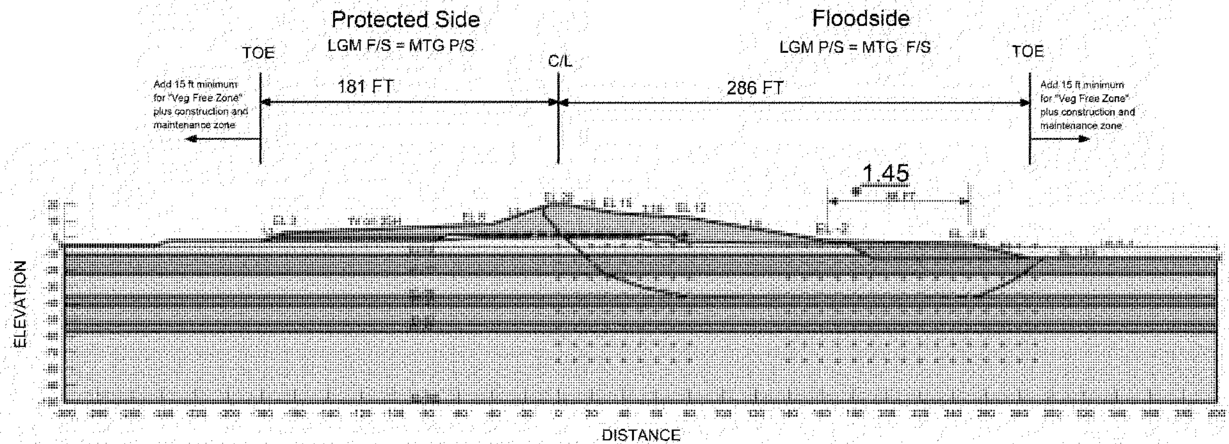

Reinforcement Fabric @ EL 4
100 foot length centered on levee
Fabric with 1200 lbs/in @ 5% Strain

MORGANZA TO THE GULF
Lockport to Larose Levee Reach (a), 100 YR
for Base Year Conditions
And Levee Reach (a), 35 YR
for Base Year Conditions w/Overbuild
Floodside and Protected Side Analyses
Fabric Reinforced Levee Section
LAFOURCHE PARISH, LOUISIANA

SWL - NonCircular Analysis Around Fabric into Berm
100-Yr Protection (Base Year)
and 35-Yr Protection (Base Year plus Overbuild)
Includes: Optimization & Tension Crack Line

US Army Corps
of Engineers
New Orleans District

SWL-A-2




| MTG Analysis - Levee Reach C-North (LGM) Soil Properties Table | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | Initial Lift | | | |
| | | FRIC. | | Centerline | | Toe | |
| Layer (ELEV) | SOIL | ANGLE | UNIT WT. (pcf) | Top | Bottom | Top | Bottom |
| Compacted Fill | CH | 0 | 115 | 600 | 600 | 600 | 600 |
| Existing Fill | CH | 0 | 112 | 400 | 400 | 400 | 400 |
| Uncompacted Fill | CH | 0 | 100 | 120 | 120 | 120 | 120 |
| GS to -10 | CH | 0 | 100 | 300 | 400 | 200 | 200 |
| -10 to -22 | ML | 15 | 117 | 200 | 200 | 200 | 200 |
| -22 to -36 | CH | 0 | 102 | 500 | 600 | 300 | 300 |
| -36 to -41 | ML | 15 | 117 | 200 | 200 | 200 | 200 |
| -41 to -52 | CH | 0 | 110 | 600 | 750 | 400 | 500 |
| -52 to -57 | ML | 15 | 117 | 200 | 200 | 200 | 200 |
| -57 to -100 | CH | 0 | 105 | 700 | 1000 | 700 | 1000 |

Soil Porperty Table Provided for Conveinence and Actual Properies may have a small variance
For Actual Soil Properies refer to the Slope/W Input/Output Report Files

US Army Corps of Engineers
New Orleans District

Reinforcement Fabric @ EL 2
130 foot length
50 foot on NEW PS and 70 foot on NEW FS
Fabric with 2000 lbs/in @5% Strain

LGM - Levee Reach C-North

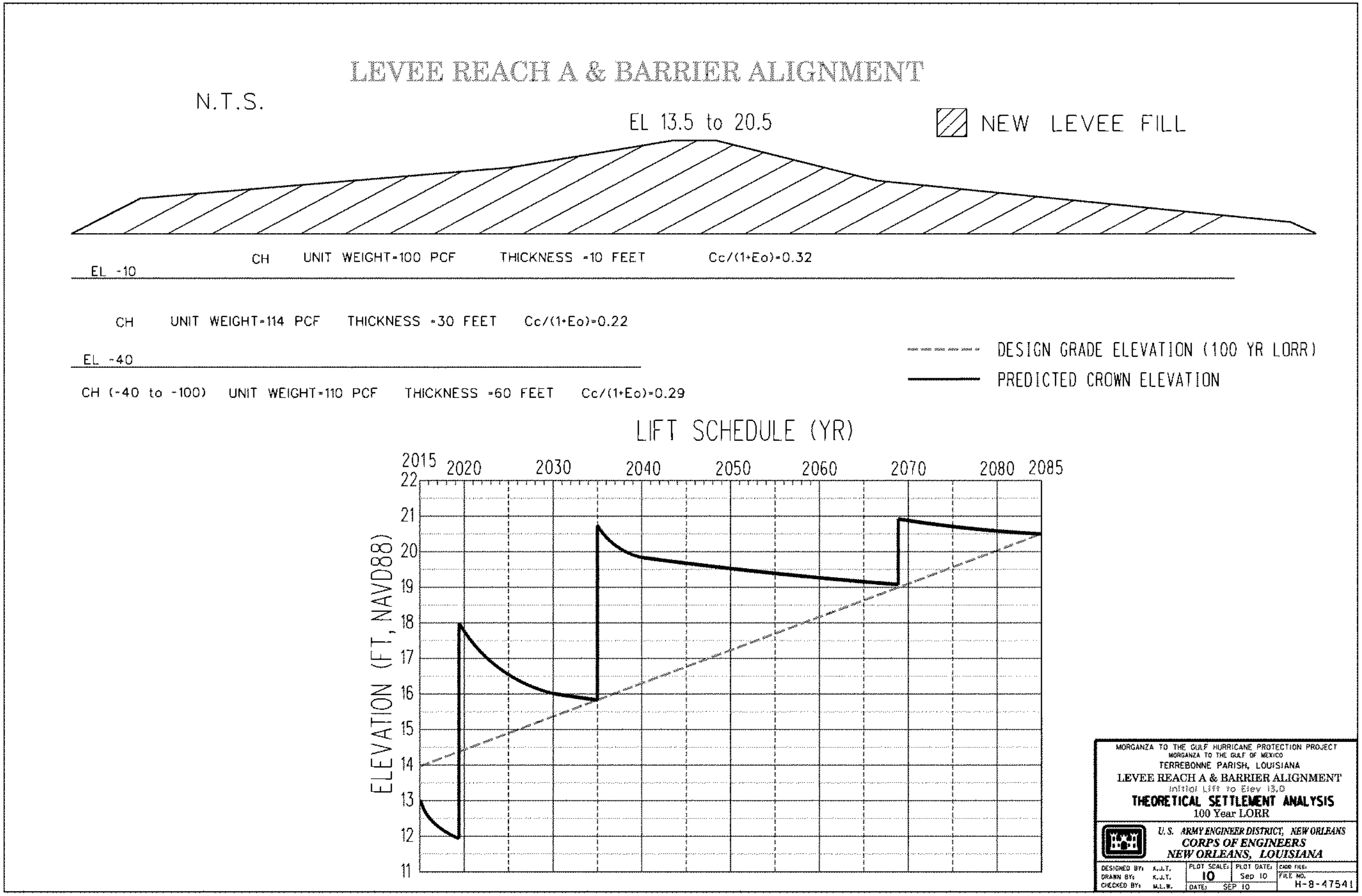
LWL - NonCircular Analysis Thru Fabric into Berm
100-Yr Protection (Base Year plus Overbuild)
Includes: Optimization & Tension Crack Line

MORGANZA TO THE GULF HURRICANE PROTECTION PROJECT
MORGANZA TO THE GULF OF MEXICO
TERREBONNE AND LAFOURCHE PARISH, LOUISIANA
Larose to Golden Meadow - Reach C-North
STABILITY ANALYSIS
Base Year Conditions (100 Yr w/Overbuild)
Fabric Reinforced Levee

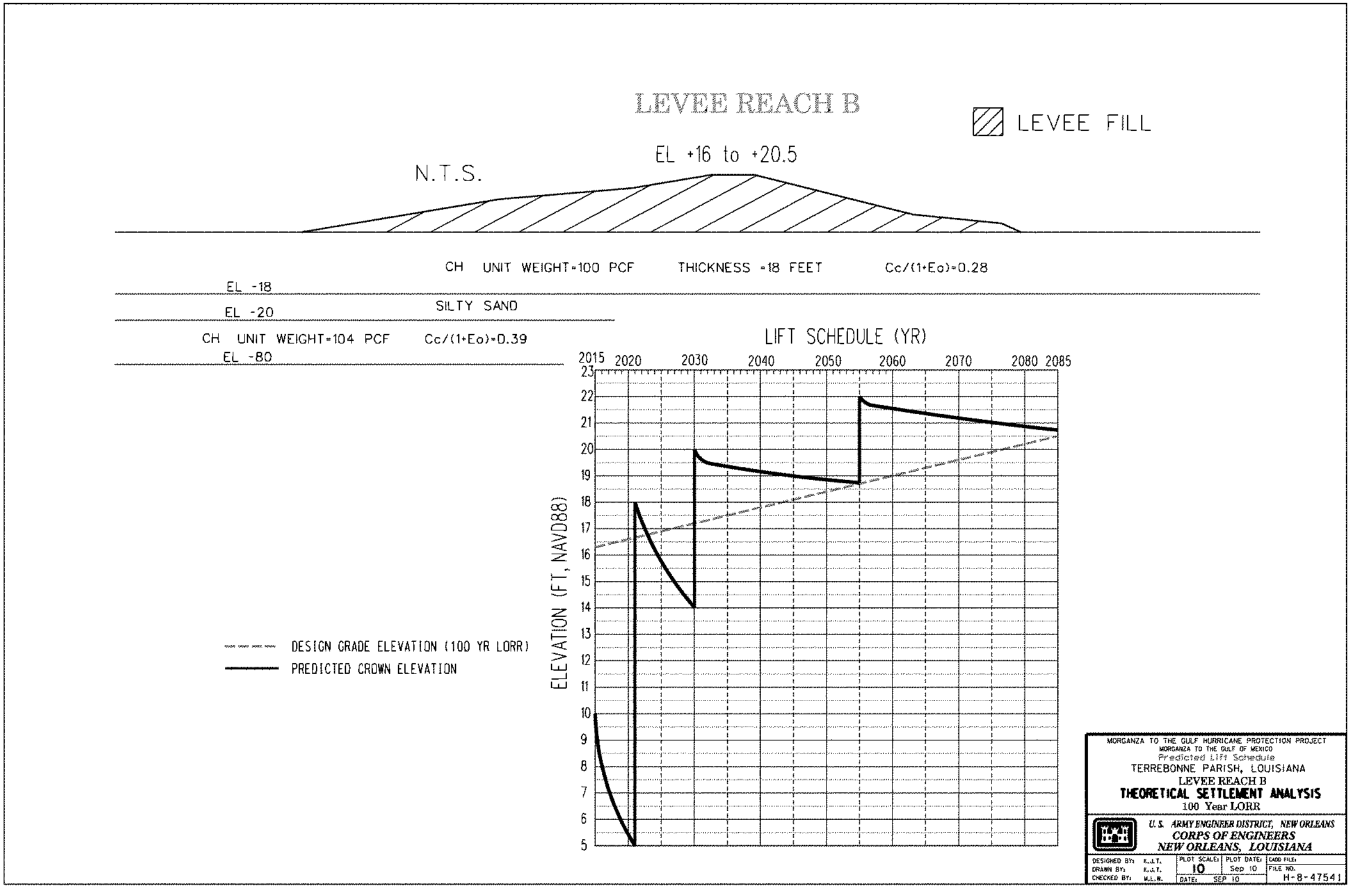
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

| | | | | |
|---|---|---|---|---|
| DESIGNED BY: K.J.T. | PLOT SCALE: | PLOT DATE: Nov 12 | CADD FILE: | |
| DRAWN BY: M.D.J. | | | FILE NO. | |
| CHECKED BY: M.L.W. | DATE: NOV 2012 | | | |

PLATE LWL-CN1%-1


LEVEE REACH A & BARRIER ALIGNMENT
N.T.S.
EL 13.5 to 20.5
NEW LEVEE FILL
EL -10
CH UNIT WEIGHT=100 PCF THICKNESS =10 FEET Cc/(1+Eo)=0.32
CH UNIT WEIGHT=114 PCF THICKNESS =30 FEET Cc/(1+Eo)=0.22
EL -40
CH (-40 to -100) UNIT WEIGHT=110 PCF THICKNESS =60 FEET Cc/(1+Eo)=0.29
DESIGN GRADE ELEVATION (100 YR LORR)
PREDICTED CROWN ELEVATION
LIFT SCHEDULE (YR)
2015
2020
2030
2040
2050
2060
2070
2080
2085
ELEVATION (FT, NAVD88)
22
21
20
19
18
17
16
15
14
13
12
11
MORGANZA TO THE GULF HURRICANE PROTECTION PROJECT
MORGANZA TO THE GULF OF MEXICO
TERREBONNE PARISH, LOUISIANA
LEVEE REACH A & BARRIER ALIGNMENT
Initial Lift to Elev 13.0
THEORETICAL SETTLEMENT ANALYSIS
100 Year LORR
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA
DESIGNED BY: K.J.T.
DRAWN BY: K.J.T.
CHECKED BY: M.L.W.
PLOT SCALE: 10
PLOT DATE: Sep 10
DATE: SEP 10
CADD FILE:
FILE NO. H-8-47541

SA-1


LEVEE REACH B
LEVEE FILL
EL +16 to +20.5
N.T.S.
CH UNIT WEIGHT=100 PCF THICKNESS =18 FEET Cc/(1+Eo)=0.28
EL -18
EL -20
SILTY SAND
CH UNIT WEIGHT=104 PCF Cc/(1+Eo)=0.39
EL -80
LIFT SCHEDULE (YR)
2015 2020 2030 2040 2050 2060 2070 2080 2085
ELEVATION (FT, NAVD88)
23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5
DESIGN GRADE ELEVATION (100 YR LORR)
PREDICTED CROWN ELEVATION
MORGANZA TO THE GULF HURRICANE PROTECTION PROJECT
MORGANZA TO THE GULF OF MEXICO
Predicted Lift Schedule
TERREBONNE PARISH, LOUISIANA
LEVEE REACH B
THEORETICAL SETTLEMENT ANALYSIS
100 Year LORR
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA
DESIGNED BY: K.J.T.
DRAWN BY: K.J.T.
CHECKED BY: M.L.W.
PLOT SCALE: 10
PLOT DATE: Sep 10
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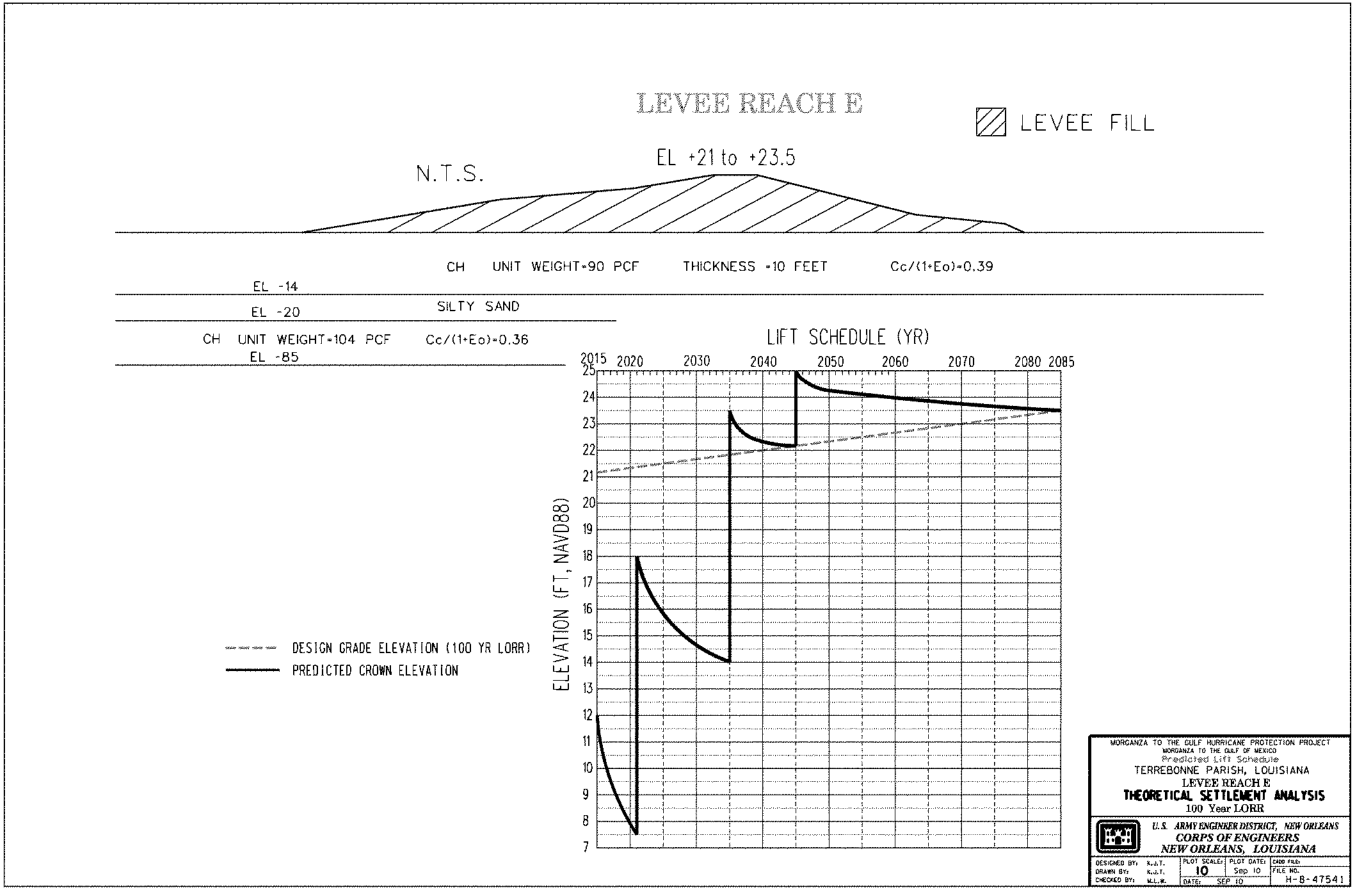
LEVEE REACH E
LEVEE FILL
N.T.S.
EL +21 to +23.5
CH UNIT WEIGHT=90 PCF THICKNESS =10 FEET Cc/(1+Eo)=0.39
EL -14
EL -20
SILTY SAND
CH UNIT WEIGHT=104 PCF Cc/(1+Eo)=0.36
EL -85
LIFT SCHEDULE (YR)
2015 2020 2030 2040 2050 2060 2070 2080 2085
ELEVATION (FT, NAVD88)
25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7
DESIGN GRADE ELEVATION (100 YR LORR)
PREDICTED CROWN ELEVATION
MORGANZA TO THE GULF HURRICANE PROTECTION PROJECT
MORGANZA TO THE GULF OF MEXICO
Predicted Lift Schedule
TERREBONNE PARISH, LOUISIANA
LEVEE REACH E
THEORETICAL SETTLEMENT ANALYSIS
100 Year LORR
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA
DESIGNED BY: K.J.T.
DRAWN BY: K.J.T.
CHECKED BY: M.L.W.
PLOT SCALE: 10
PLOT DATE: Sep 10
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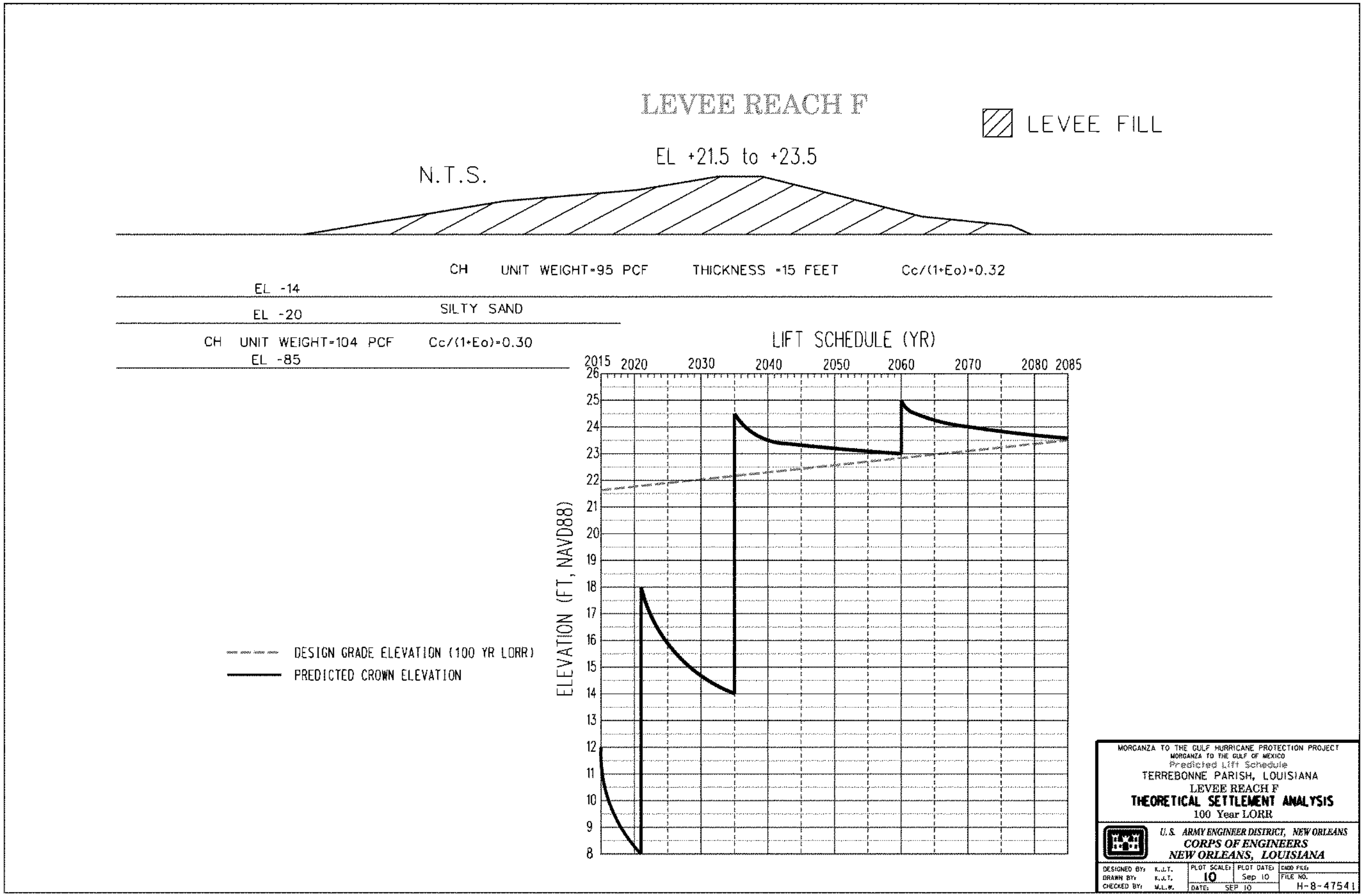
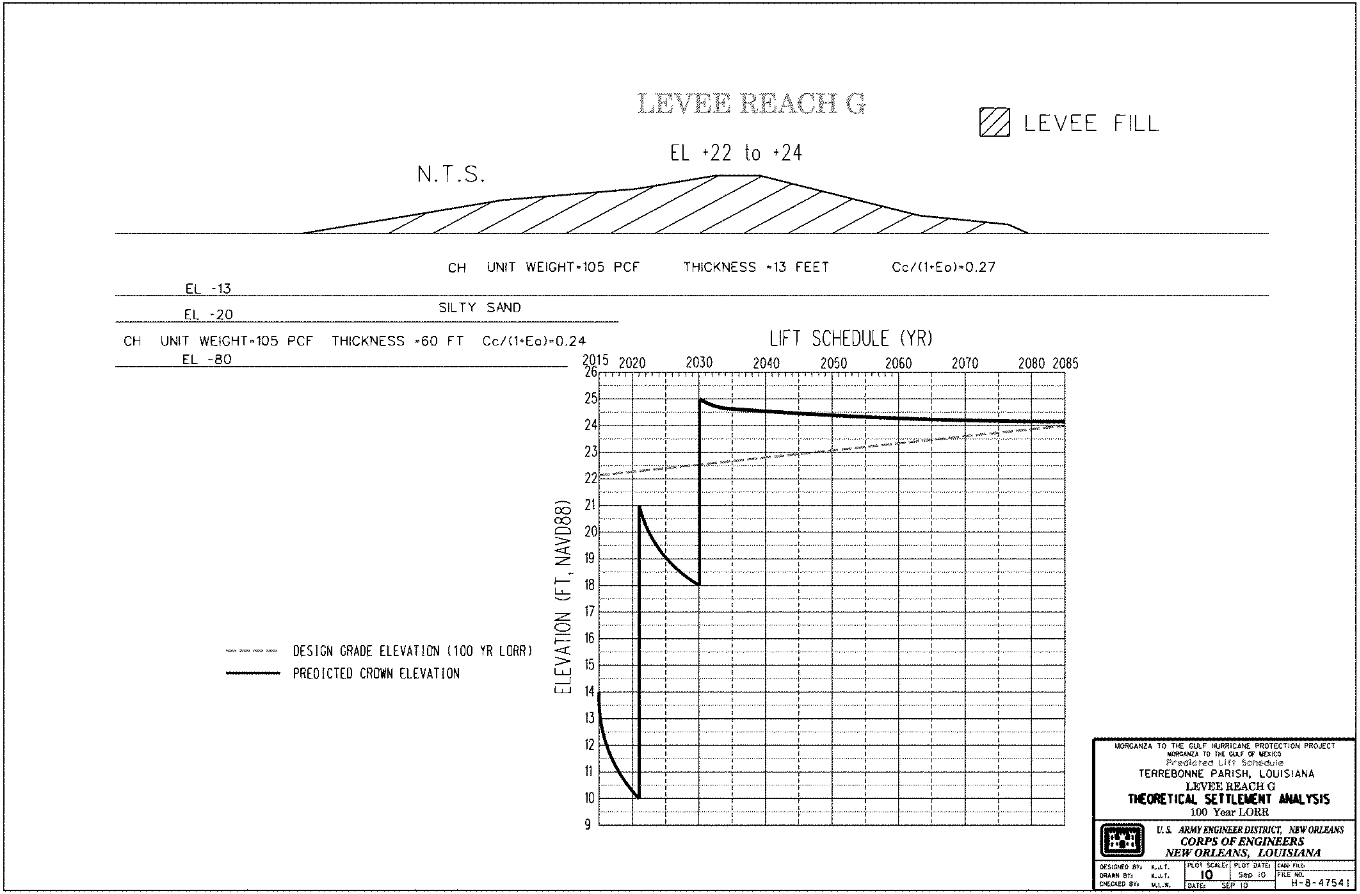
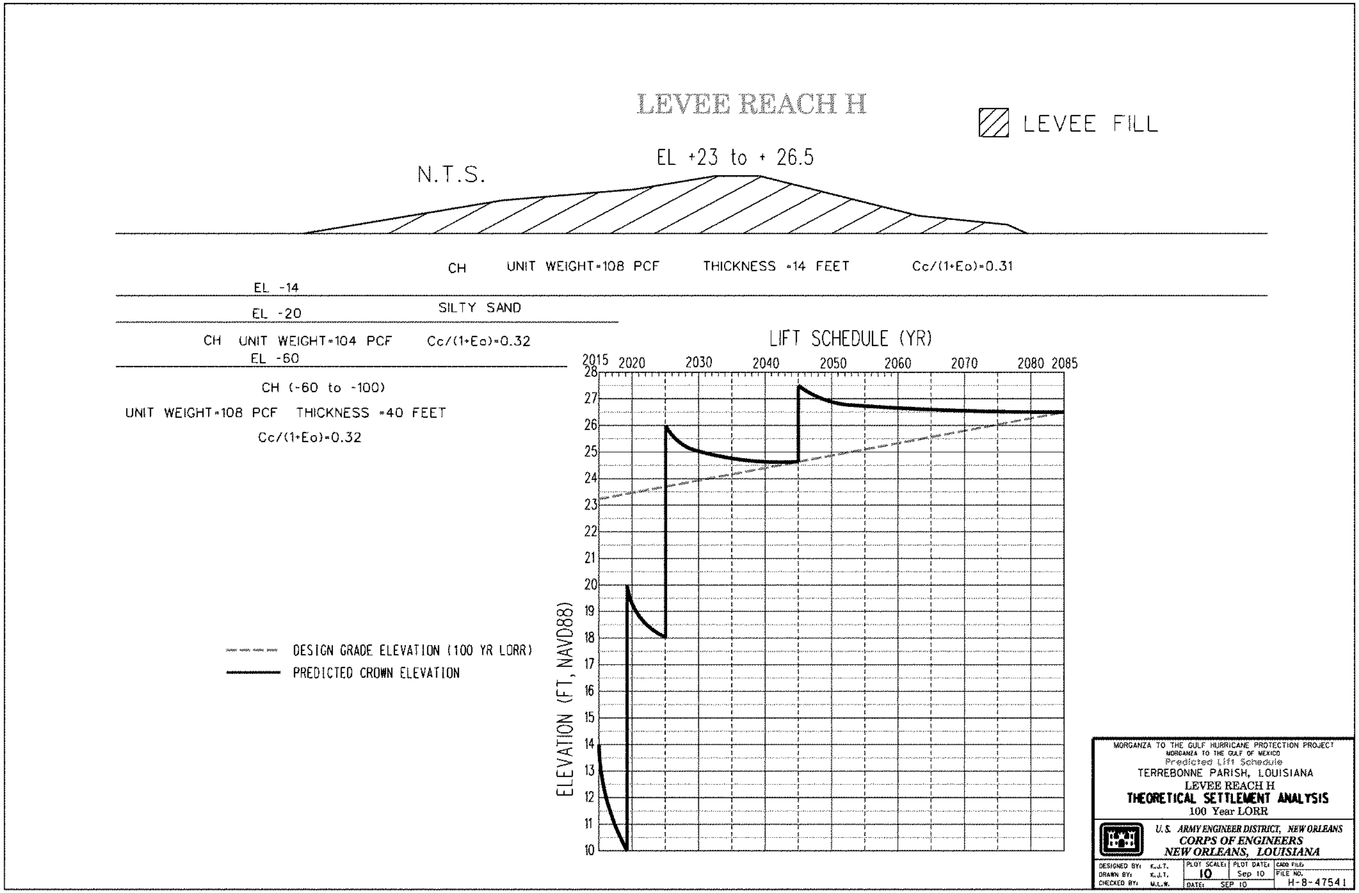
CADD FILE:
FILE NO. H-8-47541

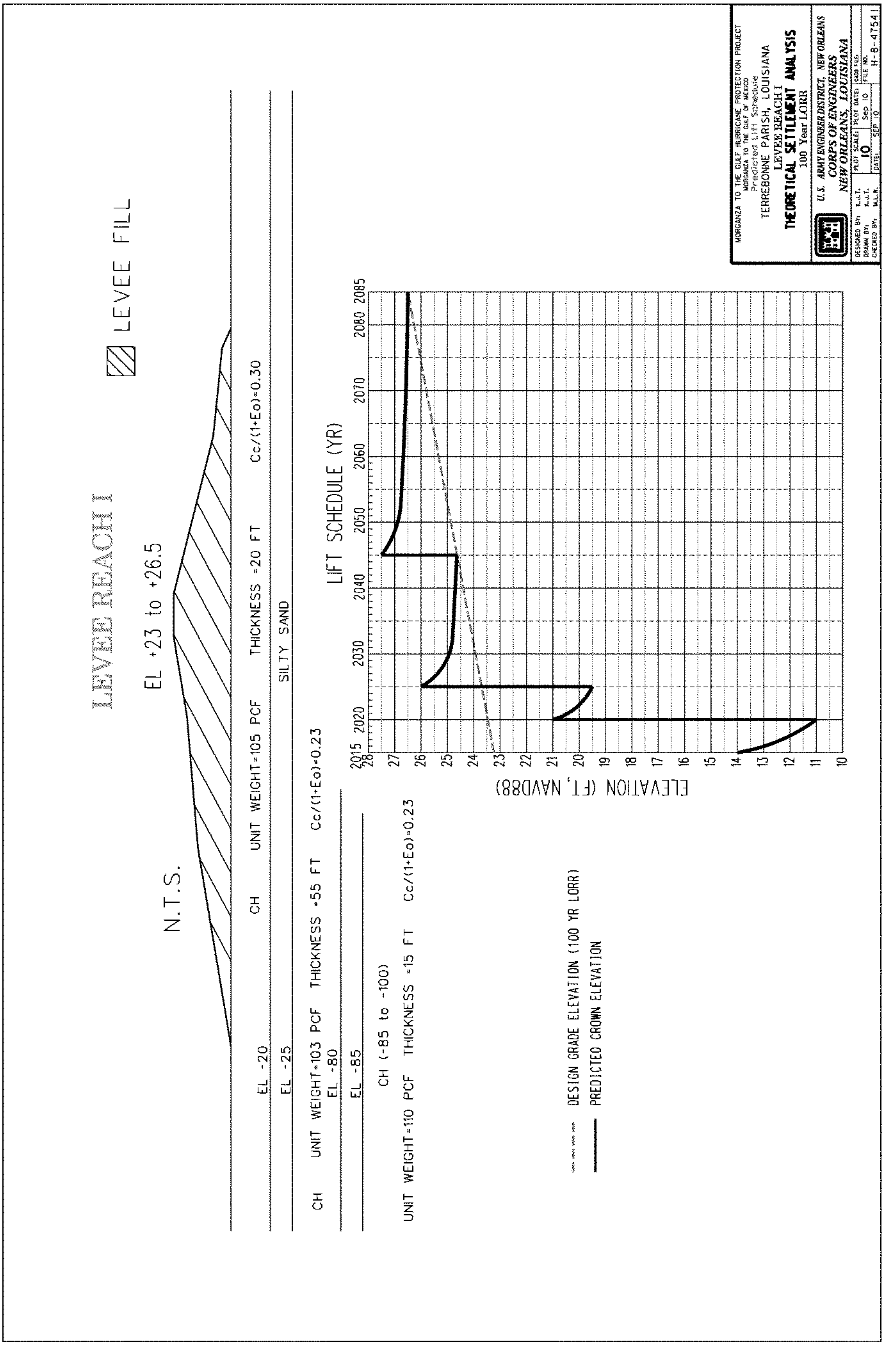

LEVEE REACH F
LEVEE FILL
EL +21.5 to +23.5
N.T.S.
CH UNIT WEIGHT=95 PCF THICKNESS =15 FEET Cc/(1+Eo)=0.32
EL -14
EL -20
SILTY SAND
CH UNIT WEIGHT=104 PCF Cc/(1+Eo)=0.30
EL -85
LIFT SCHEDULE (YR)
2015 2020 2030 2040 2050 2060 2070 2080 2085
ELEVATION (FT, NAVD88)
26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8
DESIGN GRADE ELEVATION (100 YR LORR)
PREDICTED CROWN ELEVATION
MORGANZA TO THE GULF HURRICANE PROTECTION PROJECT
MORGANZA TO THE GULF OF MEXICO
Predicted Lift Schedule
TERREBONNE PARISH, LOUISIANA
LEVEE REACH F
THEORETICAL SETTLEMENT ANALYSIS
100 Year LORR
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA
DESIGNED BY: K.J.T.
DRAWN BY: K.J.T.
CHECKED BY: M.L.W.
PLOT SCALE: 10
PLOT DATE: Sep 10
DATE: SEP 10
CADD FILE:
FILE NO. H-8-47541

SA-4

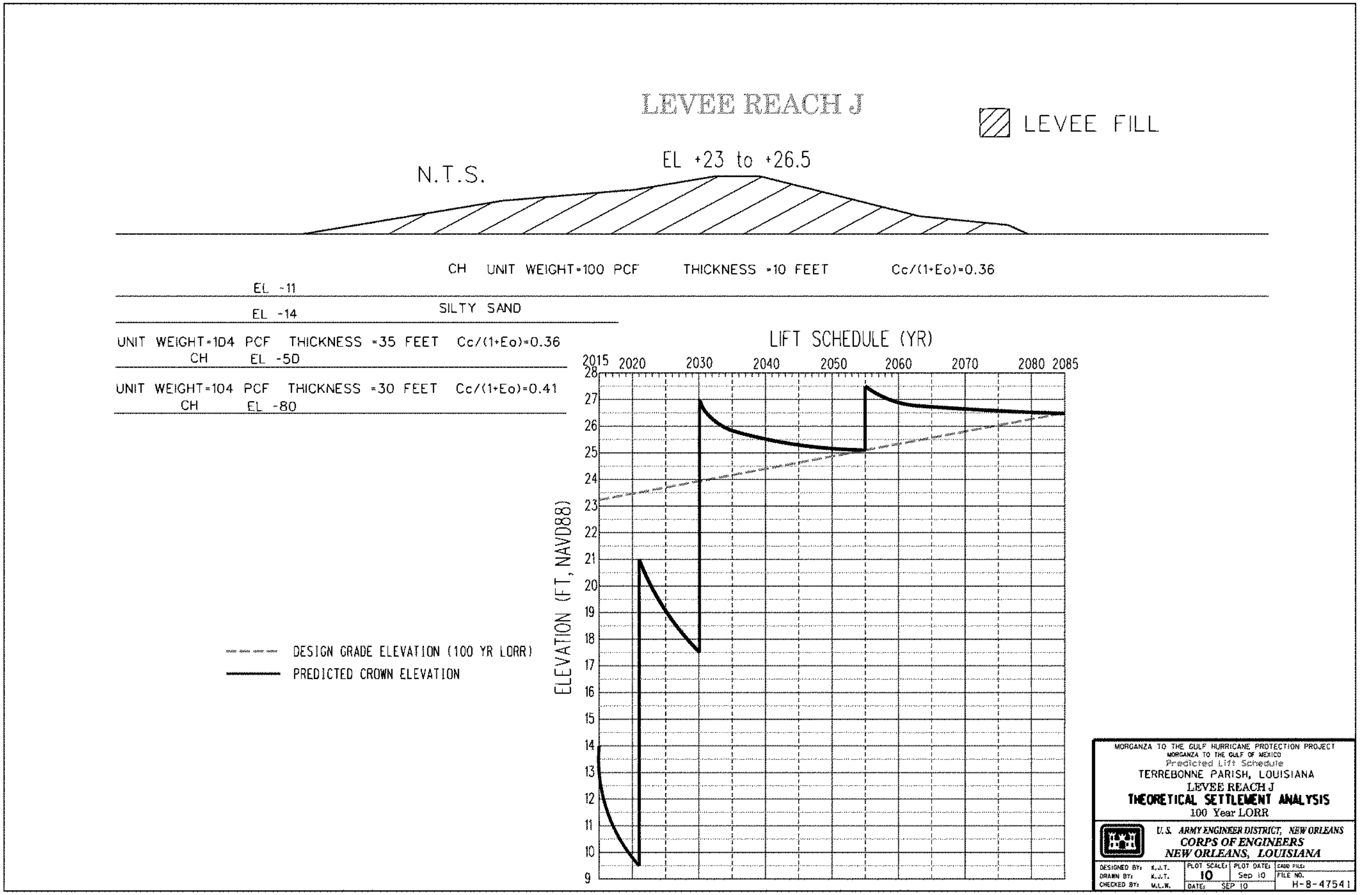

LEVEE REACH G
LEVEE FILL
EL +22 to +24
N.T.S.
CH UNIT WEIGHT=105 PCF THICKNESS =13 FEET Cc/(1+Eo)=0.27
EL -13
SILTY SAND
EL -20
CH UNIT WEIGHT=105 PCF THICKNESS =60 FT Cc/(1+Eo)=0.24
EL -80
LIFT SCHEDULE (YR)
2015 2020 2030 2040 2050 2060 2070 2080 2085
ELEVATION (FT, NAVD88)
26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9
DESIGN GRADE ELEVATION (100 YR LORR)
PREDICTED CROWN ELEVATION
MORGANZA TO THE GULF HURRICANE PROTECTION PROJECT
MORGANZA TO THE GULF OF MEXICO
Predicted Lift Schedule
TERREBONNE PARISH, LOUISIANA
LEVEE REACH G
THEORETICAL SETTLEMENT ANALYSIS
100 Year LORR
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA
DESIGNED BY: K.J.T.
DRAWN BY: K.J.T.
CHECKED BY: M.L.W.
PLOT SCALE: 10
PLOT DATE: Sep 10
DATE: SEP 10
CADD FILE:
FILE NO. H-8-47541

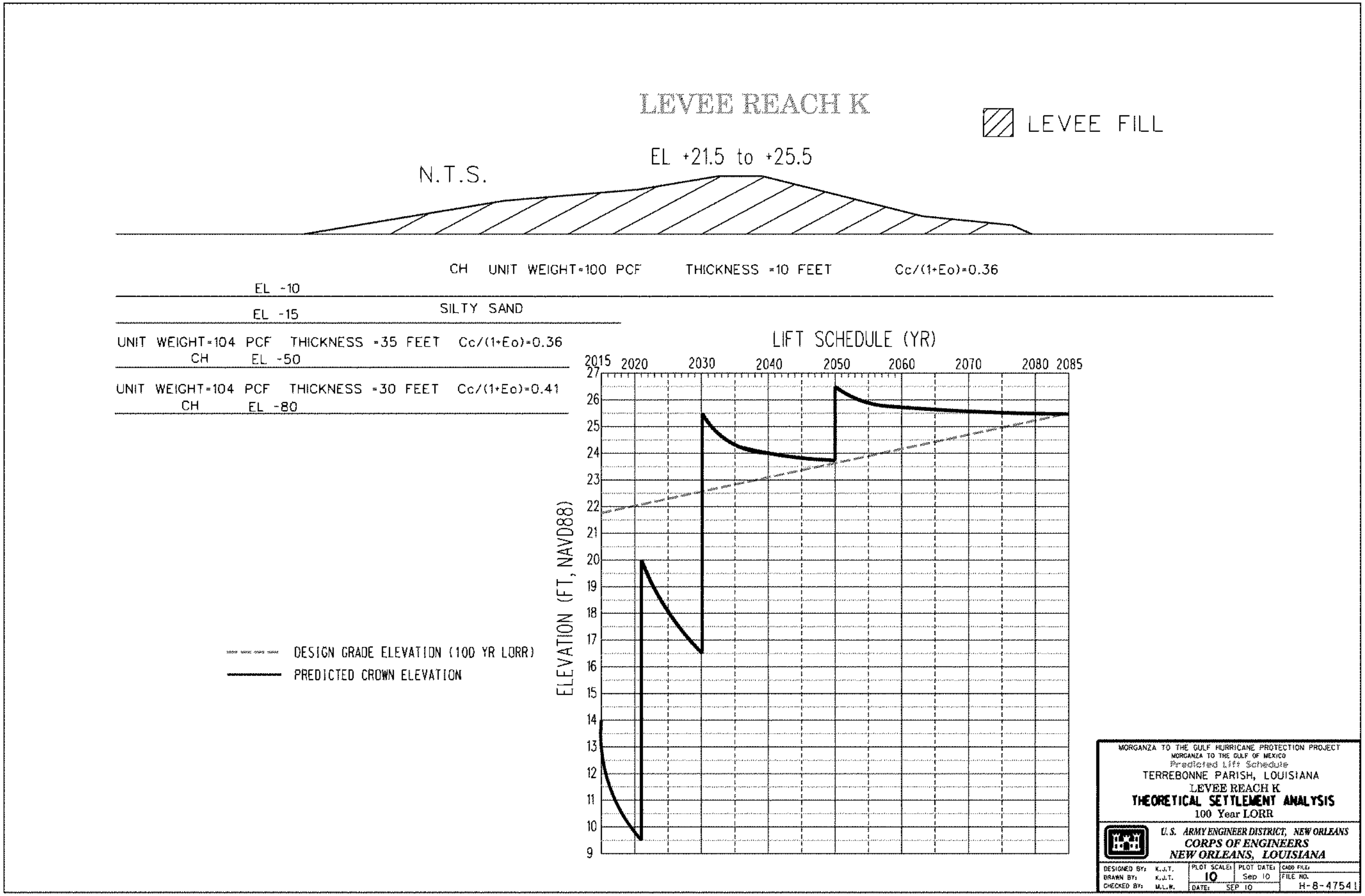

LEVEE REACH H
LEVEE FILL
EL +23 to + 26.5
N.T.S.
CH UNIT WEIGHT=108 PCF THICKNESS =14 FEET Cc/(1+Eo)=0.31
EL -14
EL -20
SILTY SAND
CH UNIT WEIGHT=104 PCF Cc/(1+Eo)=0.32
EL -60
CH (-60 to -100)
UNIT WEIGHT=108 PCF THICKNESS =40 FEET
Cc/(1+Eo)=0.32
LIFT SCHEDULE (YR)
2015 2020 2030 2040 2050 2060 2070 2080 2085
ELEVATION (FT, NAVD88)
28 27 26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10
DESIGN GRADE ELEVATION (100 YR LORR)
PREDICTED CROWN ELEVATION
MORGANZA TO THE GULF HURRICANE PROTECTION PROJECT
MORGANZA TO THE GULF OF MEXICO
Predicted Lift Schedule
TERREBONNE PARISH, LOUISIANA
LEVEE REACH H
THEORETICAL SETTLEMENT ANALYSIS
100 Year LORR
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA
DESIGNED BY: K.J.T.
DRAWN BY: K.J.T.
CHECKED BY: M.L.W.
PLOT SCALE: 10
PLOT DATE: Sep 10
CADD FILE:
FILE NO. H-8-47541
DATE: SEP 10

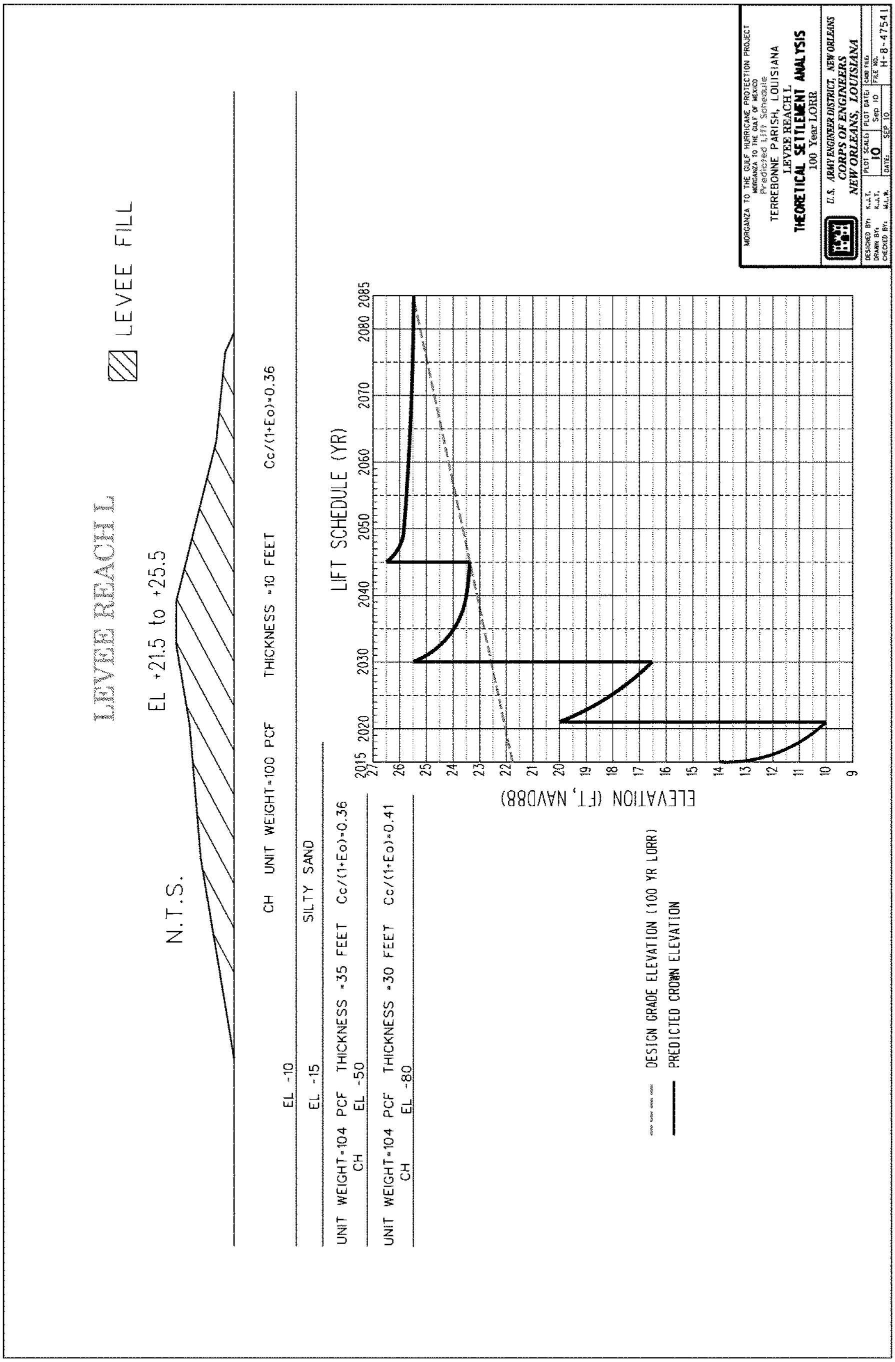
SA-6


LEVEE REACH I
EL +23 to +26.5
N.T.S.
LEVEE FILL
CH UNIT WEIGHT=105 PCF
EL -20
SILTY SAND THICKNESS =20 FT Cc/(1+Eo)=0.30
EL -25
CH UNIT WEIGHT=103 PCF THICKNESS =55 FT Cc/(1+Eo)=0.23
EL -80
EL -85
CH (-85 to -100)
UNIT WEIGHT=110 PCF THICKNESS =15 FT Cc/(1+Eo)=0.23
LIFT SCHEDULE (YR)
ELEVATION (FT, NAVD88)
DESIGN GRADE ELEVATION (100 YR LORR)
PREDICTED CROWN ELEVATION
MORGANZA TO THE GULF HURRICANE PROTECTION PROJECT
MORGANZA TO THE GULF OF MEXICO
Predicted Lift Schedule
TERREBONNE PARISH, LOUISIANA
LEVEE REACH I
THEORETICAL SETTLEMENT ANALYSIS
100 Year LORR
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA
H-8-47541

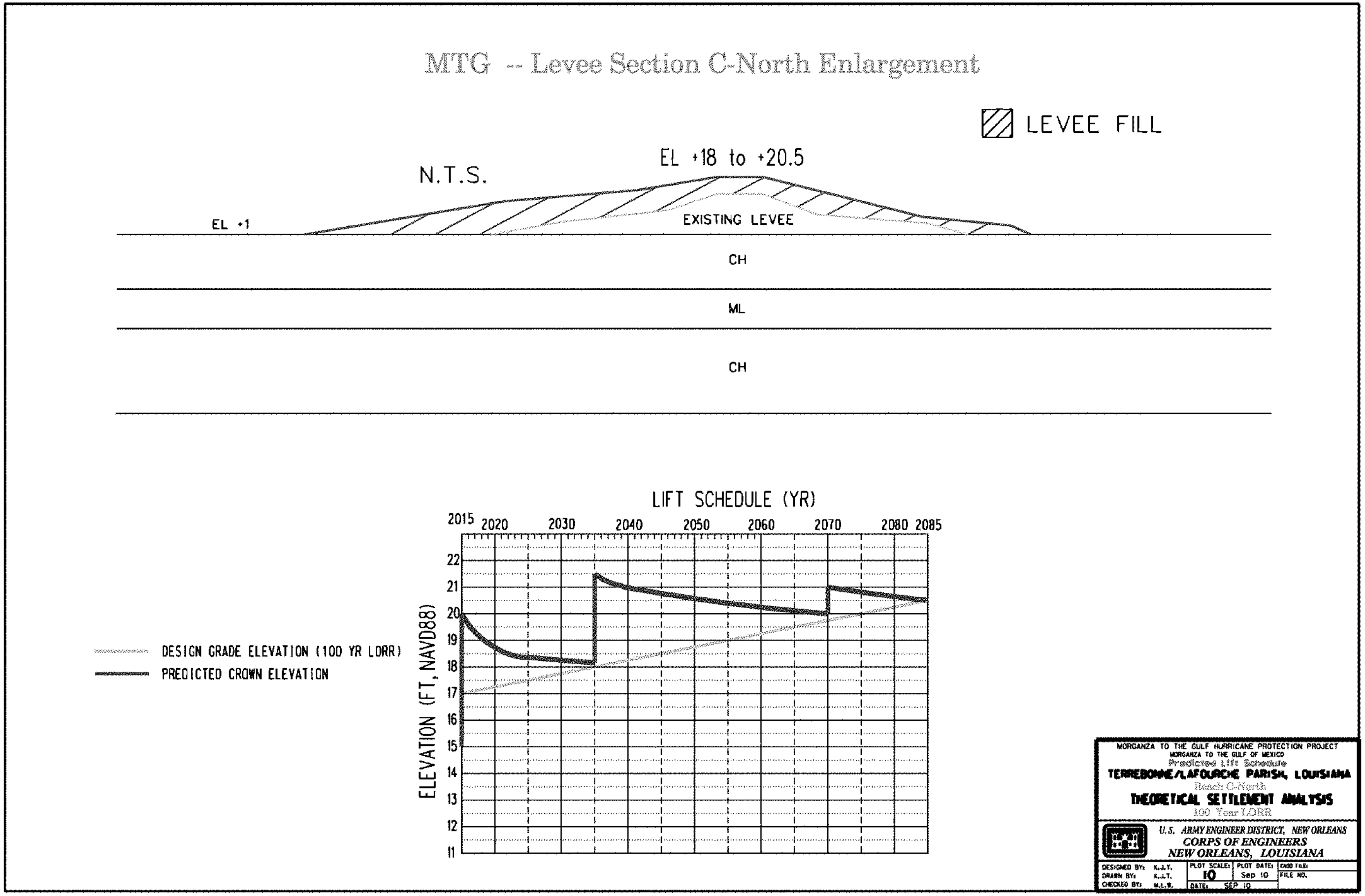
SA-7


LEVEE REACH J
LEVEE FILL
N.T.S.
EL +23 to +26.5
CH UNIT WEIGHT=100 PCF THICKNESS =10 FEET Cc/(1+Eo)=0.36
EL -11
EL -14
SILTY SAND
UNIT WEIGHT=104 PCF THICKNESS =35 FEET Cc/(1+Eo)=0.36
CH EL -50
UNIT WEIGHT=104 PCF THICKNESS =30 FEET Cc/(1+Eo)=0.41
CH EL -80
LIFT SCHEDULE (YR)
2015 2020 2030 2040 2050 2060 2070 2080 2085
ELEVATION (FT, NAVD88)
28 27 26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9
DESIGN GRADE ELEVATION (100 YR LORR)
PREDICTED CROWN ELEVATION
MORGANZA TO THE GULF HURRICANE PROTECTION PROJECT
MORGANZA TO THE GULF OF MEXICO
Predicted Lift Schedule
TERREBONNE PARISH, LOUISIANA
LEVEE REACH J
THEORETICAL SETTLEMENT ANALYSIS
100 Year LORR
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA
DESIGNED BY: K.J.T.
DRAWN BY: K.J.T.
CHECKED BY: M.L.W.
PLOT SCALE: 10
PLOT DATE: Sep 10
DATE: SEP 10
FILE NO. H-8-47541


LEVEE REACH K
LEVEE FILL
EL +21.5 to +25.5
N.T.S.
CH UNIT WEIGHT=100 PCF THICKNESS =10 FEET Cc/(1+Eo)=0.36
EL -10
EL -15
SILTY SAND
UNIT WEIGHT=104 PCF THICKNESS =35 FEET Cc/(1+Eo)=0.36
CH EL -50
UNIT WEIGHT=104 PCF THICKNESS =30 FEET Cc/(1+Eo)=0.41
CH EL -80
LIFT SCHEDULE (YR)
2015 2020 2030 2040 2050 2060 2070 2080 2085
ELEVATION (FT, NAVD88)
27 26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9
DESIGN GRADE ELEVATION (100 YR LORR)
PREDICTED CROWN ELEVATION
MORGANZA TO THE GULF HURRICANE PROTECTION PROJECT
MORGANZA TO THE GULF OF MEXICO
Predicted Lift Schedule
TERREBONNE PARISH, LOUISIANA
LEVEE REACH K
THEORETICAL SETTLEMENT ANALYSIS
100 Year LORR
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA
DESIGNED BY: K.J.T.
DRAWN BY: K.J.T.
CHECKED BY: M.L.W.
PLOT SCALE: 10
PLOT DATE: Sep 10
DATE: SEP 10
CADD FILE:
FILE NO. H-8-47541


LEVEE REACH L
EL +21.5 to +25.5
N.T.S.
LEVEE FILL
EL -10
CH UNIT WEIGHT=100 PCF THICKNESS =10 FEET Cc/(1+Eo)=0.36
EL -15
SILTY SAND
UNIT WEIGHT=104 PCF THICKNESS =35 FEET Cc/(1+Eo)=0.36
CH EL -50
UNIT WEIGHT=104 PCF THICKNESS =30 FEET Cc/(1+Eo)=0.41
CH EL -80
LIFT SCHEDULE (YR)
2015 2020 2030 2040 2050 2060 2070 2080 2085
ELEVATION (FT, NAVD88)
27 26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9
DESIGN GRADE ELEVATION (100 YR LORR)
PREDICTED CROWN ELEVATION
MORGANZA TO THE GULF HURRICANE PROTECTION PROJECT
MORGANZA TO THE GULF OF MEXICO
Predicted Lift Schedule
TERREBONNE PARISH, LOUISIANA
LEVEE REACH L
THEORETICAL SETTLEMENT ANALYSIS
100 Year LORR
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA
H-8-47541

SA-10


MTG -- Levee Section C-North Enlargement
LEVEE FILL
N.T.S.
EL +18 to +20.5
EL +1
EXISTING LEVEE
CH
ML
CH
LIFT SCHEDULE (YR)
2015 2020 2030 2040 2050 2060 2070 2080 2085
ELEVATION (FT, NAVD88)
22 21 20 19 18 17 16 15 14 13 12 11
DESIGN GRADE ELEVATION (100 YR LORR)
PREDICTED CROWN ELEVATION
MORGANZA TO THE GULF HURRICANE PROTECTION PROJECT
MORGANZA TO THE GULF OF MEXICO
Predicted Lift Schedule
TERREBONNE/LAFOURCHE PARISH, LOUISIANA
Reach C-North
THEORETICAL SETTLEMENT ANALYSIS
100 Year LORR
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA
DESIGNED BY: K.J.T.
DRAWN BY: K.J.T.
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PLOT SCALE: 10
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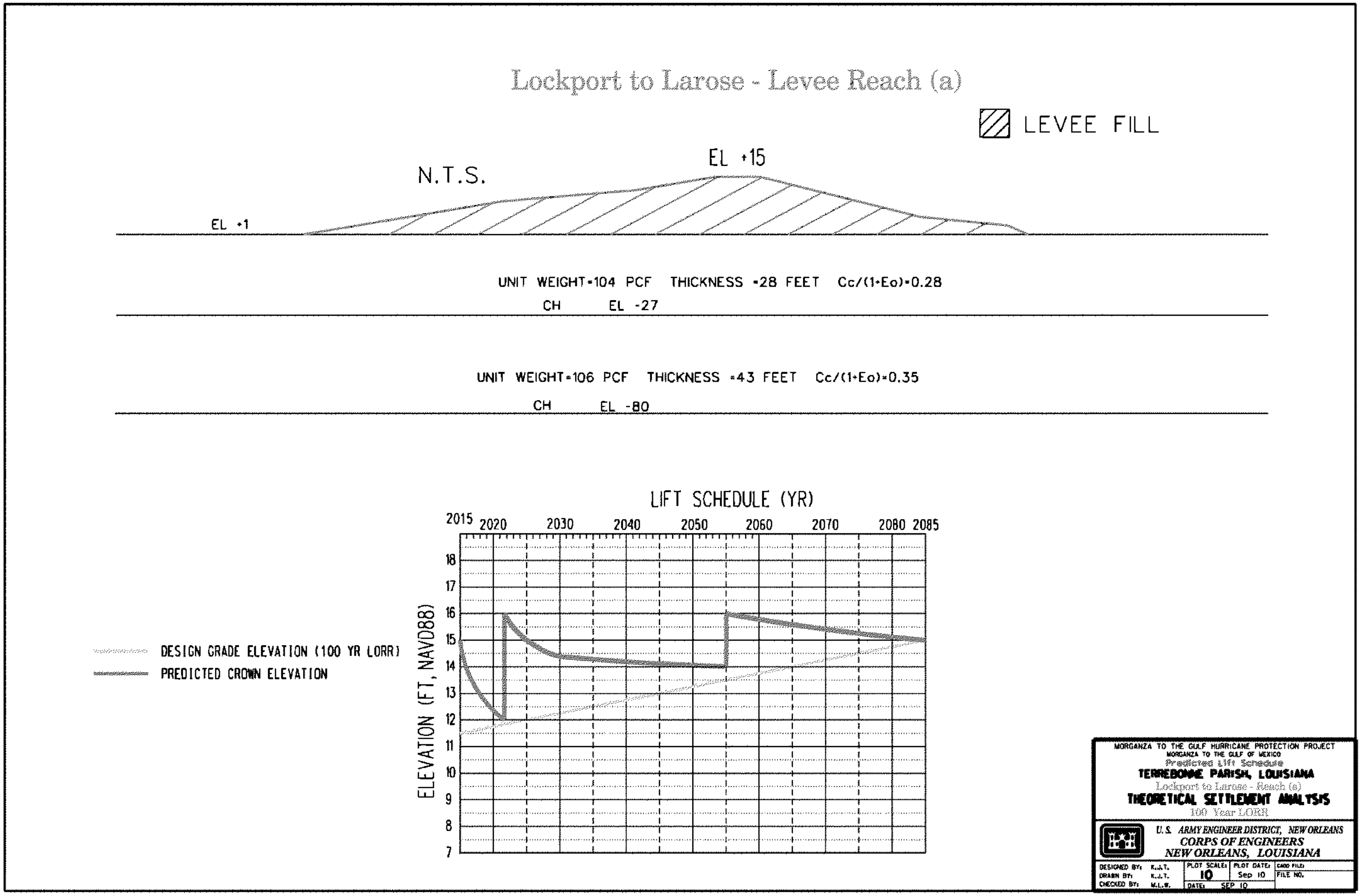
PLATE: SA-11



Lockport to Larose - Levee Reach (a)
LEVEE FILL
N.T.S.
EL +15
EL +1
UNIT WEIGHT=104 PCF THICKNESS =28 FEET Cc/(1+Eo)=0.28
CH EL -27
UNIT WEIGHT=106 PCF THICKNESS =43 FEET Cc/(1+Eo)=0.35
CH EL -80
LIFT SCHEDULE (YR)
2015 2020 2030 2040 2050 2060 2070 2080 2085
ELEVATION (FT, NAVD88)
18 17 16 15 14 13 12 11 10 9 8 7
DESIGN GRADE ELEVATION (100 YR LORR)
PREDICTED CROWN ELEVATION
MORGANZA TO THE GULF HURRICANE PROTECTION PROJECT
MORGANZA TO THE GULF OF MEXICO
Predicted Lift Schedule
TERREBONNE PARISH, LOUISIANA
Lockport to Larose - Reach (a)
THEORETICAL SETTLEMENT ANALYSIS
100 Year LORR
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA
DESIGNED BY: K.J.T.
DRAWN BY: K.J.T.
CHECKED BY: M.L.W.
PLOT SCALE: 10
PLOT DATE: Sep 10
DATE: SEP 10
CADD FILE:
FILE NO.


PLATE SA-12

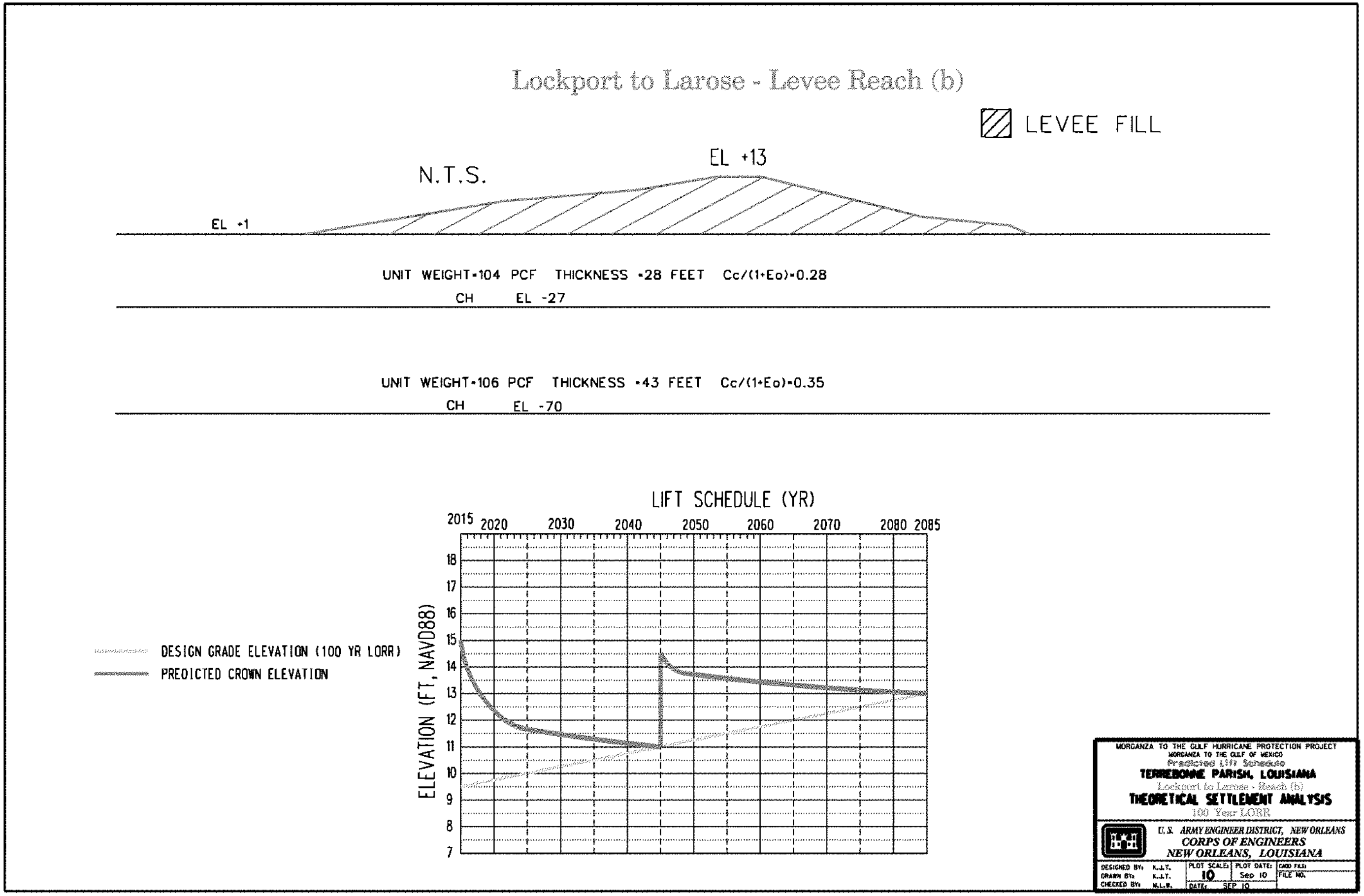
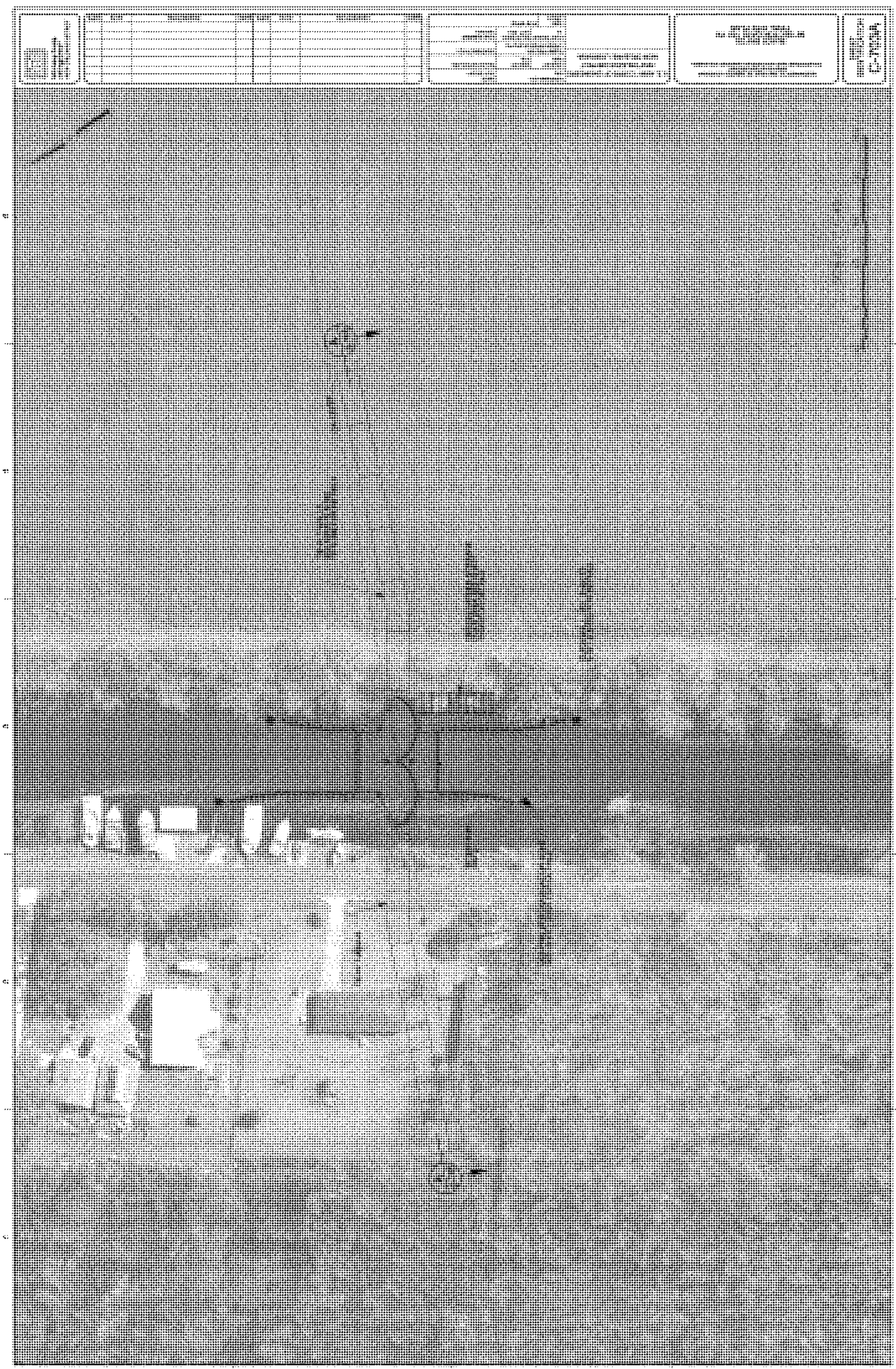
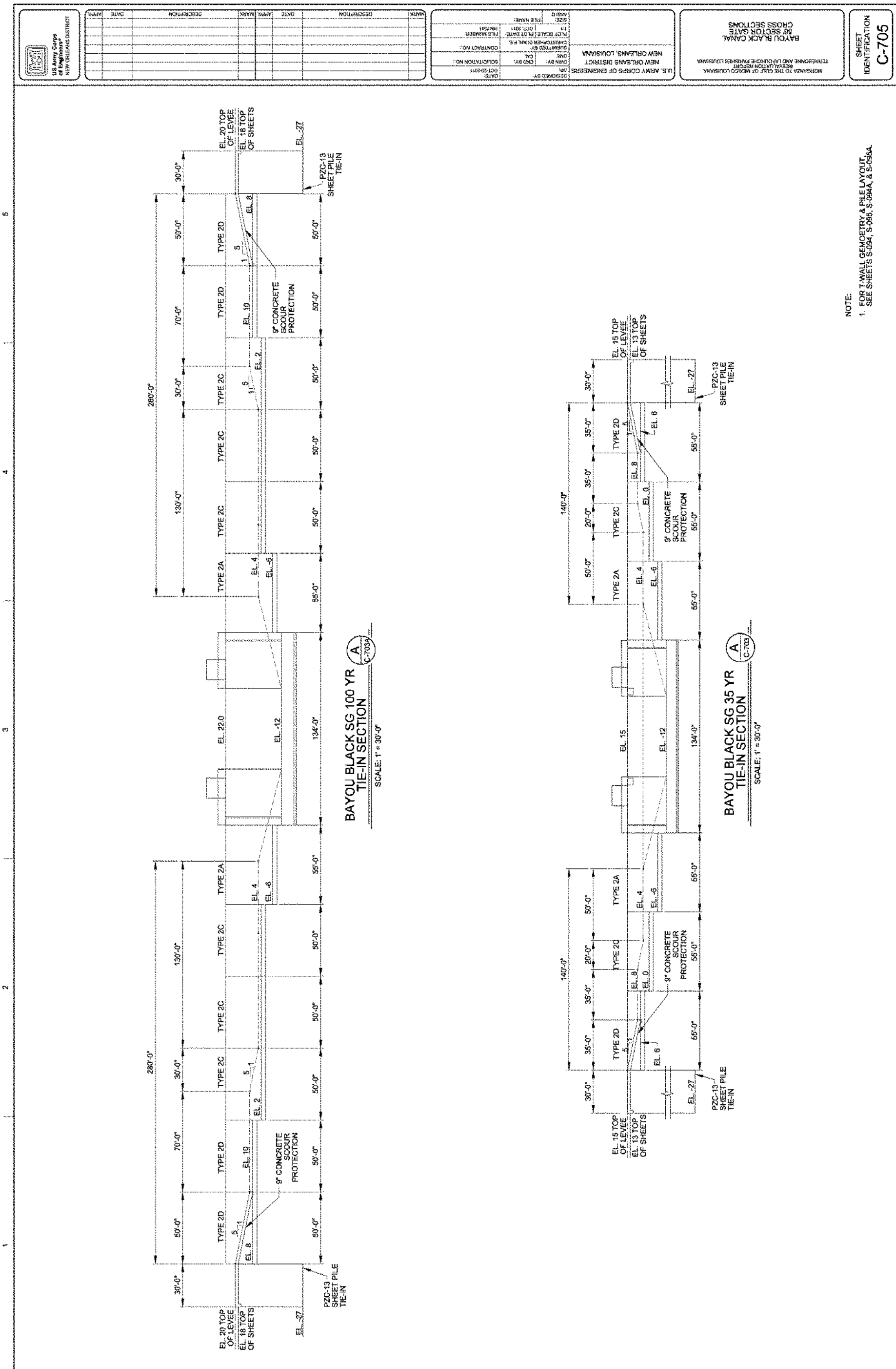
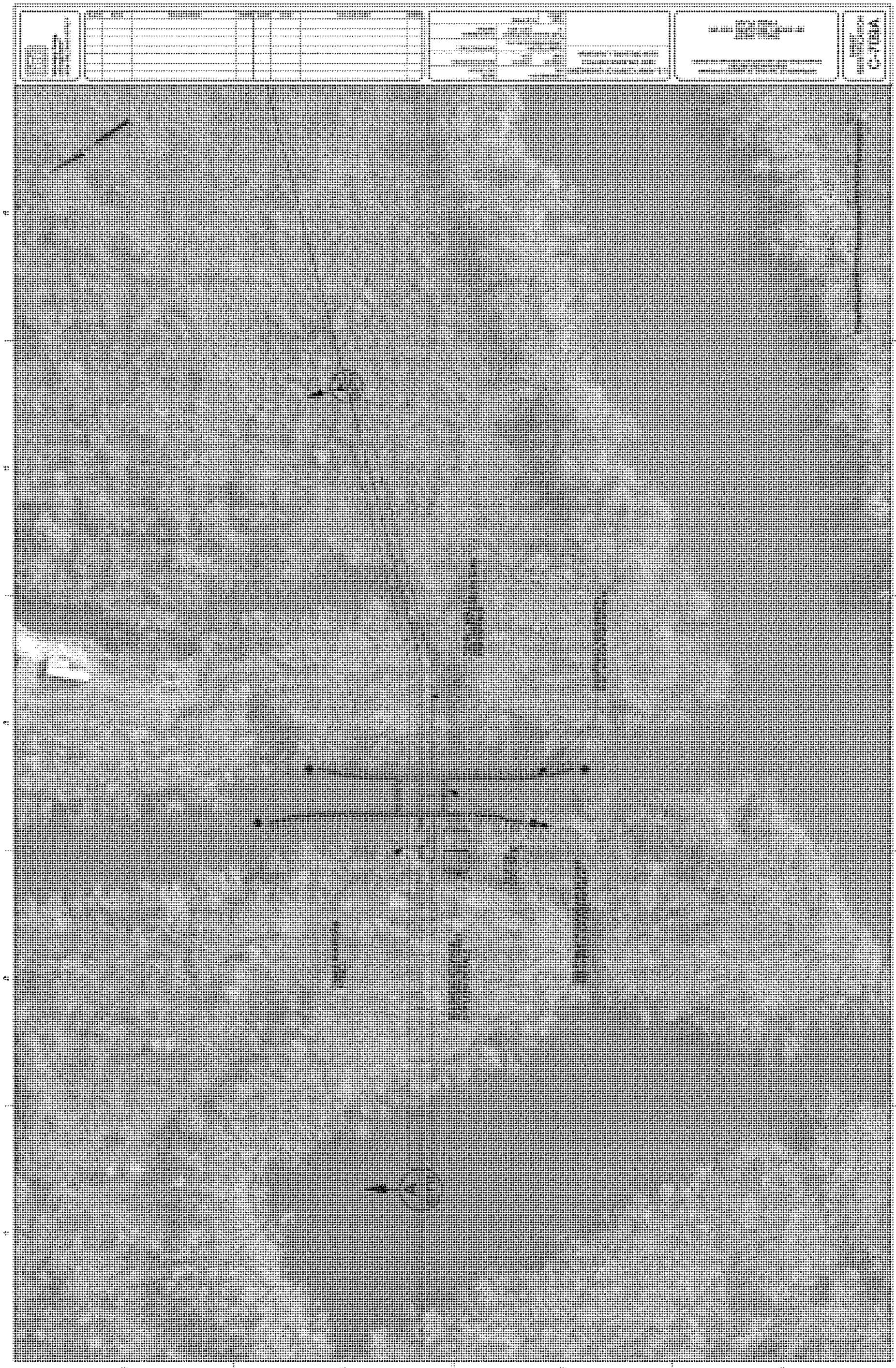
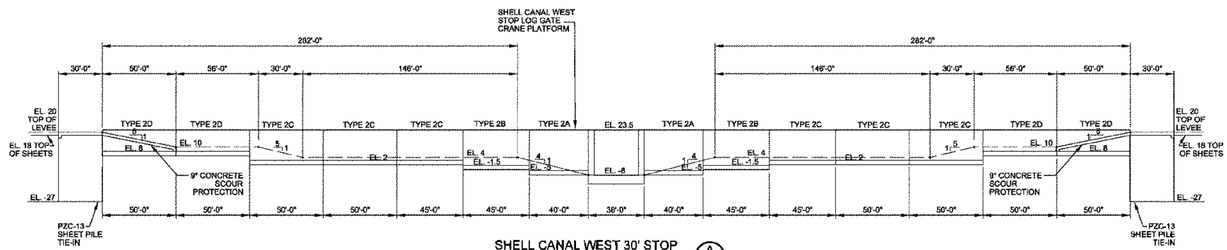

Lockport to Larose - Levee Reach (b)
LEVEE FILL
N.T.S.
EL +13
EL +1
UNIT WEIGHT=104 PCF THICKNESS =28 FEET Cc/(1+Eo)=0.28
CH EL -27
UNIT WEIGHT=106 PCF THICKNESS =43 FEET Cc/(1+Eo)=0.35
CH EL -70
LIFT SCHEDULE (YR)
2015 2020 2030 2040 2050 2060 2070 2080 2085
ELEVATION (FT, NAVD88)
18 17 16 15 14 13 12 11 10 9 8 7
DESIGN GRADE ELEVATION (100 YR LORR)
PREDICTED CROWN ELEVATION
MORGANZA TO THE GULF HURRICANE PROTECTION PROJECT
MORGANZA TO THE GULF OF MEXICO
Predicted Lift Schedule
TERREBONNE PARISH, LOUISIANA
Lockport to Larose - Reach (b)
THEORETICAL SETTLEMENT ANALYSIS
100 Year LORR
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA
DESIGNED BY: K.J.T.
DRAWN BY: K.J.T.
CHECKED BY: M.L.B.
PLOT SCALE: 10
PLOT DATE: Sep 10
DATE: SEP 10
CADD FILE:
FILE NO.

PLATE SA-13



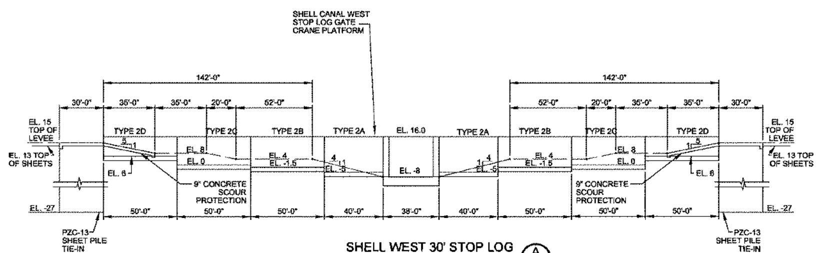

BAYOU BLACK SG 100 YR TIE-IN SECTION
SCALE: 1" = 30'-0"
BAYOU BLACK SG 35 YR TIE-IN SECTION
SCALE: 1" = 30'-0"
EL. 20 TOP OF LEVEE
EL. 18 TOP OF SHEETS
EL. 15 TOP OF LEVEE
EL. 13 TOP OF SHEETS
PZC-13 SHEET PILE TIE-IN
9" CONCRETE SCOUR PROTECTION
NOTE:
1. FOR T-WALL GEOMETRY & PILE LAYOUT, SEE SHEETS S-094, S-095, S-094A, & S-095A.
US Army Corps of Engineers NEW ORLEANS DISTRICT
U.S. ARMY CORPS OF ENGINEERS NEW ORLEANS DISTRICT NEW ORLEANS, LOUISIANA
MORGANZA TO THE GULF OF MEXICO LOUISIANA REEVALUATION REPORT TERREBONNE AND LAFOURCHE PARISHES LOUISIANA
BAYOU BLACK CANAL 56' SECTOR GATE CROSS SECTIONS
SHEET IDENTIFICATION
C-705






SHELL CANAL WEST 30' STOP LOG GATE 100 YR TIE-IN SECTION (A / C-708A)

SCALE: 1' = 30'-0"




SHELL WEST 30' STOP LOG GATE 35 YR TIE-IN SECTION (A / C-709)

SCALE: 1' = 30'-0"

NOTE:

1. FOR T-WALL GEOMETRY & PILE LAYOUT, SEE SHEETS S-094, S-094A, S-095 & S-095A.

US Army Corps of Engineers
NEW ORLEANS DISTRICT

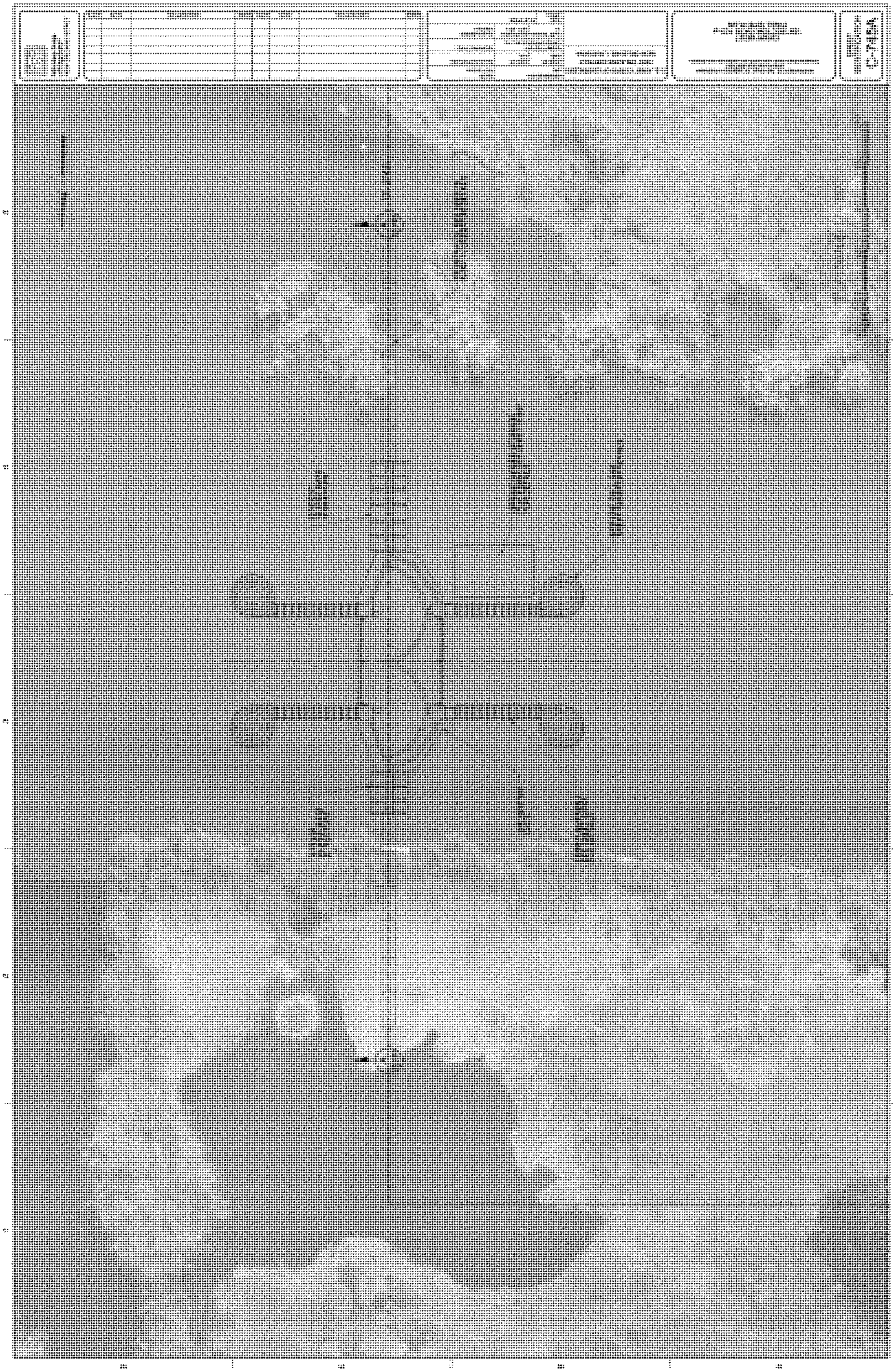
U.S. ARMY CORPS OF ENGINEERS
NEW ORLEANS DISTRICT
NEW ORLEANS, LOUISIANA

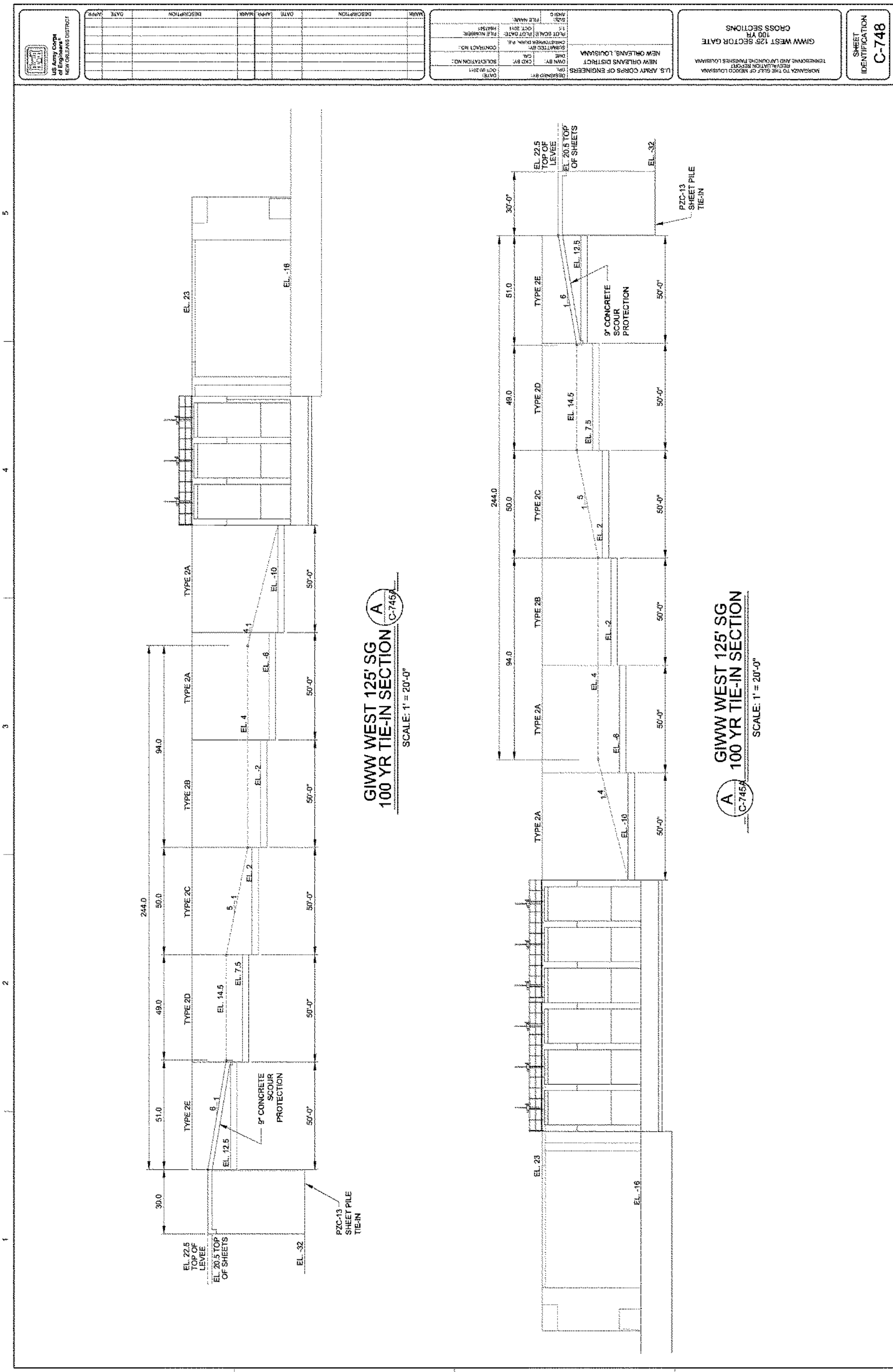
MORGANZA TO THE GULF OF MEXICO LOUISIANA
TERREBONNE AND LAFOURCHE PARISHES LOUISIANA

SHELL CANAL WEST
30' SECTOR GATE
CROSS SECTIONS

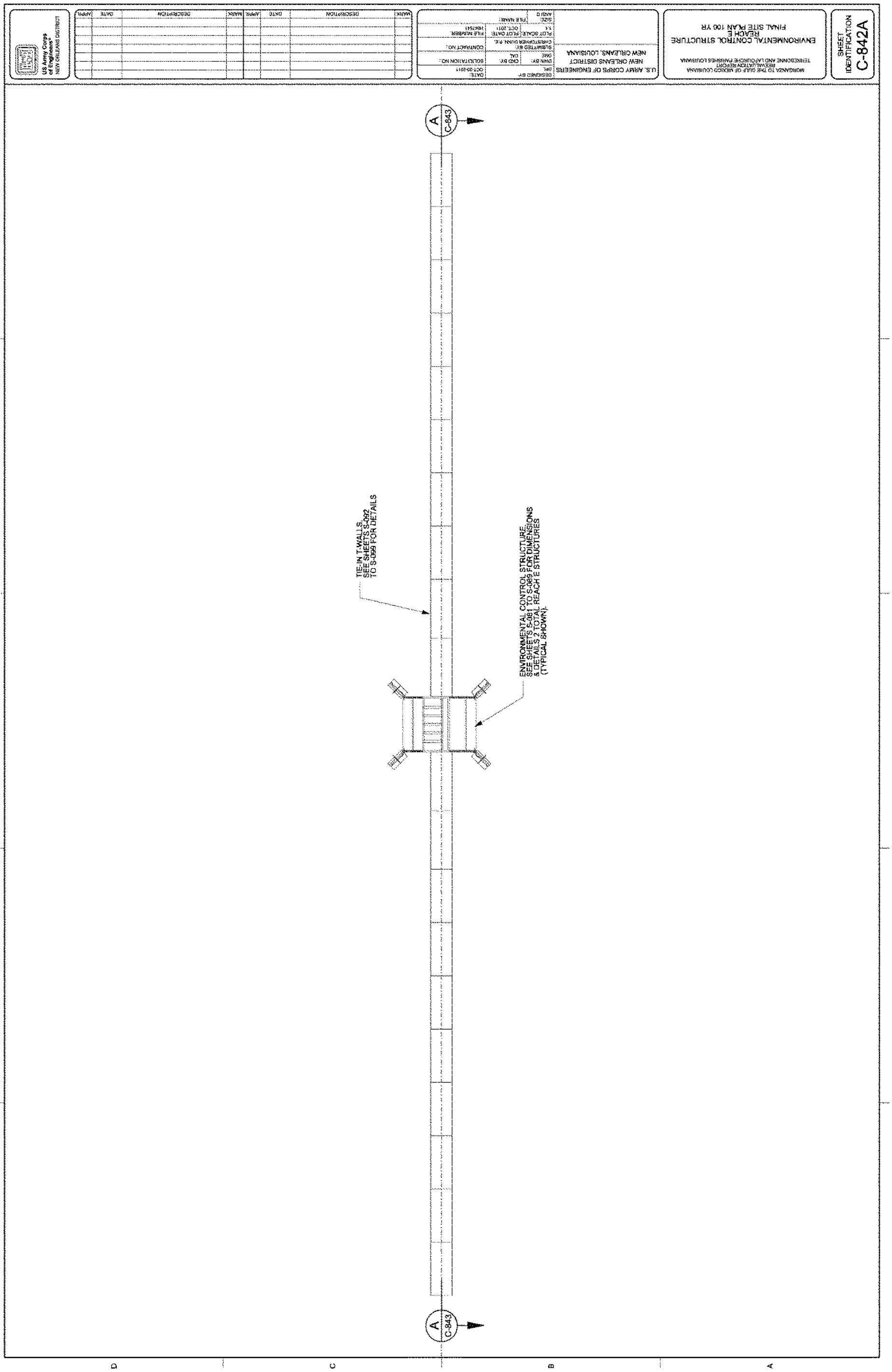
SHEET IDENTIFICATION

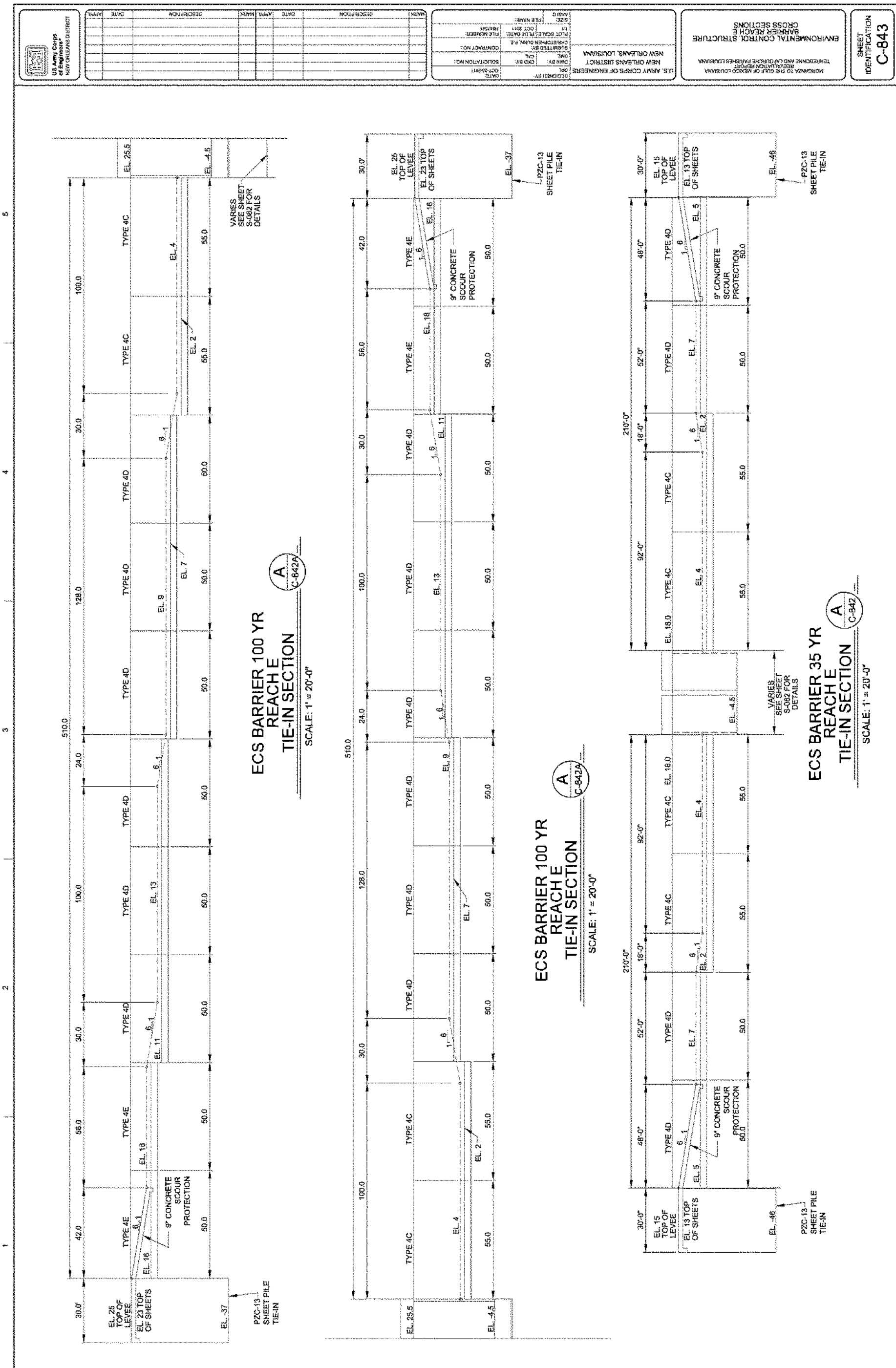
C-711





US Army Corps of Engineers
NEW ORLEANS DISTRICT
U.S. ARMY CORPS OF ENGINEERS
NEW ORLEANS DISTRICT
NEW ORLEANS, LOUISIANA
MORGANZA TO THE GULF OF MEXICO LOUISIANA
REEVALUATION REPORT
TERREBONNE AND LAFOURCHE PARISHES LOUISIANA
GIWW WEST 125' SECTOR GATE
100 YR
CROSS SECTIONS
SHEET IDENTIFICATION
C-748
GIWW WEST 125' SG
100 YR TIE-IN SECTION
SCALE: 1" = 20'-0"
A
C-745A
EL. 22.5 TOP OF LEVEE
EL. 20.5 TOP OF SHEETS
EL. -32
PZC-13 SHEET PILE TIE-IN
30.0
51.0
49.0
50.0
94.0
244.0
TYPE 2E
TYPE 2D
TYPE 2C
TYPE 2B
TYPE 2A
9" CONCRETE SCOUR PROTECTION
EL. 12.5
EL. 14.5
EL. 7.5
EL. 2
EL. -2
EL. 4
EL. -6
EL. -10
EL. 23
EL. -16
50'-0"


US Army Corps of Engineers
NEW ORLEANS DISTRICT
U.S. ARMY CORPS OF ENGINEERS
NEW ORLEANS DISTRICT
NEW ORLEANS, LOUISIANA
MORGANZA TO THE GULF OF MEXICO LOUISIANA
REEVALUATION REPORT
TERREBONNE AND LAFOURCHE PARISHES LOUISIANA
ENVIRONMENTAL CONTROL STRUCTURE
REACH E
FINAL SITE PLAN 100 YR
SHEET IDENTIFICATION
C-842A
TIE-IN T-WALLS,
SEE SHEETS S-092
TO S-099 FOR DETAILS
ENVIRONMENTAL CONTROL STRUCTURE,
SEE SHEETS S-081 TO S-089 FOR DIMENSIONS
& DETAILS 2 TOTAL REACH E STRUCTURES
(TYPICAL SHOWN).
A
C-843
A
C-843


ECS BARRIER 100 YR
REACH E
TIE-IN SECTION
SCALE: 1' = 20'-0"
ECS BARRIER 100 YR
REACH E
TIE-IN SECTION
SCALE: 1' = 20'-0"
ECS BARRIER 35 YR
REACH E
TIE-IN SECTION
SCALE: 1' = 20'-0"
U.S. ARMY CORPS OF ENGINEERS
NEW ORLEANS DISTRICT
NEW ORLEANS, LOUISIANA
ENVIRONMENTAL CONTROL STRUCTURE
BARRIER REACH E
CROSS SECTIONS
SHEET IDENTIFICATION
C-843

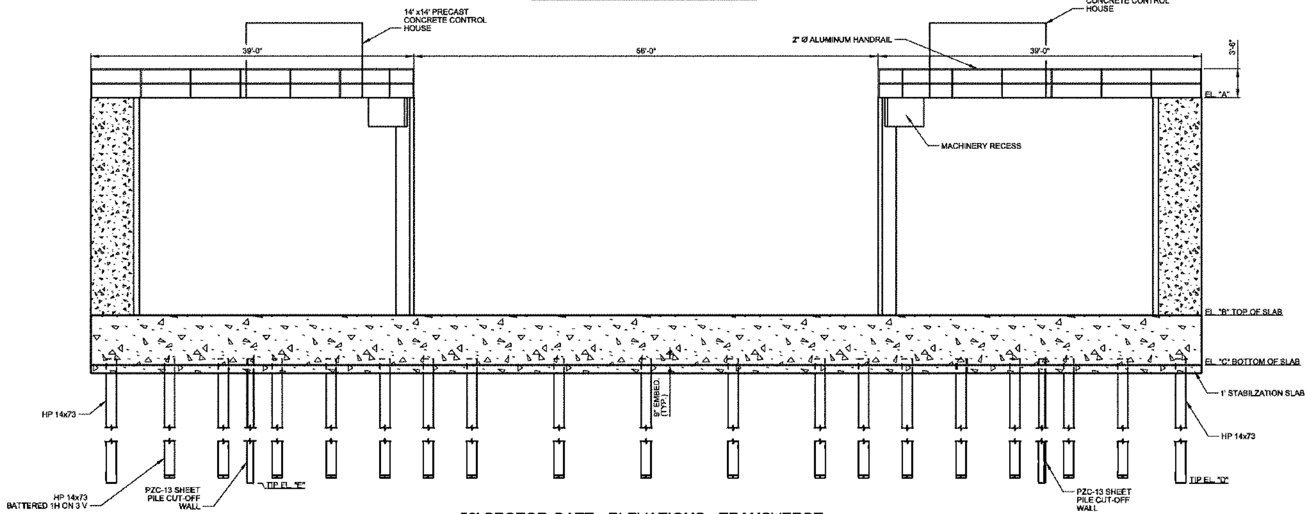
NOTES:

1.) ALL H PILES AND SHEET PILES SHALL MEET THE REQUIREMENTS OF ATM A572, GRADE 50.

2.) ALL CONCRETE SHALL HAVE A MINIMUM 28 DAY COMPRESSIVE STRENGTH OF 4000 PSI.

3.) ALL HANDRAIL SHALL BE 2"Ø ALUMINUM PIPE ALLOY 6061-T6 WITH FLANGE FITTINGS.

| LOCATION | "A" | "B" | "C" | "D" | "E" |
|---|---|---|---|---|---|
| MINORS CANAL | 23.0 | -9.0 | -17.0 | -124.0 | -50 |
| FALGOUT CANAL | 23.0 | -9.0 | -17.0 | -116.0 | -62 |
| BAYOU DULARGE | 25.5 | -7.0 | -15.0 | -116.0 | -69 |
| BAYOU GRAND CAILLOU | 25.5 | -12.0 | -21.5 | -128.5 | -54 |
| SHELL CANAL EAST | 23.5 | -12.0 | -21.5 | -111.0 | -48 |
| BAYOU BLACK | 22.0 | -12.0 | -21.5 | -111.0 | -48 |
| PLACID CANAL | 31.5 | -8.0 | -18.5 | -160.0 | -69 |
| BAYOU PETITE | 30.5 | -8.0 | -18.0 | -157.0 | -79 |
| GRAND BAYOU | 29.5 | -9.0 | -19.0 | -151.0 | -63 |
| POINT AUX CHENES | 33.0 | -6.0 | -16.0 | -137.0 | -79 |
| BAYOU TERREBONNE | 33.0 | -9.0 | -20.0 | -67.0 | -73 |
| HUMBLE CANAL | 33.0 | -9.0 | -20.0 | -129.5 | -103 |
| BUSH CANAL | 33.0 | -12.0 | -24.0 | -124.0 | -71 |
| LAROSE FG | 17.0 | -12.3 | -19.8 | -126.0 | -46 |




## 56' SECTOR GATE - ELEVATIONS - TRANSVERSE

SCALE: 3/8" = 1'-0"

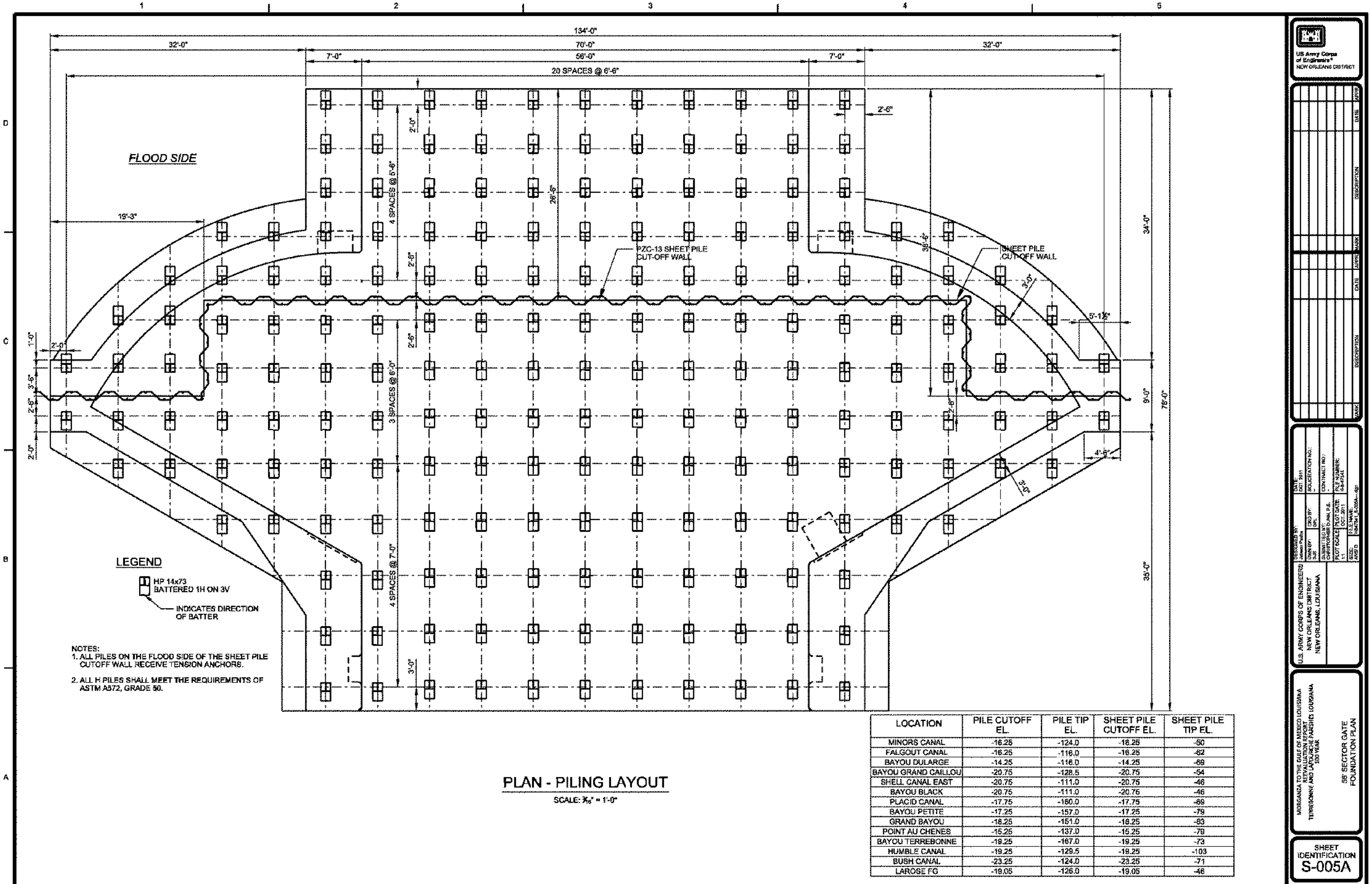
US Army Corps of Engineers®
NEW ORLEANS DISTRICT

U.S. ARMY CORPS OF ENGINEERS
NEW ORLEANS DISTRICT
NEW ORLEANS, LOUISIANA

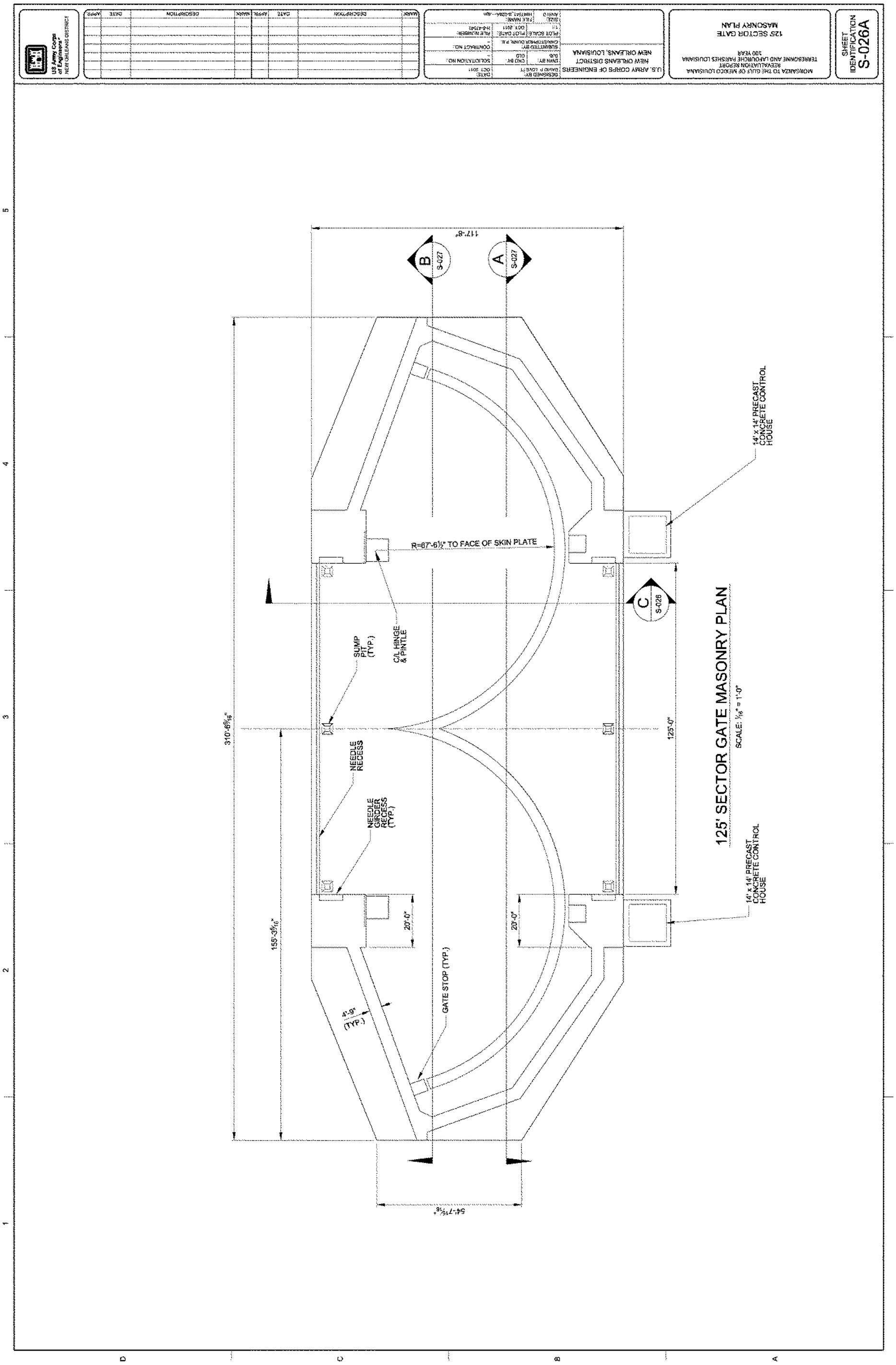
MORGANZA TO THE GULF OF MEXICO LOUISIANA
REEVALUATION REPORT
TERREBONNE AND LAFOURCHE PARISHES LOUISIANA
100 YEAR

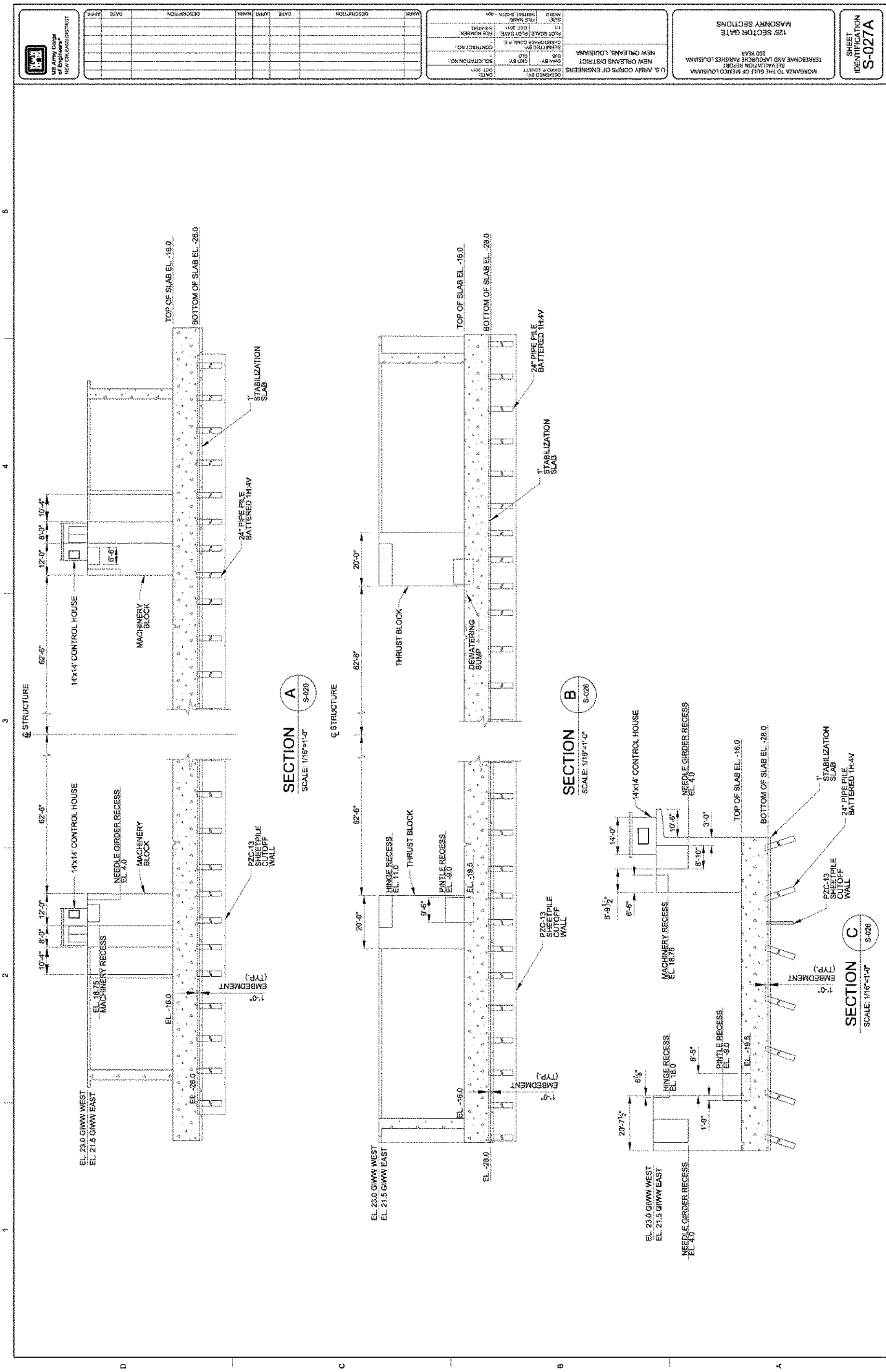
56' SECTOR GATE
MASONRY ELEVATION
TRANSVERSE

SHEET IDENTIFICATION
S-003A

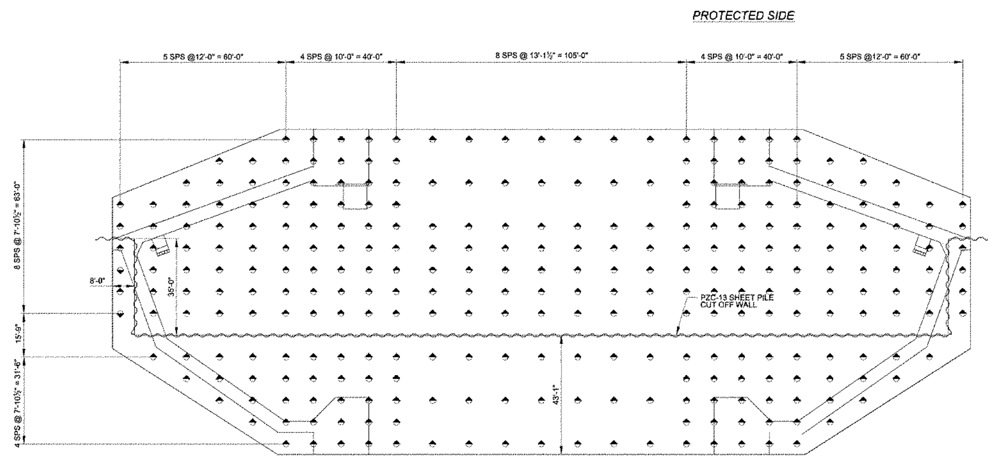



| LOCATION | PILE CUTOFF EL. | PILE TIP EL. | SHEET PILE CUTOFF EL. | SHEET PILE TIP EL. |
|---|---|---|---|---|
| MINORS CANAL | -16.25 | -124.0 | -16.25 | -50 |
| FALGOUT CANAL | -16.25 | -116.0 | -16.25 | -62 |
| BAYOU DULARGE | -14.25 | -116.0 | -14.25 | -69 |
| BAYOU GRAND CAILLOU | -20.75 | -128.5 | -20.75 | -54 |
| SHELL CANAL EAST | -20.75 | -111.0 | -20.75 | -46 |
| BAYOU BLACK | -20.75 | -111.0 | -20.75 | -46 |
| PLACID CANAL | -17.75 | -160.0 | -17.75 | -69 |
| BAYOU PETITE | -17.25 | -157.0 | -17.25 | -79 |
| GRAND BAYOU | -18.25 | -151.0 | -18.25 | -83 |
| POINT AU CHENES | -15.25 | -137.0 | -15.25 | -79 |
| BAYOU TERREBONNE | -19.25 | -167.0 | -19.25 | -73 |
| HUMBLE CANAL | -19.25 | -129.5 | -19.25 | -103 |
| BUSH CANAL | -23.25 | -124.0 | -23.25 | -71 |
| LAROSE FG | -19.05 | -126.0 | -19.05 | -46 |


125' SECTOR GATE MASONRY PLAN
SCALE: 1/16" = 1'-0"
R=67'-6½" TO FACE OF SKIN PLATE
14' x 14' PRECAST CONCRETE CONTROL HOUSE
14' x 14' PRECAST CONCRETE CONTROL HOUSE
SUMP PIT (TYP.)
C/L HINGE & PINTLE
NEEDLE RECESS
NEEDLE GIRDER RECESS (TYP.)
GATE STOP (TYP.)
4'-9" (TYP.)
20'-0"
20'-0"
125'-0"
310'-6⅝"
155'-3⁵⁄₁₆"
117'-8"
54'-7¹⁵⁄₁₆"
S-027
S-027
S-028
U.S. ARMY CORPS OF ENGINEERS
NEW ORLEANS DISTRICT
NEW ORLEANS, LOUISIANA
MORGANZA TO THE GULF OF MEXICO LOUISIANA
REEVALUATION REPORT
TERREBONNE AND LAFOURCHE PARISHES LOUISIANA
100 YEAR
125' SECTOR GATE
MASONRY PLAN
SHEET IDENTIFICATION
S-026A



U.S. ARMY CORPS OF ENGINEERS
NEW ORLEANS DISTRICT
NEW ORLEANS, LOUISIANA
MORGANZA TO THE GULF OF MEXICO LOUISIANA
TERREBONNE AND LAFOURCHE PARISHES LOUISIANA
100 YEAR
125' SECTOR GATE
MASONRY SECTIONS
SHEET IDENTIFICATION
S-027A
SECTION A
SCALE: 1/16"=1'-0"
SECTION B
SCALE: 1/16"=1'-0"
SECTION C
SCALE: 1/16"=1'-0"
14'x14' CONTROL HOUSE
MACHINERY BLOCK
THRUST BLOCK
DEWATERING SUMP
TOP OF SLAB EL. -16.0
BOTTOM OF SLAB EL. -28.0
24" PIPE PILE BATTERED 1H:4V
1' STABILIZATION SLAB
PZC-13 SHEETPILE CUTOFF WALL
NEEDLE GIRDER RECESS EL. 4.0
EL. 23.0 GIWW WEST
EL. 21.5 GIWW EAST




## FOUNDATION PLAN

SCALE: 1/16" = 1'-0"

FLOOD SIDE

### LEGEND

24" PIPE PILE BATTERED 1H ON 4V

INDICATES DIRECTION OF BATTER

NOTES:
1. ALL PILES SHALL RECEIVE TENSION ANCHORS.
2. ALL PIPE PILES SHALL MEET THE REQUIREMENTS OF API 5L, GRADE X 52.
3. SHEET PILING SHALL MEET THE REQUIREMENTS OF ASTM A572, GRADE 50.

| LOCATION | PILE CUTOFF EL. | PILE TIP EL. | PILE LENGTH | SHEET PILE CUTOFF EL. | SHEET PILE TIP EL. |
|---|---|---|---|---|---|
| GIWW EAST | -27.0 | -166.0 | 143.3 | -28.75 | -57.00 |
| GIWW WEST | -27.0 | -166.0 | 143.3 | -26.75 | -54.00 |

US Army Corps of Engineers
NEW ORLEANS DISTRICT

| MARK | DESCRIPTION | DATE | APPR | MARK | DESCRIPTION | DATE | APPR |
|---|---|---|---|---|---|---|---|

U.S. ARMY CORPS OF ENGINEERS
NEW ORLEANS DISTRICT
NEW ORLEANS, LOUISIANA

DESIGNED BY: DAVID P. LOVETT
DATE: OCT 2011
DWN BY: DJB
CKD BY: CLD
SOLICITATION NO.: -
SUBMITTED BY: CHRISTOPHER DUNN, P.E.
CONTRACT NO.: -
PLOT SCALE: 1:1
PLOT DATE: OCT 2011
FILE NUMBER: H-8-47541
SIZE: ANSI D
FILE NAME: H847541_S-029A-...

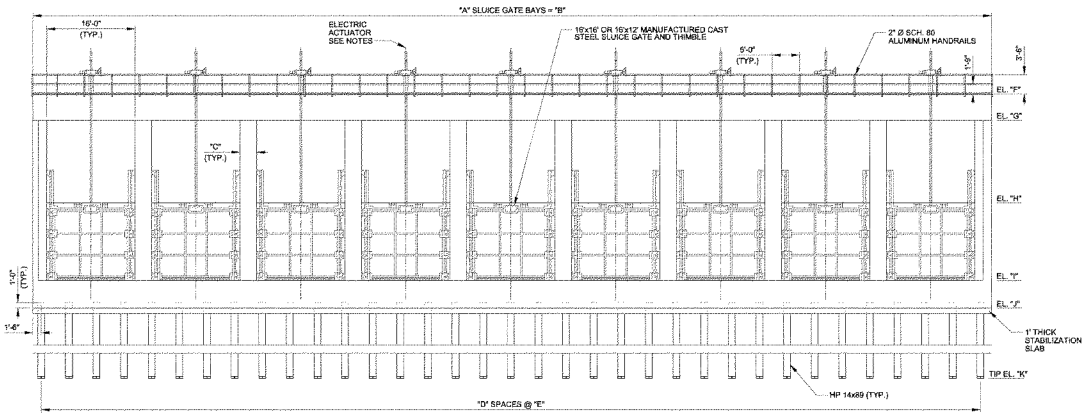
MORGANZA TO THE GULF OF MEXICO LOUISIANA
REEVALUATION REPORT
TERREBONNE AND LAFOURCHE PARISHES LOUISIANA
100 YEAR

125' SECTOR GATE
FOUNDATION PLAN

SHEET IDENTIFICATION
S-029A

| STRUCTURE | DIMENSION'S 1 | | | | | DIMENSION'S 2 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | "A" | "B" | "C" | "D" | "E" | "A" | "B" | "C" | "D" | "E" |
| BAYOU GRAND CAILLOU | 6 | 117' | 3' | 18 | 6'-4" | 3 | 60' | 3' | 9 | 6'-4" |
| BUSH CANAL | 6 | 117' | 3' | 24 | 4'-9" | 3 | 60' | 3' | 12 | 4'-9" |
| FALGOUT CANAL | 6 | 117' | 3' | 18 | 6'-4" | 3 | 60' | 3' | 9 | 6'-4" |
| GRAND BAYOU | 6 | 117' | 3' | 24 | 4'-9" | 3 | 60' | 3' | 12 | 4'-9" |
| GIWW WEST | 6 | 117' | 3' | 18 | 6'-4" | 3 | 60' | 3' | 9 | 6'-4" |
| GIWW EAST | 3 | 60' | 3' | 9 | 6'-4" | 3 | 60' | 3' | 9 | 6'-4" |
| PLACID CANAL | 3 | 60' | 3' | 12 | 4'-9" | 3 | 60' | 3' | 12 | 4'-9" |
| BAYOU PETITE CAILLOU | 3 | 60' | 3' | 12 | 4'-9" | 3 | 60' | 3' | 12 | 4'-9" |

| STRUCTURE | ELEVATION'S "F" | "G" | "H" | "I" | "J" | "K" |
|---|---|---|---|---|---|---|
| BAYOU GRAND CAILLOU | EL. 28.0 | EL. 25.5 | EL. +4.0 | EL. -12.0 | EL. -20.0 | EL. -116.0 |
| BUSH CANAL | EL. 35.5 | EL. 33.0 | EL. +4.0 | EL. -12.0 | EL. -22.0 | EL. -126.5 |
| FALGOUT CANAL | EL. 25.5 | EL. 23.0 | EL. +3.0 | EL. -9.0 | EL. -17.0 | EL. -103.0 |
| GRAND BAYOU | EL. 32.0 | EL. 29.5 | EL. +3.0 | EL. -9.0 | EL. -19.0 | EL. -151.0 |
| GIWW WEST | EL. 25.5 | EL. 23.0 | EL. +3.0 | EL. -13.0 | EL. -21.0 | EL. -130.0 |
| GIWW EAST | EL. 24.0 | EL. 21.5 | EL. +2.0 | EL. -10.0 | EL. -18.0 | EL. -131.5 |
| PLACID CANAL | EL. 34.0 | EL. 31.5 | EL. +4.0 | EL. -8.0 | EL. -18.0 | EL. -147.0 |
| BAYOU PETITE CAILLOU | EL. 33.0 | EL. 30.5 | EL. +4.0 | EL. -8.0 | EL. -18.0 | EL. -148.0 |




## SLUICE GATE FLOOD SIDE ELEVATION

SCALE: 1/8" = 1'-0"

NOTES:
1.) SLUICE GATES FOR BAYOU GRAND CAILLOU, BUSH CANAL, & GIWW WEST SHALL BE 16' x 16' W/ A BIFFI ICON 050/1440-173 ACTUATOR W/ A DIAMOND GEAR 105BG7 BEVEL GEAR W/ 4.9' DIAMETER, OR APPROVED EQUAL.
SLUICE GATES FOR FALGAUT CANAL, GRAND BAYOU, & GIWW EAST SHALL BE 16' x 12' W/ A BIFFI ICON 040/720-173 ACTUATOR W/ A DIAMOND GEAR 57BG6 BEVE GEAR W/ 3.7' DIAMETER OR APPROVED EQUAL.
2.) ALL H PILES & SHEET PILES SHALL MEET THE REQUIREMENTS OF ASTM A572, GRADE 50.
3.) ALL CONCRETE SHALL HAVE A MIN. 28 DAY COMPRESSIVE STRENGTH OF 4,000 PSI.
4.) ALL HANDRAILS SHALL BE 2" ALUMINUM PIPE ALLOY 6061-T6 W/ FLANGE FITTINGS.

US Army Corps of Engineers
NEW ORLEANS DISTRICT

| MARK | DESCRIPTION | DATE | APPR. | MARK | DESCRIPTION | DATE | APPR. |
|---|---|---|---|---|---|---|---|

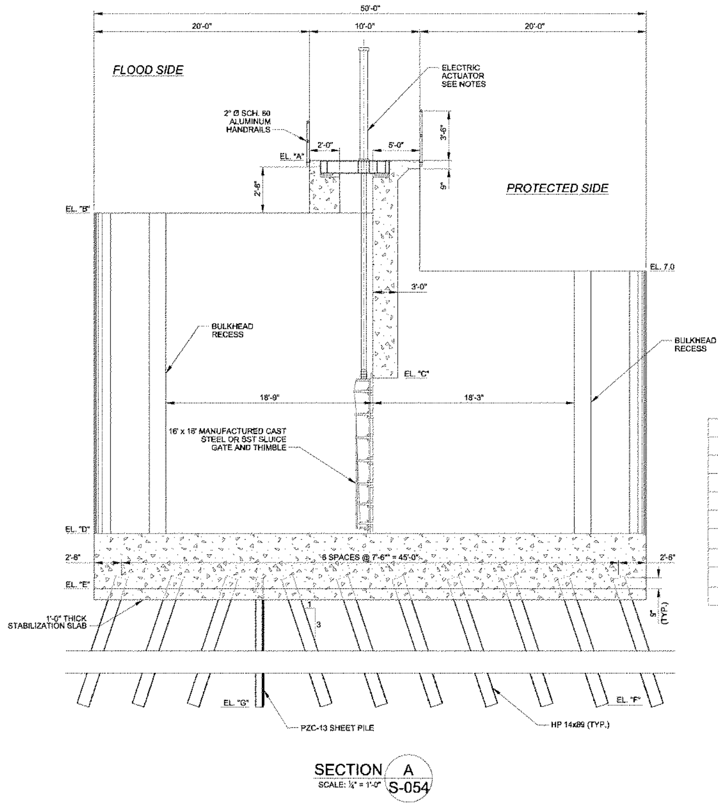
U.S. ARMY CORPS OF ENGINEERS
NEW ORLEANS DISTRICT
NEW ORLEANS, LOUISIANA

| | | |
|---|---|---|
| DESIGNED BY: DPK | | DATE: OCT 2011 |
| DWN BY: DJR | CKD BY: CAL | SOLICITATION NO.: - |
| SUBMITTED BY: CHRISTOPHER DUNN, P.E. | | CONTRACT NO.: - |
| PLOT SCALE: 1:1 | PLOT DATE: OCT 2011 | FILE NUMBER: H-8-47542 |
| SIZE: ANSI D | FILE NAME: h847541_S-055A---.dgn | |

MORGANZA TO THE GULF OF MEXICO LOUISIANA
REEVALUATION REPORT
TERREBONNE AND LAFOURCHE PARISHES LOUISIANA
100 YEAR

SLUICE GATE
FRONT ELEVATION

SHEET IDENTIFICATION
S-055A




SECTION A / S-054
SCALE: ¼" = 1'-0"

| ELEVATION'S | | | | | | | |
|---|---|---|---|---|---|---|---|
| STRUCTURE | "A" | "B" | "C" | "D" | "E" | "F" | "G" |
| BAYOU GRAND CAILLOU | EL. 28.0 | EL. 25.5 | EL. +4.0 | EL. -12 | EL. -20.0 | EL. -116.0 | EL. -54.0 |
| BUSH CANAL | EL. 35.5 | EL. 33.0 | EL. +4.0 | EL. -12 | EL. -22.0 | EL. -126.5 | EL. -71.0 |
| FALGOUT CANAL | EL. 25.5 | EL. 23.0 | EL. +3.0 | EL. - 9 | EL. -17.0 | EL. -103.0 | EL. -82.0 |
| GRAND BAYOU | EL. 32.0 | EL. 29.5 | EL. +3.0 | EL. - 9 | EL. -19.0 | EL. -151.0 | EL. -63.0 |
| GIWW WEST | EL. 25.5 | EL. 23.0 | EL. +3.0 | EL. -13 | EL. -21.0 | EL. -130.0 | EL. -54.0 |
| GIWW EAST | EL. 24.0 | EL. 21.5 | EL. +2.0 | EL. -10 | EL. -18.0 | EL. -131.5 | EL. -57.0 |
| PLACID CANAL | EL. 34.0 | EL. 31.5 | EL. +4.0 | EL. -8 | EL. -18.0 | EL. -147.0 | EL. -69.0 |
| BAYOU PETITE CAILLOU | EL. 33.0 | EL. 30.5 | EL. +4.0 | EL. -8 | EL. -18.0 | EL. -148.0 | EL. -79.0 |

NOTES:
1.) SLUICE GATES FOR BAYOU GRAND CAILLOU, BUSH CANAL, & GIWW WEST SHALL BE 16' x 16' W/ A BIFFI ICON 050/1440-173 ACTUATOR W/ A DIAMOND GEAR 105BG7 BEVEL GEAR W/ 4.9' DIAMETER, OR APPROVED EQUAL.
SLUICE GATES FOR FALGAUT CANAL, GRAND BAYOU, PLACID CANAL, BAYOU PETITE CAILLOU & GIWW EAST SHALL BE 16' x 12' W/ A BIFFI ICON 040/720-173 ACTUATOR W/ A DIAMOND GEAR 57BG6 BEVE GEAR W/3.7' DIAMETER OR APPROVED EQUAL.
2.) ALL H PILES & SHEET PILES SHALL MEET THE REQUIREMENTS OF ASTM A572, GRADE 50.
3.) ALL CONCRETE SHALL HAVE A MIN. 28 DAY CPMPRESSIVE STRENGTH OF 4,000 PSI.
4.) ALL HANDRAILS SHALL BE 2" ALUMINUM PIPE ALLOY 6061-T6 W/ FLANGE FITTINGS.

US Army Corps of Engineers
NEW ORLEANS DISTRICT

| MARK | DESCRIPTION | DATE | APPR. | MARK | DESCRIPTION | DATE | APPR. |
|---|---|---|---|---|---|---|---|

U.S. ARMY CORPS OF ENGINEERS
NEW ORLEANS DISTRICT
NEW ORLEANS, LOUISIANA

DESIGNED BY: DPL | DATE: OCT 2011
DWN BY: DJB | CKD BY: CAL | SOLICITATION NO.: -
SUBMITTED BY: CHRISTOPHER DUNN, P.E. | CONTRACT NO.: -
PLOT SCALE: 1:1 | PLOT DATE: OCT 2011 | FILE NUMBER: H-8-47541
SIZE: ANSI D | FILE NAME: H847541_S-057A-.dgn

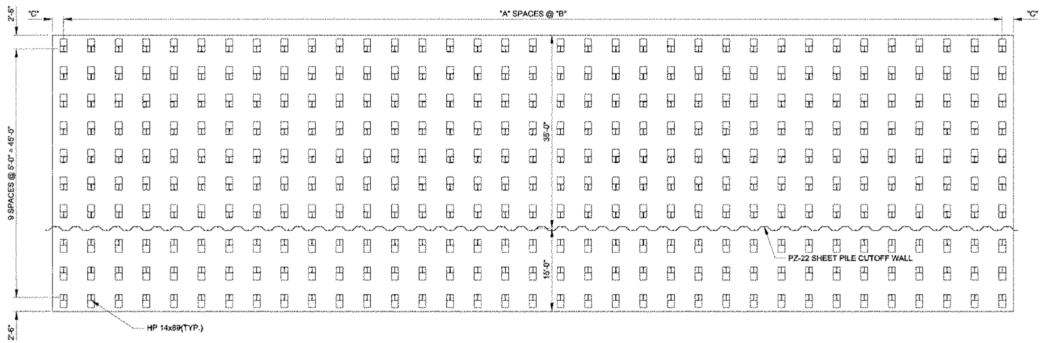
MORGANZA TO THE GULF OF MEXICO LOUISIANA
REEVALUATION REPORT
TERREBONNE AND LAFOURCHE PARISHES LOUISIANA
100 YEAR

SLUICE GATE
SECTION

SHEET IDENTIFICATION
S-057A

| STRUCTURE | 1 | | | 2 | | | DIMENSION'S | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | "A" | "B" | "C" | "A" | "B" | "C" | PILE CUTOFF | PILE TIP EL. | PILE LENGTH | SHEET PILE CUTOFF LENGTH | SHEET PILE TIP EL. |
| BAYOU GRAND CAILLOU | 18 | 6'-4" | 1'-6" | 9 | 6'-4" | 1'-6" | -19.25 | -116.0 | 101.9 | -19.25 | -54.0 |
| BUSH CANAL | 24 | 4'-9" | 1'-6" | 12 | 4'-9" | 1'-6" | -21.25 | -126.5 | 110.9 | -21.25 | -71.0 |
| FALGOUT CANAL | 18 | 6'-4" | 1'-6" | 9 | 6'-4" | 1'-6" | -16.25 | -103.0 | 91.4 | -16.25 | -62.0 |
| GRAND BAYOU | 24 | 4'-9" | 1'-6" | 12 | 4'-9" | 1'-6" | -18.25 | -151.0 | 139.9 | -18.25 | -63.0 |
| GIWW WEST | 18 | 6'-4" | 1'-6" | 9 | 6'-4" | 1'-6" | -20.25 | -130.0 | 115.7 | -20.25 | -54.0 |
| GIWW EAST | 9 | 6'-4" | 1'-6" | 9 | 6'-4" | 1'-6" | -17.25 | -131.5 | 120.4 | -17.25 | -57.0 |
| PLACID CANAL | 12 | 4'-9" | 1'-6" | 12 | 4'-9" | 1'-6" | -17.25 | -147.0 | 130.8 | -17.25 | -69.0 |
| BAYOU PEITIE CAILLOU | 12 | 4'-9" | 1'-6" | 12 | 4'-9" | 1'-6" | -17.25 | -148.0 | 137.8 | -17.25 | -79.0 |

PROTECTED SIDE




FLOOD SIDE

## SLUICE GATE PILE FOUNDATION PLAN

SCALE: 1/8" = 1'-0"

LEGEND

BATTERED 3V: 1H HP 14x89 STEEL PILE

BOX INDICATES DIRECTION OF BATTER

NOTES:
1.) ALL PILES ON THE FLOOD SIDE OF THE SHEET PILE CUTOFF WALL RECEIVE TENSION ANCHORS
2.) ALL H PILES & SHEET PILE SHALL MEET THE REQUIREMENTS OF ATSM A572, GRADE 50.

US Army Corps of Engineers®
NEW ORLEANS DISTRICT

| MARK | DESCRIPTION | DATE | APPR. | MARK | DESCRIPTION | DATE | APPR. |
|---|---|---|---|---|---|---|---|

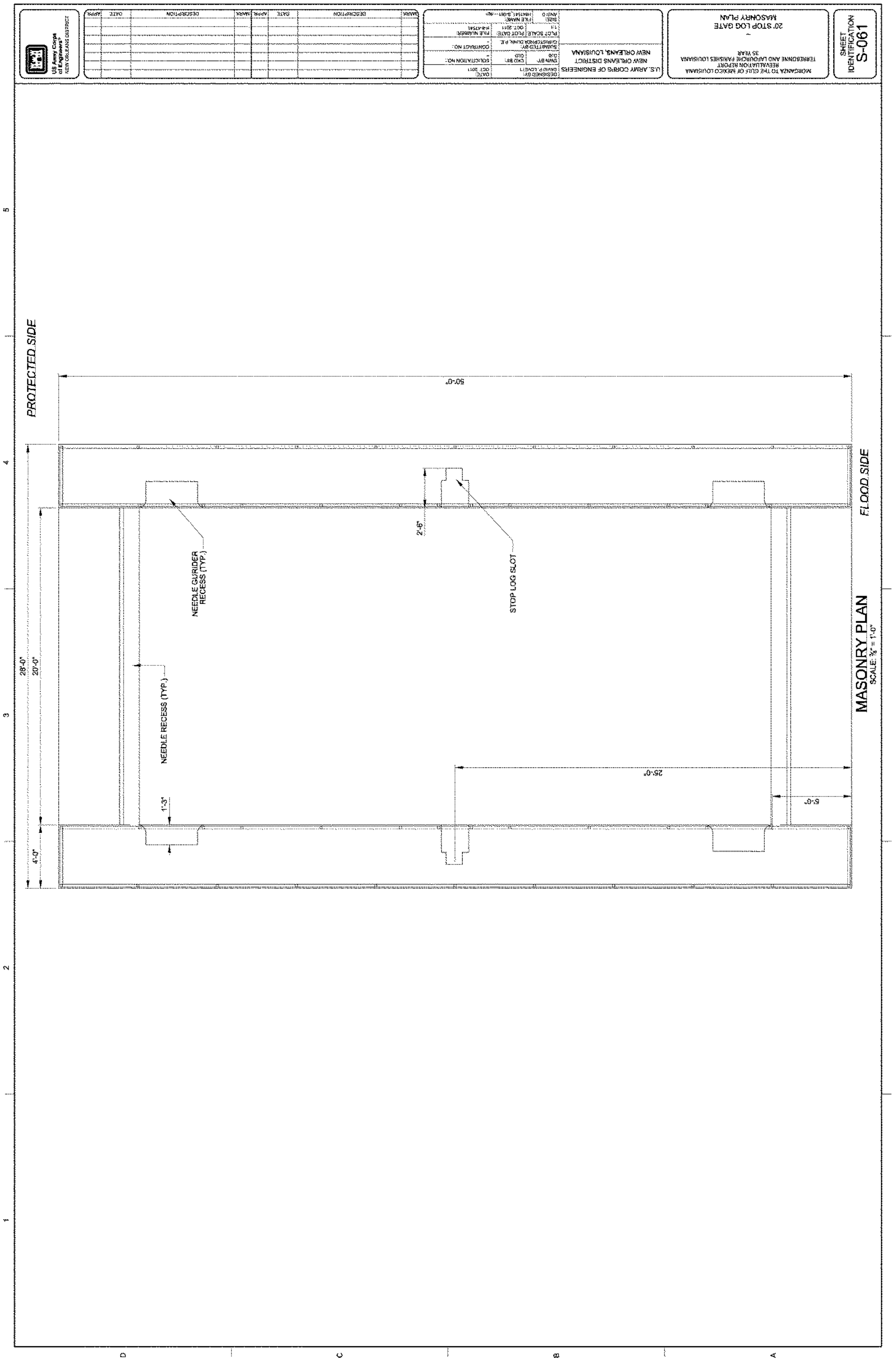
U.S. ARMY CORPS OF ENGINEERS
NEW ORLEANS DISTRICT
NEW ORLEANS, LOUISIANA

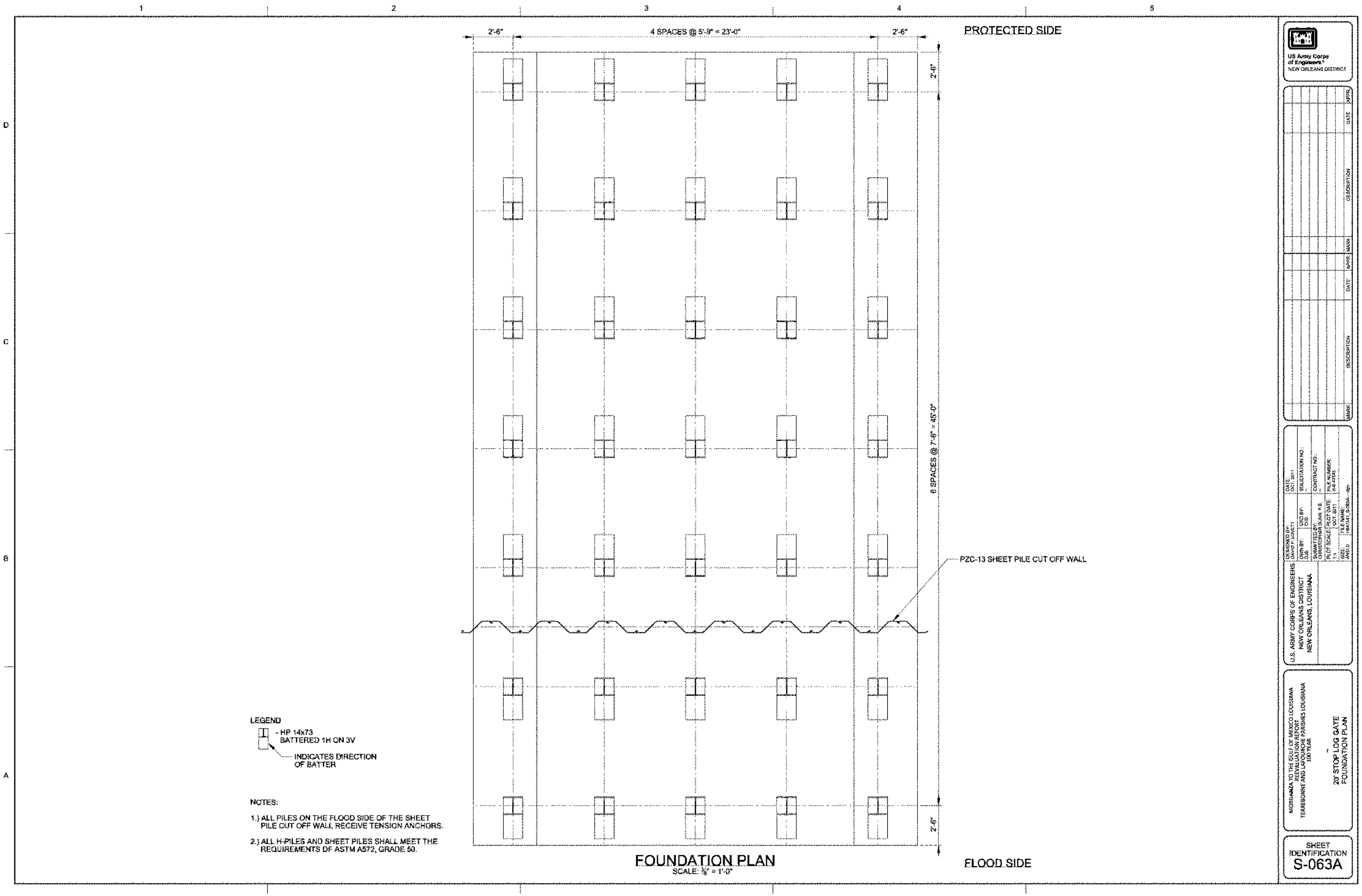
DESIGNED BY: DPL
DATE: OCT 2011
DWN BY: DJS
CKD BY: CAL
SOLICITATION NO.: -
SUBMITTED BY: CHRISTOPHER DUNN, P.E.
CONTRACT NO.: -
PLOT SCALE: 1:1
PLOT DATE: OCT. 2011
FILE NUMBER: H-8-47543
SIZE: ANSI D
FILE NAME: H847541_S-058A.dgn

MORGANZA TO THE GULF OF MEXICO LOUISIANA
REEVALUATION REPORT
TERREBONNE AND LAFOURCHE PARISHES LOUISIANA
100 YEAR

SLUICE GATE
PILE FOUNDATION
PLAN

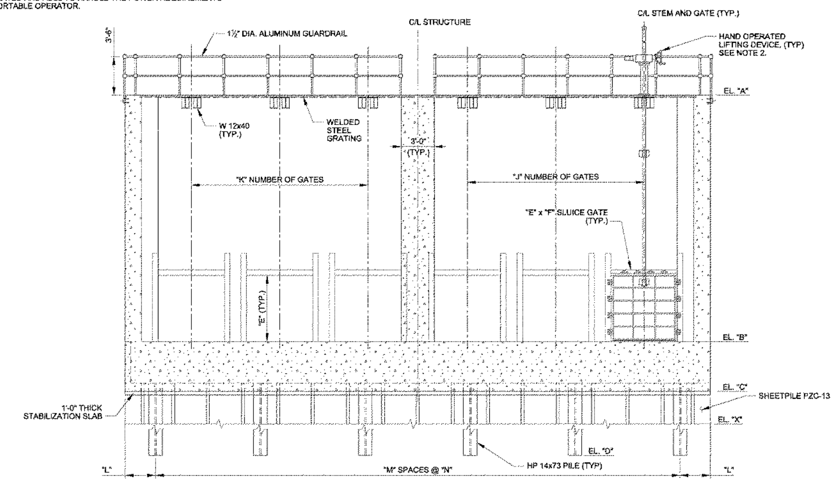
SHEET IDENTIFICATION
S-058A


US Army Corps of Engineers
NEW ORLEANS DISTRICT
U.S. ARMY CORPS OF ENGINEERS
NEW ORLEANS DISTRICT
NEW ORLEANS, LOUISIANA
MORGANZA TO THE GULF OF MEXICO LOUISIANA
REEVALUATION REPORT
TERREBONNE AND LAFOURCHE PARISHES LOUISIANA
35 YEAR
~
20' STOP LOG GATE
MASONRY PLAN
SHEET IDENTIFICATION
S-061
PROTECTED SIDE
FLOOD SIDE
50'-0"
25'-0"
5'-0"
28'-0"
20'-0"
4'-0"
1'-3"
2'-6"
NEEDLE GURIDER RECESS (TYP.)
NEEDLE RECESS (TYP.)
STOP LOG SLOT
MASONRY PLAN
SCALE: 3/8" = 1'-0"


PROTECTED SIDE
FLOOD SIDE
2'-6"
4 SPACES @ 5'-9" = 23'-0"
2'-6"
6 SPACES @ 7'-6" = 45'-0"
PZC-13 SHEET PILE CUT OFF WALL
FOUNDATION PLAN
SCALE: 3/8" = 1'-0"
LEGEND
- HP 14x73
BATTERED 1H ON 3V
INDICATES DIRECTION
OF BATTER
NOTES:
1.) ALL PILES ON THE FLOOD SIDE OF THE SHEET PILE CUT OFF WALL RECEIVE TENSION ANCHORS.
2.) ALL H-PILES AND SHEET PILES SHALL MEET THE REQUIREMENTS OF ASTM A572, GRADE 50.
US Army Corps of Engineers
NEW ORLEANS DISTRICT
U.S. ARMY CORPS OF ENGINEERS
NEW ORLEANS DISTRICT
NEW ORLEANS, LOUISIANA
MORGANZA TO THE GULF OF MEXICO LOUISIANA
REEVALUATION REPORT
TERREBONNE AND LAFOURCHE PARISHES LOUISIANA
100 YEAR
20' STOP LOG GATE
FOUNDATION PLAN
SHEET
IDENTIFICATION
S-063A

NOTES:

1. SEE SHEET S-088 FOR THE SCHEDULE OF VARIABLES.
2. PROVIDE A PORTABLE OPERATOR AND GENERATOR FROM THE MANUFACTURER OF THE HAND-CRANK OPERATOR, WHICH WILL BE USED TO LIFT THE SLUICE GATES. THE OPERATOR SHALL BE MANUFACTURED BY THE MANUFACTURER OF THE SLUICE GATE. THE OPERATOR SHALL INCLUDE REVERSING FEATURES, AN OVERLOAD RELEASE CLUTCH, AND ALL NECESSARY ADAPTORS TO OPERATE THE SLUICE GATES. THE GENERATOR SHALL BE PORTABLE, GAS OPERATED AND ABLE TO HANDLE THE POWER REQUIREMENTS OF THE PORTABLE OPERATOR.
3. ALL H PILES AND SHEET PILES SHALL MEET THE REQUIREMENTS OF ATM A572, GRADE 50.
4. ALL CONCRETE SHALL HAVE A MINIMUM 28 DAY COMPRESSIVE STRENGTH OF 4000 PSI.
5. ALL HANDRAIL SHALL BE 1 1/2"Ø ALUMINUM PIPE ALLOY 6061-T6 WITH FLANGE FITTINGS.




## FLOOD SIDE ELEVATION OF DRAINAGE STRUCTURE

SCALE: ¼" = 1'-0"

US Army Corps of Engineers
NEW ORLEANS DISTRICT

| MARK | DESCRIPTION | DATE | APPR. | MARK | DESCRIPTION | DATE | APPR. |
|---|---|---|---|---|---|---|---|

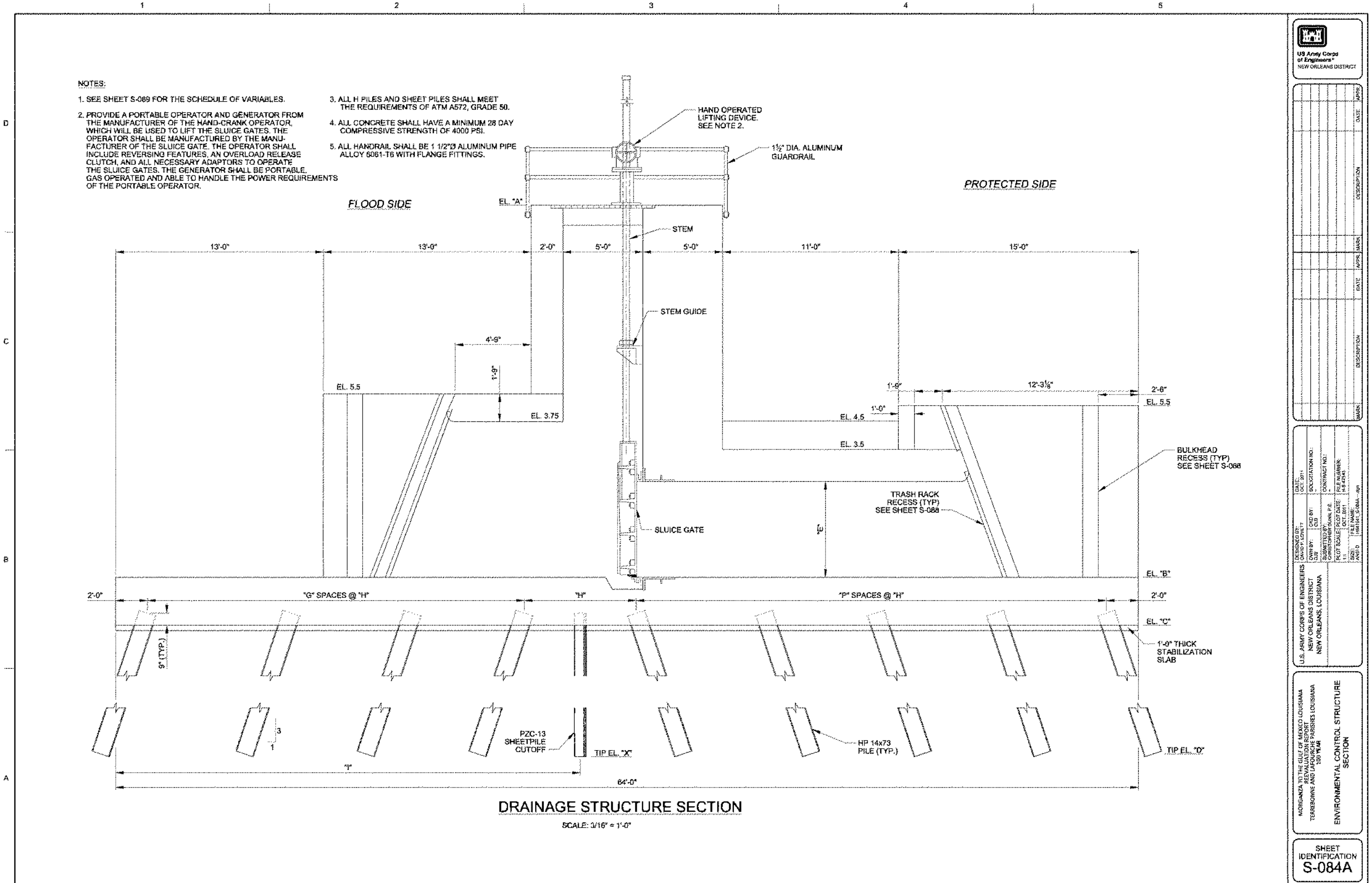
U.S. ARMY CORPS OF ENGINEERS
NEW ORLEANS DISTRICT
NEW ORLEANS, LOUISIANA

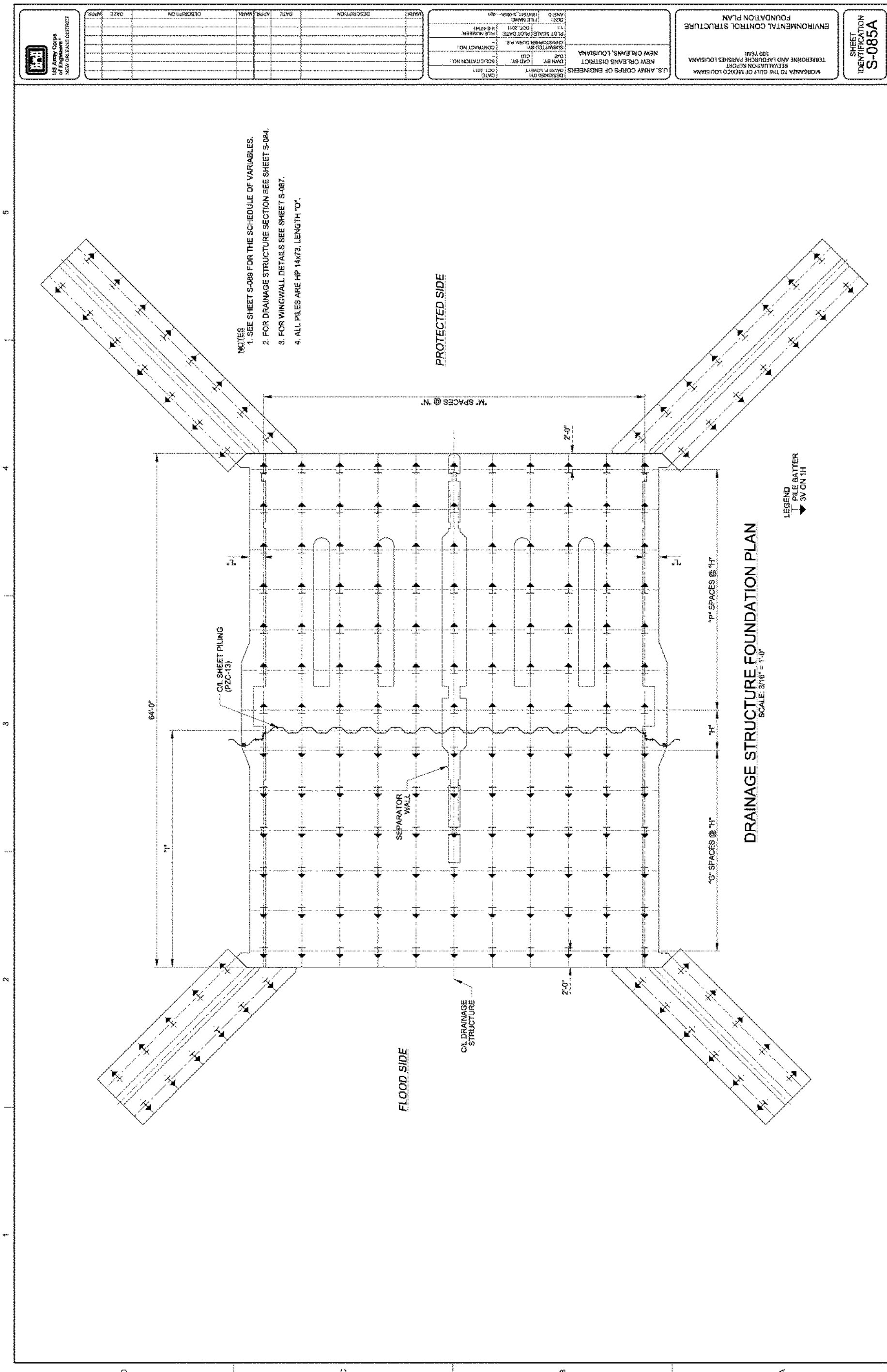
DESIGNED BY: DAVID P. LOVETT | DATE: OCT. 2011
DWN BY: DJB | CKD BY: CLD | SOLICITATION NO.: -
SUBMITTED BY: CHRISTOPHER DUNN, P.E. | CONTRACT NO.: -
PLOT SCALE: 1:1 | PLOT DATE: OCT. 2011 | FILE NUMBER: H-8-47542
SIZE: ANSI D | FILE NAME:

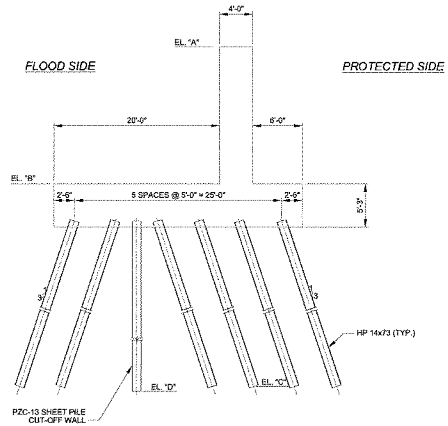
MORGANZA TO THE GULF OF MEXICO LOUISIANA
REEVALUATION REPORT
TERREBONNE AND LAFOURCHE PARISHES LOUISIANA
100 YEAR

ENVIRONMENTAL CONTROL STRUCTURE
MASONRY ELEVATION
FLOOD SIDE

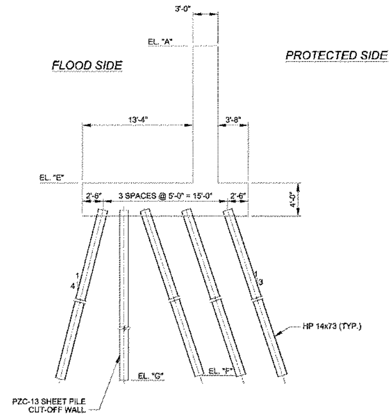
SHEET IDENTIFICATION
S-082A


NOTES:
1. SEE SHEET S-089 FOR THE SCHEDULE OF VARIABLES.
2. PROVIDE A PORTABLE OPERATOR AND GENERATOR FROM THE MANUFACTURER OF THE HAND-CRANK OPERATOR, WHICH WILL BE USED TO LIFT THE SLUICE GATES. THE OPERATOR SHALL BE MANUFACTURED BY THE MANUFACTURER OF THE SLUICE GATE. THE OPERATOR SHALL INCLUDE REVERSING FEATURES, AN OVERLOAD RELEASE CLUTCH, AND ALL NECESSARY ADAPTORS TO OPERATE THE SLUICE GATES. THE GENERATOR SHALL BE PORTABLE, GAS OPERATED AND ABLE TO HANDLE THE POWER REQUIREMENTS OF THE PORTABLE OPERATOR.
3. ALL H PILES AND SHEET PILES SHALL MEET THE REQUIREMENTS OF ATM A572, GRADE 50.
4. ALL CONCRETE SHALL HAVE A MINIMUM 28 DAY COMPRESSIVE STRENGTH OF 4000 PSI.
5. ALL HANDRAIL SHALL BE 1 1/2"Ø ALUMINUM PIPE ALLOY 6061-T6 WITH FLANGE FITTINGS.
HAND OPERATED LIFTING DEVICE. SEE NOTE 2.
1½" DIA. ALUMINUM GUARDRAIL
FLOOD SIDE
PROTECTED SIDE
EL. "A"
STEM
STEM GUIDE
SLUICE GATE
13'-0"
13'-0"
2'-0"
5'-0"
5'-0"
11'-0"
15'-0"
4'-9"
1'-9"
EL. 5.5
EL. 3.75
1'-6"
12'-3⅛"
2'-6"
EL. 5.5
1'-0"
EL. 4.5
EL. 3.5
BULKHEAD RECESS (TYP) SEE SHEET S-088
TRASH RACK RECESS (TYP) SEE SHEET S-088
"E"
EL. "B"
2'-0"
"G" SPACES @ "H"
"H"
"P" SPACES @ "H"
2'-0"
EL. "C"
9" (TYP.)
1'-0" THICK STABILIZATION SLAB
3
1
PZC-13 SHEETPILE CUTOFF
TIP EL. "X"
HP 14x73 PILE (TYP.)
TIP EL. "D"
"I"
64'-0"
DRAINAGE STRUCTURE SECTION
SCALE: 3/16" = 1'-0"
US Army Corps of Engineers
NEW ORLEANS DISTRICT
U.S. ARMY CORPS OF ENGINEERS
NEW ORLEANS DISTRICT
NEW ORLEANS, LOUISIANA
MORGANZA TO THE GULF OF MEXICO LOUISIANA
REEVALUATION REPORT
TERREBONNE AND LAFOURCHE PARISHES LOUISIANA
100 YEAR
ENVIRONMENTAL CONTROL STRUCTURE
SECTION
SHEET IDENTIFICATION
S-084A


US Army Corps of Engineers
NEW ORLEANS DISTRICT
U.S. ARMY CORPS OF ENGINEERS
NEW ORLEANS DISTRICT
NEW ORLEANS, LOUISIANA
MORGANZA TO THE GULF OF MEXICO LOUISIANA
REEVALUATION REPORT
TERREBONNE AND LAFOURCHE PARISHES LOUISIANA
100 YEAR
ENVIRONMENTAL CONTROL STRUCTURE
FOUNDATION PLAN
SHEET IDENTIFICATION
S-085A
NOTES
1. SEE SHEET S-089 FOR THE SCHEDULE OF VARIABLES.
2. FOR DRAINAGE STRUCTURE SECTION SEE SHEET S-084.
3. FOR WINGWALL DETAILS SEE SHEET S-087.
4. ALL PILES ARE HP 14x73, LENGTH "O".
PROTECTED SIDE
"M" SPACES @ "N"
2'-0"
64'-0"
C/L SHEET PILING (PZC-13)
SEPARATOR WALL
C/L DRAINAGE STRUCTURE
"P" SPACES @ "H"
"H"
"Q" SPACES @ "H"
FLOOD SIDE
DRAINAGE STRUCTURE FOUNDATION PLAN
SCALE: 3/16" = 1'-0"
LEGEND
PILE BATTER 3V ON 1H




TYPE 2A, 100 YR.
SCALE: 3/16" = 1'-0"




TYPE 2B, 100 YR.
SCALE: 3/16" = 1'-0"

| LOCATION | TYPE 2A NUMBER OF MONOLITHS | TYPE 2A LENGTH OF MONOLITHS | TYPE 2B NUMBER OF MONOLITHS | TYPE 2B LENGTH OF MONOLITHS | "A" | "B" | "C" | "D" | "E" | "F" | "G" |
|---|---|---|---|---|---|---|---|---|---|---|---|
| FALGOUT CANAL 56' SECTOR GATE | 1 | 1 @ 55' | 2 | 2 @ 55' | 23.0 | -9.0 | -98.0 | -62.0 | -3.5 | -110.5 | -45.0 |
| ELLIOT JONES 20' STOP LOG GATE | 1 | 1 @ 40' | 2 | 2 @ 45' | 23.5 | -5.0 | -112.5 | -46.0 | -1.5 | -128.0 | -46.0 |
| HUMPHRIES 20' STOP LOG GATE | 1 | 1 @ 40' | 2 | 2 @ 45' | 23.5 | -5.0 | -112.5 | -46.0 | -1.5 | -128.0 | -46.0 |
| MINORS CANAL 56' SECTOR GATE | N/A | N/A | 2 | 2 @ 55' | 23.0 | N/A | N/A | N/A | -3.5 | -128.0 | -50.0 |
| GIWW WEST 125' SECTOR GATE | 4 | 4 @ 50' | 2 | 2 @ 50' | 23.0 | -8.0,-10.0 | -112.5 | -54.0 | -2.0 | -128.0 | -54.0 |
| GIWW EAST 125' SECTOR GATE | 4 | 2 @ 40', 2 @ 45' | 2 | 1 @ 40', 1 @ 45' | 25.0 | -6.0,-10.0 | -123.0 | -57.0 | -2.0 | -136.0 | -57.0 |
| BAYOU BLACK 56' SECTOR GATE | 2 | 2 @ 55' | N/A | N/A | 22.0 | -6.0 | -112.5 | -46.0 | N/A | N/A | N/A |
| SHELL CANAL WEST 30' STOP LOG GATE | 1 | 1 @ 40' | 2 | 2 @ 45' | 23.5 | -6.0 | -112.5 | -46.0 | N/A | N/A | N/A |
| SHELL CANAL EAST 56' SECTOR GATE | 2 | 2 @ 55' | N/A | N/A | 23.5 | -6.0 | -112.5 | -46.0 | N/A | N/A | N/A |
| MARMANDE CANAL 30' STOP LOG GATE | 1 | 1 @ 40' | 2 | 2 @ 40' | 23.5 | -5.0 | -112.5 | -45.5 | -1.5 | -128.0 | -45.0 |

NOTES:
1.) ALL CONCRETE SHALL HAVE A MINIMIM 28 DAY COMPRESSIVE STRENGTH OF 4,000 PSI.
2.) ALL H-PILES SHEET PILES SHALL MEET THE REQUIREMENTS OF ASTM A572, GRADE 50.
3.) THE TOP 5' OF ALL PILING SHALL BE PAINTED WITH SYSTEM NO 6, COAL TAR EPOXY.

US Army Corps of Engineers
New Orleans District

| MARK | DESCRIPTION | DATE | APPR. | MARK | DESCRIPTION | DATE | APPR. |
|---|---|---|---|---|---|---|---|

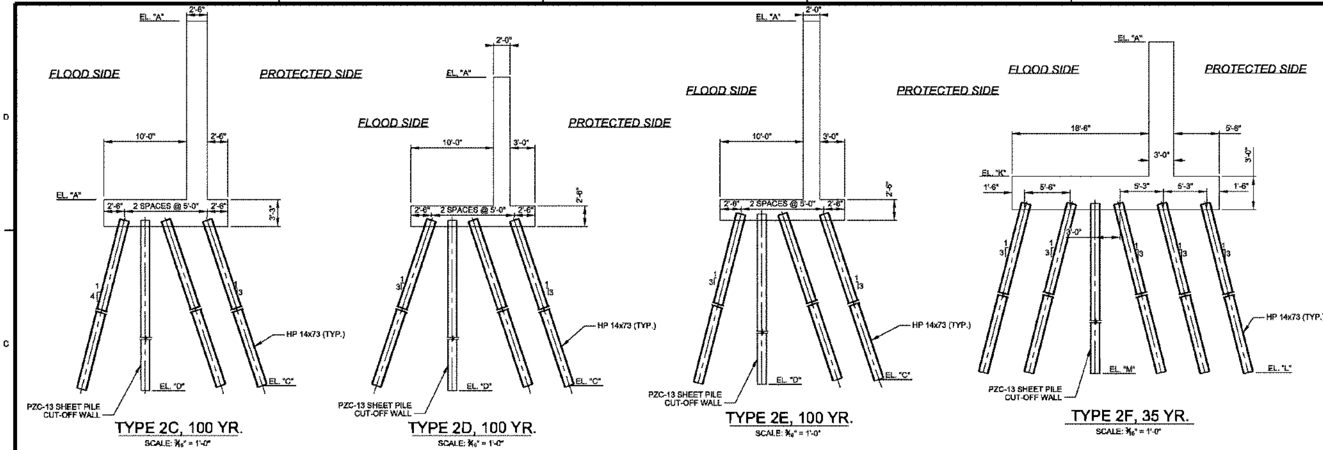
U.S. ARMY CORPS OF ENGINEERS
NEW ORLEANS DISTRICT
NEW ORLEANS, LOUISIANA

DESIGNED BY: DAVID P. LOVETT | DATE: OCT. 2011
DWN BY: DJS | CKD BY: CLD | SOLICITATION NO.: -
SUBMITTED BY: CHRISTOPHER DUNN, P.E. | CONTRACT NO.: -
PLOT SCALE: 1:1 | PLOT DATE: OCT. 2011 | FILE NUMBER: H8-47541
SIZE: ANSI D | FILE NAME: H-867541_S-094A.dgn

MORGANZA TO THE GULF OF MEXICO LOUISIANA
REEVALUATION REPORT
TERREBONNE AND LAFOURCHE PARISHES LOUISIANA
100 YEAR

T-WALL TYPE 2A-2B

SHEET IDENTIFICATION
S-094A




| LOCATION | TYPE 2C NUMBER OF MONOLITHS | TYPE 2C LENGTH OF MONOLITHS | TYPE 2D NUMBER OF MONOLITHS | TYPE 2D LENGTH OF MONOLITHS | TYPE 2E NUMBER OF MONOLITHS | TYPE 2E LENGTH OF MONOLITHS | "A" | "B" | "C" | "D" | "E" | "F" | "G" | "H" | "I" | "J" | "K" | "L" | "M" |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FALGOUT CANAL 56' SECTOR GATE | 2 | 2 @ 55' | 6 | 4 @ 55', 2 @ 50' | 6 | 1 @ 55', 5 @ 50' | 23.0 | 2.0 | -112.0 | -45.0 | 8.0 | -86.0 | -39.0 | 13.0 | -82.0 | -34.0 | N/A | N/A | N/A |
| ELLIOT JONES 20' STOP LOG GATE | 6 | 4 @ 50', 2 @ 45' | 4 | 4 @ 50' | N/A | N/A | 23.5 | 2.0 | -130.0 | -33.0 | 8.0 | -101.0 | -27.0 | N/A | N/A | N/A | N/A | N/A | N/A |
| HUMPHRIES 20' STOP LOG GATE | 6 | 4 @ 50', 2 @ 45' | 4 | 4 @ 50' | N/A | N/A | 23.5 | 2.0 | -130.0 | -33.0 | 8.0 | -101.0 | -27.0 | N/A | N/A | N/A | N/A | N/A | N/A |
| MINORS CANAL 56' SECTOR GATE | 4 | 4 @ 50' | 2 | 2 @ 50' | 2 | 2 @ 50' | 23.0 | 2.0 | -130.0 | -50.0 | 7.0 | -101.0 | -32.0 | 12.0 | -94.5 | -22.0 | N/A | N/A | N/A |
| GIWW WEST 125' SECTOR GATE | 2 | 2 @ 50' | 2 | 2 @ 50' | 2 | 2 @ 50' | 23.0 | 2.0 | -137.0 | -67 | 7.5 | -111.0 | -35.0 | 12.5 | -104.0 | -25.0 | N/A | N/A | N/A |
| GIWW EAST 125' SECTOR GATE | 1 | 1 @ 45' | N/A | N/A | N/A | N/A | 25.0 | 2.0 | -130.0 | -54.0 | 7.5 | -101.0 | -32.0 | 12.5 | -94.5 | -22.0 | N/A | N/A | N/A |
| MARMANDE CANAL 30' STOP LOG GATE | 4 | 4 @ 50' | 6 | 6 @ 50' | 6 | 6 @ 50' | 23.0 | 2.0 | -122.0 | -32.0 | 8.0 | -90.0 | -26.0 | 13.0 | -82.5 | -21.0 | N/A | N/A | N/A |
| ENVIRONMENTAL CONTROL STRUCTURE - REACH A | 6 | 6 @ 45' | 6 | 4 @ 50', 2 @ 45' | 6 | 6 @ 50' | 23.0 | 2.0 | -122.0 | -32.0 | 8.0 | -90.0 | -26.0 | 13.0 | -82.5 | -21.0 | N/A | N/A | N/A |
| BAYOU BLACK 56' SECTOR GATE | 6 | 6 @ 50' | 4 | 4 @ 50' | N/A | N/A | 22.0 | 2.0 | -130.0 | -33.0 | 8.0 | -101.0 | -27.0 | N/A | N/A | N/A | N/A | N/A | N/A |
| SHELL CANAL WEST 30' STOP LOG GATE | 6 | 2 @ 45', 4 @ 50' | 4 | 4 @ 50' | N/A | N/A | 23.5 | 2.0 | -130.0 | -33.0 | 8.0 | -101.0 | -27.0 | N/A | N/A | N/A | N/A | N/A | N/A |
| SHELL CANAL EAST 56' SECTOR GATE | 6 | 6 @ 50' | 4 | 4 @ 50' | N/A | N/A | 23.5 | 2.0 | -130.0 | -33.0 | 8.0 | -101.0 | -27.0 | N/A | N/A | N/A | N/A | N/A | N/A |
| NAFTA T-WALL @ 38' SWING GATE | 13 | 13 @ 50' | 4 | 4 @ 50' | N/A | N/A | 23.5 | 2.0 | -130.0 | -33.0 | 8.0 | -101.0 | -27.0 | N/A | N/A | N/A | N/A | N/A | N/A |
| ENVIRONMENTAL CONTROL STRUCTURE - BARRIER 1 | 8 | 8 @ 45' | 4 | 4 @ 50' | N/A | N/A | 23.5 | 2.0 | -130.0 | -33.0 | 8.0 | -101.0 | -27.0 | N/A | N/A | N/A | N/A | N/A | N/A |
| ENVIRONMENTAL CONTROL STRUCTURE - BARRIER 2 | 8 | 8 @ 45' | 4 | 4 @ 50' | N/A | N/A | 23.5 | 2.0 | -130.0 | -33.0 | 8.0 | -101.0 | -27.0 | N/A | N/A | N/A | N/A | N/A | N/A |
| ENVIRONMENTAL CONTROL STRUCTURE - BARRIER 3 | 8 | 8 @ 45' | 4 | 4 @ 50' | N/A | N/A | 23.5 | 2.0 | -130.0 | -33.0 | 8.0 | -101.0 | -27.0 | N/A | N/A | N/A | N/A | N/A | N/A |
| ENVIRONMENTAL CONTROL STRUCTURE - BARRIER 4 | 8 | 8 @ 45' | 4 | 4 @ 50' | N/A | N/A | 23.5 | 2.0 | -130.0 | -33.0 | 8.0 | -101.0 | -27.0 | N/A | N/A | N/A | N/A | N/A | N/A |
| ENVIRONMENTAL CONTROL STRUCTURE - BARRIER 5 | 8 | 8 @ 45' | 4 | 4 @ 50' | N/A | N/A | 23.5 | 2.0 | -130.0 | -33.0 | 8.0 | -101.0 | -27.0 | N/A | N/A | N/A | N/A | N/A | N/A |
| ENVIRONMENTAL CONTROL STRUCTURE - BARRIER 6 | 8 | 8 @ 45' | 4 | 4 @ 50' | N/A | N/A | 23.5 | 2.0 | -130.0 | -33.0 | 8.0 | -101.0 | -27.0 | N/A | N/A | N/A | N/A | N/A | N/A |
| ENVIRONMENTAL CONTROL STRUCTURE - BARRIER 7 | 8 | 8 @ 45' | 4 | 4 @ 50' | N/A | N/A | 23.5 | 2.0 | -130.0 | -33.0 | 8.0 | -101.0 | -27.0 | N/A | N/A | N/A | N/A | N/A | N/A |
| BAYOU BLACK PUMPING STATION FRONTING PROTECTION | 15 | 7 @ 50', 8 @ 45' | 3 | 3 @ 50' | N/A | N/A | 23.5 | 2.0 | -130.0 | -33.0 | 8.0 | -101.0 | -27.0 | N/A | N/A | N/A | N/A | N/A | N/A |
| HANSON CANAL PUMPING STATION FRONTING PROTECTION | 15 | 7 @ 50', 8 @ 45' | 3 | 3 @ 50' | N/A | N/A | 23.5 | 2.0 | -130.0 | -33.0 | 8.0 | -101.0 | -27.0 | N/A | N/A | N/A | N/A | N/A | N/A |
| C NORTH GULF SOUTH PIPELINE | 3 | 1 @ 55', 2 @50' | 4 | 4@50' | N/A | N/A | 23.0 | 3.0 | -130.0 | -33.0 | 8.0 | -101.0 | -27.0 | N/A | N/A | N/A | N/A | N/A | N/A |
| C NORTH ENBRIDGE PIPELINE | 3 | 1 @ 55', 2 @50' | 4 | 4@50' | N/A | N/A | 23.0 | 3.0 | -130.0 | -33.0 | 8.0 | -101.0 | -27.0 | N/A | N/A | N/A | N/A | N/A | N/A |
| C NORTH WILLIAMS DISCOVERY PIPELINE | 3 | 1 @ 55', 2 @50' | 4 | 4@50' | N/A | N/A | 23.0 | 3.0 | -130.0 | -33.0 | 8.0 | -101.0 | -27.0 | N/A | N/A | N/A | N/A | N/A | N/A |
| ECS LOCKPORT TO LAROSE 1 | 4 | 4@50' | 4 | 4@50' | N/A | N/A | 18.0 | 2.0 | -130.0 | -33.0 | 8.0 | -101.0 | -27.0 | N/A | N/A | N/A | N/A | N/A | N/A |
| ECS LOCKPORT TO LAROSE 1 | 4 | 4@50' | 4 | 4@50' | N/A | N/A | 18.0 | 2.0 | -130.0 | -33.0 | 8.0 | -101.0 | -27.0 | N/A | N/A | N/A | N/A | N/A | N/A |
| UNION PACIFIC RAILROAD GATE | 4 | 4@50' | 4 | 4@50' | N/A | N/A | 18.0 | 2.0 | -130.0 | -33.0 | 8.0 | -101.0 | -27.0 | N/A | N/A | N/A | N/A | N/A | N/A |
| GIWW FLOODWALL | N/A | N/A | N/A | N/A | 248 | 248@50' | 17.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 2.0 | -100.0 | -33.0 |
| LAROSE FLOODGATE | N/A | N/A | N/A | N/A | 38 | 38 @ 50' | 17.0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 2.0 | -100.0 | -33.0 |

NOTES:
1.) ALL CONCRETE SHALL HAVE A MINIMIM 28 DAY COMPRESSIVE STRENGTH OF 4,000 PSI.
2.) ALL H-PILES SHEET PILES SHALL MEET THE REQUIREMENTS OF ASTM A572, GRADE 50.
3.) THE TOP 5' OF ALL PILING SHALL BE PAINTED WITH SYSTEM NO 6, COAL TAR EPOXY.

US Army Corps of Engineers New Orleans District

U.S. ARMY CORPS OF ENGINEERS
NEW ORLEANS DISTRICT
NEW ORLEANS, LOUISIANA

DESIGNED BY: DAVID P. LOVETT
DATE: OCT. 2011

MORGANZA TO THE GULF OF MEXICO LOUISIANA
REEVALUATION REPORT
TERREBONNE AND LAFOURCHE PARISHES LOUISIANA
100 YEAR

T-WALL TYPE 2C-2E

SHEET IDENTIFICATION
S-095A

# MORGANZA TO THE GULF OF MEXICO, LOUISIANA, POST-AUTHORIZATION CHANGE REPORT (PAC)

## ECONOMIC APPENDIX OUTLINE

# PART 1: BACKGROUND INFORMATION

## INTRODUCTION

**General**. This appendix presents an economic evaluation of the two storm surge risk reduction alternatives being considered for the Morganza to the Gulf of Mexico, Louisiana evaluation area, which includes portions of two parishes in the state of Louisiana. It was prepared in accordance with Engineering Regulation (ER) 1105-2-100, Planning Guidance Notebook, and ER 1105-2-101, Planning Guidance, Risk Analysis for Flood Damage Reduction Studies. The National Economic Development Procedures Manual for Flood Risk Management and Coastal Storm Risk Management, prepared by the Water Resources Support Center, Institute for Water Resources, was also used as a reference, along with the Users Manual for the Hydrologic Engineering Center Flood Damage Analysis Model.

The economic appendix consists of a description of the methodology used to determine National Economic Development (NED) damages and benefits under existing and future conditions, projects costs, net benefits, and benefit-to-cost ratios. The evaluation reports benefits and costs at October 2011 price level. The proposed alternatives were evaluated by comparing estimated equivalent annual benefits that would accrue to the study area with estimated average annual project costs. Benefits were converted to equivalent annual values by use of the current FY 2012 Federal discount rate of 3.75 percent and a period of analysis of 50 years. The year in which significant benefits will accrue as a result of project construction is 2026 for the 0.03 annual exceedance probability (AEP) storm surge risk reduction system alternative and 2035 for the 0.01 AEP alternative. The alternatives in the remainder of the appendix will be referred to as the 3% AEP alternative and the 1% AEP alternative. The year 2035 was chosen as the base year for each of the alternatives as the basis for plan comparison. The alternatives that were screened to arrive at the selected alignment and alternatives are discussed in Section 4 and 5 of the Main Report.

In addition to the NED account, two other project accounts have been used to evaluate the project alternatives: Regional Economic Development (RED) and Other Social Effects (OSE). Each of these accounts will be discussed in separate appendices.

**NED Benefit Categories Considered**. The NED procedure manuals for coastal and urban areas recognize four primary categories of benefits for flood risk management measures: inundation reduction, intensification, location, and employment benefits. The majority of the benefits attributable to a project alternative generally result from the reduction of actual or potential damages caused by inundation. Inundation reduction, which is the only category of NED benefits addressed in this evaluation, includes the reduction of physical damages to structures, contents, and vehicles, avoidance of structure-raising costs, emergency cost reduction, agricultural benefits, water supply benefits, and safe harbor benefits.

*Physical Flood Damage Reduction.* Physical flood damage reduction benefits include the decrease in potential damages to residential and commercial structures, their contents, and the privately owned vehicles associated with these structures. Inundation reduction benefits were considered under both existing and future conditions. Projections of the future development expected to place in the study area during the period of analysis were included as part of the future condition analysis.

Since partial storm surge risk reduction will be provided before the base year of each project alternative, inundation reduction benefits for residential and commercial structures, their contents, and vehicles can be achieved during construction. The benefits during construction were computed by comparing the expected without-project damages to the with-project damages receiving partial risk reduction. The benefits during construction begin in the year 2024 for both of the alternatives.

Office of Management and Budget (OMB) survey forms were used to collect information on the value and placement of contents in the 24 industrial facilities located in the study area. The information from these surveys was used to develop the physical flood damage and benefits for these industrial properties. Additional information regarding the use of the OBM approved forms can be found in the final report dated May 2009 entitled *Morganza to the Gulf Post Authorization Change Report: Residential and Nonresidential Structure Inventory and Nonresidential Surveys*.

*Avoidance of Structure-Raising Costs.* Typically, property owners in areas that incur repetitive flooding have three options for reducing their flood risk: raise their structures in place, floodproof/retrofit their structures, or relocate to other areas. For purposes of this evaluation, only structure-raising measures were considered. The avoidance of structure-raising costs for all residential and non-residential structures that would otherwise incur repetitive flooding is considered a benefit attributable to the project alternative.

*Emergency Cost Reduction Benefits.* Emergency costs are those costs incurred by the community during and immediately following a major storm. They include the costs of emergency measures, such as evacuation and reoccupation activities conducted by local governments and homeowners, repair of streets, highways, and railroad tracks, and the subsequent cleanup and restoration of private, commercial, and public properties. In this evaluation, only the emergency cost reduction benefits associated with debris removal and cleanup and the reduction of damages to major and secondary highways and streets were considered.

*Agricultural Benefits.* NED agricultural benefits are defined as the increase in the value of the agricultural output of the area and the decrease in the cost of maintaining a given level of output attributable to a project alternative. These benefits include reductions in production costs and in associated costs, the reduction in damage costs from floods, erosion, sedimentation, inadequate drainage, or inadequate water supply, the value of increased production of crops, and the economic efficiency of increasing the production of crops in the project area.

Agricultural benefits have not been quantified and are not included in this appendix. However, the average annual agricultural acres inundated under without-project and with-project conditions have been provided for each of the project alternatives.

*Municipal Water Supply Benefits.* The NED benefits from municipal water supply are defined as the willingness of a community to pay for an increase in the value of goods and services attributable to the water supply. In most cases, the marginal cost of supplying water is used to calculate the willingness of the consumers to pay for the additional water supply. However, because the marginal cost was not determined in this study, the water supply benefits were measured by comparing the reduction in the cost of treating water for municipal usage during periods of high salinity that is attributable to each of the project alternatives.

*Safe Harbor Benefits for Large Recreational and Commercial Boat Fleets.* The project alternatives reduce the risk of physical damage to large recreational and commercial boat fleet boats from the storm surges associated with minor storms, tropical storms, and hurricanes. The reduction in damages to large vessels and the reduction in the cost of moving the vessels to safer areas are considered benefits attributable to the project alternatives. However, only the reduction in travel costs was considered in this evaluation.

**Regional Economic Development.** The RED account has been addressed in a separate appendix to evaluate the project alternatives. If the economic activity lost in the flooded region can be transferred to another area or region in the national economy, then these losses are not included in the NED account. However, the impacts on the employment, income, and output of the non-Federal or regional economy are considered part of the RED account. The input-output macroeconomic model RECONS was used to address the impacts of the construction spending associated with each of the project alternatives on the regional economy.

**Other Social Effects.** The OSE account has been addressed in a separate appendix to evaluate the project alternatives. OSE focuses on the health and safety impacts that each of the project alternatives has on the local population. Also, Environmental Justice (EJ) issues were investigated as part of the Environmental Impact Statement.

## DESCRIPTION OF THE STUDY AREA

**Geographic Location**. The study area, which is located in coastal Louisiana approximately 60 miles southwest of the city of New Orleans, includes all of Terrebonne Parish and the portion of Lafourche Parish to the south and west of Bayou Lafourche. Communities located within the study area include the city of Houma, the towns of Chauvin, Dulac, and Montegut in southern Terrebonne Parish, the towns of Donner and Gibson in western Terrebonne Parish, and the towns of Gray and Schriever in northern Terrebonne Parish. Also included are the towns of Raceland, Lockport, and Pointe aux Chenes in Lafourche Parish and the portion of the city of Thibodaux south of Bayou Lafourche. The Gulf Intracoastal Waterway (GIWW) passes through the northern part of the study area in an east-west direction, and the Houma Navigation Channel (HNC) extends due south from Houma to the Gulf of Mexico. The southern extent of the study area is the alignment for the proposed hurricane protection structure that would cross the southern part of Terrebonne Parish in an east-west direction. The Morganza evaluation area was divided into 276 unique hydrologic reaches to enable an economic analysis of the project alternatives through the use of the HEC-FDA certified model. However, an inventory of residential and non-residential structures was only assembled in the 264 study area reaches that could be impacted by storm surges under the without-project condition.

**Land Use.** The total number of acres of developed, agricultural, and undeveloped land in Terrebonne Parish and the portion of Lafourche Parish included in the study area as of the year 2009 is shown in Table 1. The portions of Lafourche Parish north and east of Bayou Lafourche were not included in the analysis.

As shown in the table, approximately 10 percent of the total acres in the study area are currently developed. Since there are approximately 76,000 acres of agricultural land and 2,100 acres of shrub land and grassland available for future development, there is sufficient land available to accommodate the projected residential and non-residential development through the year 2085 without impacting the wetlands in the area.

## SOCIOECONOMIC SETTING

**Population and Number of Households**. Table 2 displays the population in each of the parishes for the years 1970, 1980, 1990, 2000, and 2010 (study year), as well as projections for the year 2035 and the year 2085, the two years that engineering inputs were modeled and used to calculate damages and benefits. Population projections are based on the Moody's County Forecast Database, which has population projections to the year 2038. Moody's projections were extended by New Orleans District from the year 2038 to the year 2085 based on the growth rate forecasted by Moody's for the years 2018 through 2038. The slow, steady growth rate projected by Moody's during this 20-year period was consistent with the growth predicted by parish planning officials.

As shown in Table 2, both Lafourche and Terrebonne Parishes experienced a steady increase in population between 1970 and 2010. According to U.S. Census data, the population of Lafourche Parish increased from 89,974 in 2000 to 96,318 in 2010, a growth of 6,344 residents over the ten-year period. During the same period, the population of Terrebonne Parish increased from 104,503 to 111,860, an increase of 7,357 residents. The population in both parishes is projected to maintain this steady increase in population growth, with Lafourche Parish expected to have approximately 97,900 residents in 2035 and approximately 104,200 residents in the year 2085. Terrebonne Parish is expected to experience even more growth with an estimated population of approximately 120,900 in 2035 and 142,800 in 2085. Approximately 218,800 residents are projected to reside in the two-parish area in 2035, while approximately 247,000 residents are projected for the year 2085.

Table 3 displays the estimated population of the two parishes located within the inventoried portion of the study area for the year 2010 and the projected population for the years 2035 and 2085. The 2010 estimates are based on an inventory of residential and non-residential properties assembled in 2009 by field survey teams. The number of inventoried residential structures was then multiplied by 2.9, the average number of persons per household in the study area in 2010. In 2010, there were approximately 28,800 people residing in the inventoried structures in Lafourche Parish and approximately 104,900 people in Terrebonne Parish for a total of 133,700 residents. The projected population for the years 2035 and 2085 was based on the 2010 proportion of the total population residing within the inventoried area. The projected population for the years 2035 and 2085 for each parish was then multiplied by these proportions to determine the projected population for each parish. The population of Lafourche Parish is projected to total approximately 29,300 in 2035 and about 31,200 in 2085. In Terrebonne Parish, the population in this area is expected to total approximately 113,200 in 2035 and 133,800 in 2085.

Table 4 shows the total number of households in each parish for the years 1970, 1980, 1990, 2000, and 2010 and projections for the years 2035 and 2085. The projected number of households was based on the Moody's County Forecast Database and extended from the year 2038 to the year 2085 by New Orleans District based on the a growth rate forecasted by Moody's for the years 2018 through 2038.

The total number of households in Lafourche and Terrebonne Parishes experienced a steady increase between 1970 and 2010, which paralleled the growth in population. This increase, which was commensurate with the population growth experienced by the entire Gulf Coast region during the same period, can be attributed to increases in oil and gas exploration in the Gulf of Mexico and technological advancements in the industry. Similar to the projected population growth in the two-parish area, the number of households is expected to continue increasing through the year 2085. Lafourche Parish is projected to have approximately 36,300 households in the year 2035, while Terrebonne Parish is projected to have about 43,400 households. By the year 2085, the number of households in Lafourche Parish is expected to reach approximately 38,100, while the number in Terrebonne Parish is expected to reach to approximately 50,400. In total, the two parishes are projected to have approximately 88,600 households in the year 2085.

**Income**. Table 5 shows the per capita personal income levels for each parish for the years 1990, 2000, 2005, 2008, and 2009, the year with the latest available data.

As shown in the table, both parishes experienced a steady increase in per capita income between 1990 and 2008. The growth in per capita income during this time reflects the increased oil and gas exploration and production activities in the Gulf of Mexico and the improvement in the economy of the state. It also reflects the improvement in the national economy that occurred from the late 1990s through the year 2008.

Between 2008 and 2009, however, both parishes experienced a slight decline in per capita income, which is likely a result of the global economic recession experienced during this time. The decline is slightly lower than the decline in per capita income seen in the state of Louisiana, which decreased from a per capita income of $38,142 in 2008 to $37,632 in 2009.

**Employment**. Table 6 shows the total nonfarm employment by parish for the years 1970, 1980, 1990, 2000, 2010, and projections for the years 2035 and 2085. The employment projections were based on the Moody's County Forecast Database and extended from the year 2038 to the year 2085 by New Orleans District based on the growth rate forecasted by Moody's for the years 2018 through 2038.

Employment trends in the area have historically moved with the demand for oil and gas resources. The unemployment rate in Terrebonne and Lafourche parishes averaged approximately three percent prior to the end of 2008. The Houma-Thibodaux Metropolitan Statistical Area (MSA) continues to lead the state in jobs created and has one of the lowest unemployment rates in the state.

While the oil and gas industry pays the highest wages of all of the sectors of the economy, the services industry employs the largest number of residents. The retail sector is the second largest employer followed by government and other public agencies. The oil and gas sector in Terrebonne Parish employs slightly over 5,000 residents.

In addition to the oil and gas industry, there are three other sectors of the economy that are important to the region: commercial navigation, fisheries, and agriculture. The GIWW, the Houma Navigation Canal, and Bayou Lafourche provide key navigational channels for the energy sector. The coastal region provides a fertile spawning ground for fisheries including shrimp, crabs, oysters, and finfish. Finally, the area grows and processes sugarcane.

**Future Trends**. In all portions of the study area, growth is highly dependent upon the major employment sectors. In addition, the growth in manufacturing is another major sector dependent upon the shipbuilding industry adjacent to Bayou Lafourche and the Houma Navigation Canal. The cyclical nature of the oil and gas industry has caused temporary fluctuations in the local economy since 1970. However, the overall level of growth in the population, income, and employment of the region has shown a steady increase. During the 1990s and early 2000s, technological advancements were made in the offshore oil exploration industry, such as 3D seismic drilling, which spurred exploration activity. Also during this decade, a regional cancer treatment facility was opened in the city of Houma.

The area was significantly impacted by the 2010 Deepwater Horizon British Petroleum oil spill and the decision by the Federal government to suspend the issuance of new deepwater drilling permits while safety standards were reassessed. Even though the first deep-water drilling permit since the oil spill was issued in March 2011, the area has not yet returned to the level of economic activity that it experienced prior to the oil spill and the resulting ban on drilling. According to data released by the Louisiana Department of Natural Resources at the end of 2011, there are currently 35 rigs in operation, the highest rig count off the Louisiana coast since the oil spill. The weekly rig count prior to the oil spill averaged 42 rigs. This appears to be a positive sign that the area is beginning to recover, albeit at a slow pace.

While the long term impact of the oil spill to the study area is unknown, there are other positive developments occurring in the area. During the past two decades, improvements were made in the transportation network including the opening of Interstate 310, which facilitates travel between the cities of Houma and New Orleans. The proposed I-49 highway will provide an efficient traffic route between the cities of New Orleans and Lafayette, although funding has not yet been obtained for its construction. This project may lead to increased development in the northern portion of the study area near the town of Gray in Terrebonne Parish. A proposed highway that will connect Louisiana Highway 3127 to the cities of Thibodaux and Houma could also facilitate growth in the study area.

**Compliance with Policy Guidance Letter (PGL) 25 and Executive Order 11988**. Given the recent growth trends, it is reasonable to assume that development will continue to occur in the study area with or without the storm surge risk reduction system, and will not conflict with PGL 25 and EO 11988, which state that the primary objective of a flood risk reduction project is to protect existing development, rather than to make undeveloped land available for more valuable uses. With the project in place, future development may shift from the northern portions of the study area to the southern portion of the study area south of Houma. However, the overall growth rate is anticipated to be the same with or without the project in place. Thus, the project will not induce development, but would rather reduce the risk of the population being displaced after a major storm event.

## RECENT FLOOD HISTORY

**Tropical Flood Events**. While Lafourche and Terrebonne parishes have periodically experienced localized flooding from excessive rainfall events, the primary cause of the flood events that have taken place in the two-parish study area has been the tidal surges from hurricanes and tropical storms. During the past 25 years, coastal Louisiana was impacted by eight major tropical events: Hurricane Juan (1985), Hurricane Andrew (1992), Tropical Storm Isidore and Hurricane Lili (2002), Hurricanes Katrina and Rita (2005), and Hurricanes Gustav and Ike (2008). While none of these storms tracked directly through the study area, the tidal surges associated with these storm events inundated structures and resulted in billions of dollars in damages to coastal Louisiana.

Table 7 provides a summary of the total FEMA flood claims paid to all Louisiana policyholders as a result of these tropical events. The table includes the number of paid losses, the total amount paid, and the average amount paid on each loss. The total and average paid losses have been converted to reflect 2011 price levels. The table only includes losses that were covered by flood insurance.

The following is a summary of each of the eight major tropical events and their effects on the two-parish area and coastal Louisiana.

*Hurricane Juan*. Hurricane Juan caused extensive flooding throughout southern Louisiana due to its prolonged 5-day movement back and forth along the Louisiana coast. Rainfall totals in the area ranged from 5 inches to almost 17 inches. The storm was responsible for storm surges of 5 to 8 feet and tides of 3 to 6 above normal. According to FEMA officials, the estimated value of the residential and commercial damage and public assistance throughout coastal Louisiana totaled $112.5 million.

Over 800 homes were inundated in the coastal portion of Terrebonne Parish south of the city of Houma. Scattered pockets of flooding were also reported in the portions of Terrebonne and Lafourche Parishes north of Houma. Approximately 40 percent of the homes in the coastal areas of Lafourche Parish, including Pointe aux Chenes, were also inundated by the high tides.

Agricultural damages from the storm totaled $175 million, with 24 percent of these damages occurring in the two-parish study area. The soybean crop suffered over half of the agricultural damage, while the sugar cane crop incurred 20 percent of the damage.

Excessive rains and storm surge oversaturated the fields and caused a reduction in crop yields. The saturated fields also made it easier for the winds to topple over the cane stalks.

*Hurricane Andrew*. On August 26, 1992, Hurricane Andrew made landfall in St. Mary Parish, 80 miles west of Morgan City. FEMA reported that over 2,000 flood claims were filed as a result of the storm in Louisiana. These claims had a total value of over $25 million. Over 90 percent of this flood damage occurred in the Terrebonne Parish communities south of Houma, where up to six feet of water was reported. Only minor flooding in the back parts of subdivisions was reported in the city of Houma and in the areas north of the city. The unleveed portion of Lafourche Parish along its border with Terrebonne Parish, which includes the community of Pointe aux Chenes, also incurred extensive flood damage. However, most of the agricultural damage in the area occurred as the result of wind damage to the sugar cane crop.

*Tropical Storm Isidore and Hurricane Lili*. On October 3, 2002, one week after Tropical Storm Isidore affected the southeastern and south central coastal areas of Louisiana, Hurricane Lili made landfall on the western edge of Vermilion Bay south of the cities of Abbeville and New Iberia as a weak Category 2 hurricane. The high winds caused tidal flooding in the communities east of the eye of the storm. The ridge communities in Terrebonne Parish south of the city of Houma, including Cocodrie, Dulac, Isle de Jean Charles, and Montegut, and the community of Pointe aux Chenes in Lafourche Parish were affected by tidal flooding. The only community south of Houma that did not flood was Chauvin.

Insured flood losses from Tropical Storm Isidore and Hurricane Lili totaled nearly $600 million. Approximately $105 million of insured losses were related to Tropical Storm Isidore, while Hurricane Lili caused $471 million of insured losses. According to windshield surveys conducted by the American Red Cross, approximately 10,000 residential structures were damaged by winds and storm surges of the two storms. These surveys included both insured and uninsured structures. Tropical Storm Isidore caused damage to 2,905 structures, while Hurricane Lili caused damage to 7,356 structures.

In a revised report released in mid-November by the Louisiana State University Agricultural Center (LSU AgCenter), the estimated agricultural damages caused by Tropical Storm Isidore and Hurricane Lili totaled $454.3 million. This estimate also includes the agricultural damages caused by the continuation of rain during the month of October, which delayed the harvesting of crops. The excessive rains and storm surge flooded the agricultural fields and increased the harvest costs.

The wind and waves of Tropical Storm Isidore and Hurricane Lili caused extensive beach erosion in the barrier islands of Louisiana. These islands protect the Louisiana coastline from storm surges and provide a natural habitat for many species of wildlife. The barrier islands west of the mouth of the Mississippi River that were affected by the two storm events include the Isles Dernieres (Whiskey Bayou, Raccoon Island, Trinity Island, and East Island), Timbalier Island, East Timbalier Island, Elmer Island, and Grand Terre.

Grand Isle incurred extensive damage along its eastern beach. Three small islands east of the mouth of the Mississippi River, Grand Gosier Island, Curlew Island, and Chandeleur Island, incurred extensive damage and beach erosion. A monetary value has not been determined for these environmental damages.

*Hurricane Katrina.* On August 29, 2005, Hurricane Katrina made landfall near the town of Buras in Plaquemines Parish about 50 miles east of coastal Lafourche and Terrebonne parishes. While it entered as a category 3 storm with winds in excess of 120 mile per hour. However, its storm surge of approximately 30 feet was more characteristic of a Category 5 hurricane. The majority of the damages from Hurricane Katrina occurred outside of the Morganza study area. However, if the hurricane had taken a more westerly track, the Houma area could have experienced the same magnitude of flooding as the city of New Orleans.

According to the Department of Health and Hospitals, approximately 1,400 deaths were reported following Hurricane Katrina. Approximately 1.3 million residents were displaced immediately following the storm, and 900,000 residents remained displaced as of October 5, 2005. According to the Louisiana Recovery Authority, two years after the storm, approximately 210,000 FEMA applicants still had out-of state mailing addresses, while 230,000 FEMA applicants had an in-state mailing address in a different zip code.

The storm caused more than $40.6 billion of insured losses to the homes, businesses, and vehicles in six states. Approximately two thirds of these losses, or $25.3 billion, occurred in Louisiana based on data obtained from the Insurance Information Institute. According to the LRA, approximately 150,000 housing units were damaged, and according to the Department of Environmental Quality, 350,000 vehicles, and 60,000 fishing and recreational vessels were damaged.

The storm surge from Hurricane Katrina inundated marshes and farmland throughout the coastal area including Terrebonne and Lafourche parishes. According to the LSU AgCenter, agricultural losses totaled approximately $825 million. The agricultural resources impacted by the storm include sugarcane, cotton, rice, soybeans, timber, pecans, citrus, and livestock. The losses to aquaculture (crawfish, alligators, and turtles), fisheries (shrimp, oysters, and menhaden), and wildlife and recreational resources totaled approximately $175 million.

*Hurricane Rita.* The hurricane made landfall along the Texas-Louisiana border on September 24, 2005, as a Category 3 storm with winds in excess of 120 miles per hour. As the hurricane passed south of the study area, its high winds pushed water north into coastal Lafourche and Terrebonne parishes. A storm surge of approximately 15 - 20 feet affected Coastal Louisiana from Terrebonne Parish to the Texas border. With estimated insured losses of approximately $3 billion, Hurricane Rita became one of the most costly natural disasters in U.S. history.

Approximately 2,000 square miles of farmland and marshes throughout the coastal area were inundated. According to the LSU AgCenter, agricultural losses totaled approximately $490 million. The agricultural resources impacted by the storm include sugarcane, cotton, rice, soybeans, timber, pecans, citrus, and livestock. The losses to aquaculture (crawfish, alligators, and turtles), fisheries (shrimp, oysters, and menhaden), and wildlife and recreational resources totaled approximately $100 million.

*Hurricanes Gustav and Ike*. On September 1, 2008, almost exactly three years after Hurricane Katrina, Hurricane Gustav made landfall near Cocodrie in Terrebonne Parish as a strong Category 2 hurricane. It followed a northwest path into central Louisiana, and most of the damages caused by the storm resulted from its high winds and heavy rain. Coastal flooding occurred in the low lying areas of Jefferson and Lafourche Parishes and the coastal areas of Terrebonne Parish south of the City of Houma.

Nearly 2 million residents of South Louisiana evacuated in the days before Gustav made landfall. Louisiana officials reported that emergency spending totaled approximately $500 million, which included $210 million for state agencies, $48 million for deploying the National Guard, $13.5 million for general evacuation shelters, $3 million for special-needs medical shelters, $6.1 million for transporting the medical needy, $21 million for costs of contraflow and evacuation from coastal communities and other areas, $20 million in special generators to open ice plants, pharmacies and service stations throughout the impacted areas, $5 million for state-purchased fuel, $19.7 million for ready-to-eat meals, $5.3 million for ice, and $2.5 million for water supplies. The State Department of Transportation estimated that it cost approximately $50 million to remove 1.5 million cubic yards of debris, and approximately $20 million to repair draw bridges.

Almost two weeks later, on September 12 and 13, the Louisiana coastal region incurred additional flood damages as Hurricane Ike moved along the Louisiana coast. According to estimates from the state officials, approximately 12,000 homes and businesses were flooded by the two storms. Approximately 2,500 buildings in Terrebonne Parish south of the City of Houma incurred flood damages from Hurricane Ike.

The LSU AgCenter estimated that potential lost revenues and damages to the infrastructure of the agriculture, forestry, and fisheries industries in Louisiana resulting from the two hurricanes totaled approximately $959 million. The storm surge primarily affected the cattle, rice, soybeans, and sugarcane.

**FEMA Flood Claims**. While Lafourche and Terrebonne parishes have periodically experienced localized flooding from excessive rainfall events, the primary cause of the flood events that have taken place in the two-parish study area has been the tidal surges from hurricanes and tropical storms. The total FEMA flood claims for the two parishes in the Morganza to the Gulf evaluation area that were paid between 1978 and September 2011 are summarized in Table 8. The table includes only those claims that were covered by flood insurance. Figure 1 shows the location of the repetitive loss properties that have had two or more FEMA flood claims during any 10-year period between 1978 and 2010.

## SCOPE OF THE STUDY

**Problem Description**. The study area is characterized by low, flat terrain with ridges surrounding the waterways. The terrain has made the area highly susceptible to flooding from the tidal surges of hurricanes and tropical storms. The apparent subsidence, or relative sea level rise, that has been taking place in the Morganza study area, is expected to magnify the flooding problems in the future. While the Terrebonne Levee and Conservation District is currently maintaining a system of forced drainage levees, pump stations, and flood control structures for Terrebonne Parish, an adequate overall storm surge risk reduction system is not currently available for the entire study area.

**Project Alternatives.** As part of the 2002 Morganza to the Gulf, Louisiana Feasibility Report, a project alignment was selected and later authorized to provide storm surge risk reduction for portions of Terrebonne and Lafourche parishes. The authorized alignment was designed to contain the pre-Katrina surge elevations associated with the 1% (100-year) annual exceedance probability (AEP) storm surge risk reduction system, and the costs were provided in 2002 price levels. Since that time, the hydrology, project design criteria, and implementation costs have changed. A Revised Project Cost Estimate (RPCE) report was developed in 2008 using post-Katrina design criteria and water surface profiles for the 1% (100-year) AEP storm surge risk reduction system. A second alternative under consideration, the 3% (approximately 35-year) AEP storm surge risk reduction system, applies pre-Katrina design criteria and authorized levee height elevations to the authorized alignment. This alignment involves the construction of new earthen levees that would run parallel to Louisiana Highway 57 south of Lake Boudreaux and north of the Falgout Canal and would connect to existing forced drainage levees. The levees will be used in conjunction with flood risk management and environmental structures and would minimize the adverse impacts to the environment, local interests, navigation, and industry. Finally, construction of a lock structure on the Houma Navigation Canal (HNC) south of Bayou Grand Caillou has been included as part of the system. Figure 2 shows the location of the study area reaches and the project alignment. The study area reaches are also shown in the 11x17 maps attached to the main report.

# PART 2: ECONOMIC AND ENGINEERING INPUTS TO THE HEC-FDA MODEL

## HEC-FDA MODEL

**Model Overview.** The Hydrologic Engineering Center Flood Damage Analysis (HEC-FDA) Version 1.2.5a Corps-certified model was used to calculate the damages and benefits for the Morganza evaluation. The economic and engineering inputs necessary for the model to calculate damages for existing conditions (2010), the first year of partial storm surge risk reduction (2024), the project base year (2035), and the final year in the period of analysis (2085) are described in this section of the report. The economic inputs include structure inventory, future development, contents-to-structure value ratios, vehicles, first floor elevations, and depth-damage relationships. The engineering inputs include ground elevations, exterior and interior relationships, local levee performance, and Federal levee performance. A separate HEC-FDA model was executed for the industrial structures in the study area for the years 2024, 2035, and 2085.

The uncertainty surrounding each of the economic and engineering variables was also entered into the model. Either a normal probability distribution, with a mean value and a standard deviation, or a triangular probability distribution, with a most likely, a maximum and a minimum value, was entered into the model to quantify the uncertainty associated with the key economic variables. A normal probability distribution was entered into the model to quantify the uncertainty surrounding the ground elevations. The number of years that stages were recorded at a given gage was entered for each study area reach to quantify the hydrologic uncertainty or error surrounding the stage-probability relationships. The uncertainty associated with the levee performance was quantified using the levee features section of the model, which related the elevation of exterior storm surges to the probability of levee failure.

## ECONOMIC INPUTS TO THE HEC-FDA MODEL

**Structure Inventory**. Field surveys were conducted in 2009 to develop a residential and non-residential structure inventory for the economic analysis. The areas to be inventoried had been selected in 2008 based on estimates of surge elevations for this area developed as part of the Louisiana Coastal Protection and Restoration (LACPR) evaluation.
Since the ground elevations in the northern portions of the evaluation area near Bayou Lafourche, including the towns of Gray and Schriever in Terrebonne Parish and the

southern portion of the city of Thibodaux in Lafourche Parish, and in the western portions of the study area near Donner and Gibson in Terrebonne Parish, were determined to be above these storm surge estimates, the structures in these areas were not included in the inventory.

Based on the structural information collected during the field surveys, the Marshall and Swift Valuation Service was used to calculate a depreciated replacement cost for all residential and non-residential structures in the study area reaches. The inventoried structures were classified as one of 14 structure types: residential one-story with slab or pier foundation, residential two-story with slab or pier foundation, mobile home, eating and recreation, grocery and gas station, multi-family residence, professional building, public and semi-public building, repairs and home use establishment, retail and personal services building, and warehouse, and contractor services building. The inventory also included 24 industrial structures that were inventoried using OMB approved interview forms. Table 9 shows the number of structures by structure category and the total number of vehicles associated with the residential structures for existing conditions (2010) for each study area reach or HEC-FDA model station number. The value of the land was not included in the analysis.

**Future Development Inventory**. Projections were made of the future residential and non-residential development to take place in the Morganza study area under without-project conditions. Based on historical economic trends, a total of 7,320 residential and 1,319 non-residential structures were placed on the undeveloped land within the study area reaches as part of the structure inventory for the year 2035. An additional 16,332 residential and 4,661 non-residential structures were added to the inventory for the year 2010 to obtain the structure inventory for the year 2085.

The development projected to occur in each study area reach between the year 2010 and the year 2035 was placed at an elevation equal to the stage associated with the without-project one percent annual chance exceedance (1% ACE) (100-year) event, unless the ground elevation was higher. The projected development occurring after the year 2035 was placed at an elevation equal to the stage associated with the without-project 1% ACE (100-year) event for the year 2085, unless the ground elevation was higher. The values for the projected residential and non-residential structures were assigned using the average value calculated for each structure category based on the 2010 existing development.

Table 10 shows the number of structures in each structure category and the average depreciated replacement values for (2010) existing conditions. Table 11 shows the projected number of structures in each structure category for the future years 2035 and 2085, respectively. The value of the land was not included in the analysis.

**Residential and Non-Residential Content-to-Structure Value Ratios**. On-site interviews were conducted with the owners of a sample of ten structures from each of the three residential content categories (30 residential structures) and each of the eight non-residential content categories (80 non-residential structures). A CSVR was computed for each residential and non-residential structure in the sample based on the total depreciated content value developed from the surveys. An average CSVR for each of the five residential structure categories and nine commercial structure classifications was calculated as the average of the individual structure CSVRs.

Since only a limited number of field surveys were conducted for each of the residential and non-residential content categories, statistical bootstrapping was performed to address the potential error in estimating the mean and standard deviation CSVR values. Statistical bootstrapping is a method that uses re-sampling with replacement to improve the estimate of a population statistic when the sample size is insufficient for straightforward statistical inference. The bootstrapping method has the effect of increasing the sample size. Thus, bootstrapping provides a way to account for the distortions caused by the specific sample that may not be fully representative of the population.

With use of the @Risk software, a simulation using 100,000 iterations was executed for each content category. Within each iteration, a new ten-observation sample with replacement, called a bootstrap sample, was taken from the original sample of ten observations. Each observation within the original sample was given a uniform probability or chance of being selected as each one of the ten values within the bootstrap sample. The @Risk spreadsheet calculated a mean value and a standard deviation for each of the bootstrap samples, and then calculated a mean value for all of the bootstrap means and mean value of all the standard deviations.

Table 12 shows the CSVRs and standard deviations for each of the residential and non-residential structure categories derived using the statistical bootstrapping technique. The CSVRs and standard deviations were used in the HEC-FDA model along with the depth-damage relationships to calculate flood damages for residential and non-residential structures. A unique CSVR was developed for each of the 24 industrial structures in the study area based on the content values provided by the owners of the properties using OMB approved interview forms.

**Vehicle Inventory**. Based on 2000 Census block group data for the evaluation area, it was determined that there are an average of 1.64 vehicles associated with each household (owner occupied housing or rental unit). According to the Southeast Louisiana Evacuation Behavioral Report published in 2006 following Hurricanes Katrina and Rita, approximately 70 percent of privately owned vehicles are used for evacuation during storm events. The remaining 30 percent of the privately owned vehicles remain parked at the residences and are subject to flood damages. Using the Manheim Used Vehicle Value Index, which is based on over 4 million annual automobile transactions adjusted to reflect retail replacement value, each vehicle was assigned an average value of $12,879. Since only those vehicles not used for evacuation can be included in the damage calculations, an adjusted average vehicle value of $6,336 ($12,879 x 1.64 x .30) was assigned to each individual residential structure record in the HEC-FDA model. The adjusted vehicle value was adjusted upward by 3.7 percent using the Manheim index from 2010 to 2011 to reflect an October 2011 price level. If an individual structure had more than one housing unit, then the adjusted vehicle value was assigned to each housing unit in a residential or multi-family structure category.

**First Floor Elevations and Elevation of Vehicles**. Topographical data obtained from the Light Detection and Ranging (LIDAR) digital elevation model (DEM) using the NAVD88 (2004.65 epoch) were used to determine ground elevations. Field survey teams estimated the height of each residential and non-residential structure above the ground using hand levels. The ground elevation was added to the height of the foundation of the structure above the ground in order to determine the first floor elevation of the structure. Vehicles were assigned to the ground elevation of the adjacent residential structures.

**Depth-Damage Relationships**. Site-specific saltwater, long duration (approximately one week) depth-damage relationships, developed by a panel of building and construction experts for the Morganza evaluation, were used in the economic analysis. These curves indicate the percentage of the total structure value that would be damaged at various depths of flooding. Damage percentages were determined for each one-half foot increment from one-half foot below first floor elevation to two feet above first floor, and for each one-foot increment from 2 feet to 15 feet above first floor elevation. The panel of experts developed depth-damage relationships for five residential structure categories and for three commercial structure categories. Depth-damage relationships were also developed for three residential content categories and eight commercial content categories. A unique depth-damage relationship was developed for the contents of each of the 24 industrial structures in the study area based on information provided by the owners of the properties using OMB approved interview forms.

The depth-damage relationships for vehicles were developed based on interviews with the owners of automobile dealerships that had experienced flood damages and were used to calculate flood damages to vehicles at the various levels of flooding.

Table 13 shows the residential and non-residential depth-damage relationships developed for structures, contents, and vehicles. More specific data regarding the depth-damage relationships can be found in the final report dated May 1997 entitled *Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-to-Structure Value Ratios (CSVRs) in Support of the Lower Atchafalaya and Morganza to the Gulf, Louisiana, Feasibility Study*.

**Uncertainty Surrounding the Economic Inputs**. The uncertainty surrounding the four key economic variables was quantified and entered into the HEC-FDA model. These economic variables included structure values, contents-to-structure value ratios, first floor elevations, and depth-damage relationships. The HEC-FDA model used the uncertainty surrounding these variables to estimate the uncertainty surrounding the stage-damage relationships developed for each study area reach.

*Structure and Vehicle Values.* In order to quantify the uncertainty surrounding the values calculated for the residential and non-residential structure inventory, several survey teams valued an identical set of structures from various evaluation areas in the Gulf Coast region. The structure values calculated by each of the teams during windshield surveys were used to develop a mean value and a standard deviation for each structure in the sample. The standard deviation was then expressed as a percentage of the mean value for that structure. The average standard deviation as a percentage of the mean for the sampled structures was then used to represent the uncertainty surrounding the structure value for all the inventoried residential and non-residential structures. The average standard deviation, which was expressed as a percentage of the mean structure value, totaled 12.15 percent for residential structures and 14.28 percent for non-residential structures.

The uncertainty surrounding the values assigned to the vehicles in the inventory was determined using a triangular probability distribution function. The Manheim vehicle value, adjusted for number of vehicles per household and for the evacuation of vehicles prior to a storm event, was used as the most likely value. The average value of a new vehicle before taxes, license, and shipping charges was used as the maximum value, while the average 10-year depreciation value of a vehicle was used as the minimum value.

*Content-to-Structure Value Ratios.* On-site interviews were conducted with the owners of a sample of ten structures from each of the three residential content categories (30 residential structures) and each of the eight non-residential content categories (80 non-residential structures). A CSVR was computed for each residential and non-residential structure in the sample based on the total depreciated content value developed from these interviews. A probability distribution function derived using the statistical bootstrapping method was then used to describe the distribution of these observations around the expected mean value. The mean and standard deviation values for each residential and non-residential category were entered into the HEC-FDA model. The model used a normal probability density function to describe the uncertainty surrounding the CSVR for each content category. The expected values and standard deviations are shown for each of the three residential categories and the eight non-residential categories in the final report dated May 1997 entitled *Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-to-Structure Value Ratios (CSVRs) in Support of the Lower Atchafalaya and Morganza to the Gulf, Louisiana Feasibility Study.* Since the CSVRs for the 24 industrial structures in the study area were based on information provided by the property owners, there was no uncertainty surrounding these ratios.

*First Floor Elevations.* The topographical data used to estimate the first floor elevations assigned to the structure inventory contain two sources of uncertainty. The first source of uncertainty arises from the use of the 2009 LIDAR data, and the second source of uncertainty arises from the use of hand levels to determine the structure foundation heights above ground elevation. The error implicit in using LIDAR data to estimate the ground elevation of each of the inventoried structures is normally distributed with a mean of zero and a standard deviation of 0.219 feet. These statistics were calculated based on comparing 2,241 engineering survey points or spot elevations to the elevations determined using the 2009 LIDAR data throughout the evaluation area. According to the Hydrologic Engineering Center training manual, the uncertainty implicit in estimating foundation heights using hand levels from within 50 feet of the structure is normally distributed with a mean of zero and a standard deviation of 0.3 feet at the 95 percent level of confidence.

Based on the error surrounding the LIDAR data and the error arising from the use hand levels, the total uncertainty was estimated for each structure category at the 90 percent level of confidence. The two standard deviations (LIDAR and hand levels) were squared and then totaled. The square root of this total, 0.297 feet, represents the uncertainty surrounding the first floor elevations assigned to the structures located in the Morganza evaluation area.

*Depth-Damage Relationships.* A triangular probability density function was used to determine the uncertainty surrounding the damage percentage associated with each depth of flooding. A minimum, maximum and most likely damage estimate was provided by a panel of experts for each depth of flooding. The specific range of values regarding probability distributions for the depth-damage curves can be found in the final report dated May 1997 entitled *Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-to-Structure Value Ratios (CSVRs) in Support of the Lower Atchafalaya and Morganza to the Gulf, Louisiana, Feasibility Study.*

The owners of the 24 industrial properties provided a minimum, maximum, and most likely content damage estimate for each depth of flooding using OBM approved survey forms. Copies of the OBM survey forms used to develop the depth-damage relationships can be found in the final report dated May 2009 entitled *Morganza to the Gulf Post Authorization Change Report: Residential and Nonresidential Structure Inventory and Nonresidential Surveys.*

## ENGINEERING INPUTS TO THE HEC-FDA MODEL

**Ground Elevations**. Geospatial Engineering acquired elevation data for the Morganza study area in 2009. The LIDAR data were processed and used to create a digital elevation model (DEM) with a five-foot by five-foot horizontal grid resolution. The DEM used NAVD88 2004.65 vertical datum to determine the ground elevations for each of the residential and non-residential structures in the evaluation area.

**Stage-Probability Relationships**. Stage-probability relationships were provided for the existing (2010) without-project condition, and for the first year of partial storm surge reduction (2024), the base year of the project (2035), and the final year in the period of analysis (2085) under both without-project and with-project conditions for each of the 276 study area. Water surface profiles were provided for eight annual chance exceedance (ACE) events: 99% (1-year), 20% (5-year), 10% (10-year), 4% (25-year), 2% (50-year), 1% (100-year), 0.5% (200-year), and 0.2% (500-year). The water surface profiles were based only on storm surge and did not incorporate heavy rainfall events.

The 99% ACE (1-year) event, 20% ACE (5-year) event, and 10% ACE (10-year) event water surface profiles for the year 2010 were based on gage data. For each of these ACE events, the water surface profiles for the years 2024, 2035, and 2085 were determined by adding relative sea level rise to the gage data. The water surface profiles for the 2% ACE (50-year) event through the 0.2% ACE (500-year) event were based on results from the ADCIRC model. The 4% ACE (25-year) event stages were determined by interpolation between the 10% ACE (10-year) event stages and the 2% ACE (50-year) event stages.

In cases where an analysis of the hydrology indicated that the surge elevation for a particular probability storm event would not impact a study area reach, the stages for that event were assigned using an elevation lower than the minimum ground elevation in that study area reach. This was done to ensure that flood damages due to storm surge would not be reported for these areas. The minimum ground elevations were referenced to the LIDAR data for the Morganza evaluation.

**Non-Federal and Federal Levee Performance**. Local levee systems provide flood risk reduction under existing conditions (2010) for over 29,000 residential and non-residential structures located within 78 of the study area reaches. A set of fragility curves, which relates specific stages in NAVD 88 (2004.65 epoch) on the exterior side of the levee to four probabilities of levee failure (zero percent, ten percent, forty-five percent, and ninety-five percent), were developed for each of the local levee systems under the without-project condition. It was assumed that there was a zero percent probability of failure at the 2-foot stage for all local levees.

The fragility curves developed for each of the local levee systems considered multiple failure modes including the slope of the levee, seepage, wave heights, overtopping, and erodability. The failure of an existing non-Federal levee typically occurs when the structural integrity of the levee is compromised by the storm surge. However, geotechnical failure analyses conducted in the evaluation area determined that there is only a one to three percent probability of failure at the top of the levee due to stability issues. Thus, overtopping and erodability were used to develop the non-Federal levee fragility curves.

The fragility curves for the non-Federal levee system were entered into the HEC-FDA model for each study area reach containing a non-Federal levee in order to assess the performance of the non-Federal levee system. Table 14 shows the non-Federal levee fragility curves and the top of levee elevation developed for each of the study area reaches containing a levee.

Federal levees will provide flood risk reduction under future conditions for approximately 52,000 residential and non-residential structures located within 233 of the study area reaches. Each of the study area reaches was assigned to one of the ten major Federal levee reaches (A, B, and E through L) based on the location of the reach and the path of the storm surge should the Federal levee fail. Fragility curves were not developed for the Federal levee system. Only a top of the Federal levee elevation was entered into the HEC-FDA model for each of the study area reaches. The top of the levee elevation in this analysis does not represent the actual height of the Federal levee; rather, it represents the still water stage elevation at which the levee is assumed to fail. At this stage, which is below the actual top of the levee, waves will overtop the Federal levee at a rate of 2.0 cubic feet per second (cfs). Table 15 shows the top of Federal levee still water stage or elevation for each of the major levee reaches for each of the project alternatives.

When existing non-Federal or Federal levees are included in the analysis, an exterior-interior stage relationship must be considered in the analysis. The exterior-interior stage relationship defines the relationship between the water surface, or stage, outside of the levee and the stage within the floodplain behind the levee. Under the with-project conditions, exterior and interior stage relationships were provided for each study area reach. In the event of a Federal levee failure, the interior surge elevation changes as the distance from the levee increases. Thus, a unique interior surge elevation curve was provided for each interior study area reach under with-project conditions. Under the without-project condition, an exterior-interior stage relationship was not provided for each study area reach. In the event of a non-Federal levee failure, the elevation of the surges within the reach is the same on both sides of the levee regardless of the distance from the levee.

Figures 2-1 and 2-2 in the main report provide a conceptual depiction of how the engineering inputs are used in the HEC-FDA model.

**Uncertainty Surrounding the Engineering Inputs**. The uncertainty surrounding three key engineering parameters was quantified and entered into the HEC-FDA model. These engineering variables included ground elevations, stage-probability curves, and performance of the non-Federal and Federal levees. The HEC-FDA model used the uncertainty surrounding these variables to estimate the uncertainty surrounding the elevation of the storm surges for each study area reach.

*Ground Elevations*. An engineering survey was conducted to estimate the uncertainty surrounding the use of the 2009 LIDAR data to estimate ground elevations in urbanized areas. The LIDAR data were compared to 2,241 spot elevations, or engineering survey points, throughout the urbanized portions of the evaluation area. The uncertainty surrounding these data was found to be normally distributed with a mean of zero and a standard deviation of 0.219 feet. (A combination of the uncertainty surrounding the ground elevations and the foundation height of a residential and non-residential structure was discussed in the first floor elevation uncertainty section of this report.)

*Stage-Probability Relationships.* A 50-year equivalent record length was used to quantify the uncertainty surrounding the stage-probability relationships for each study area reach. Based on this equivalent record length, the HEC-FDA model calculated the confidence limits surrounding the stage-probability functions.

*Levee Performance.* The uncertainty surrounding the performance of the non-Federal levees was based on the fragility curves entered for each study area reach. The Federal levees are assumed to fail with certainty once the surge stage reaches the top of the levee height assigned to each study area reach.

## PART 3: NATIONAL ECONOMIC DEVELOPMENT (NED) FLOOD DAMAGE AND BENEFIT CALCULATIONS

## NED FLOOD DAMAGE AND BENEFIT CALCULATIONS FOR STRUCTURES, CONTENTS, AND VEHICLES

**HEC-FDA Model Calculations**. The HEC-FDA model was utilized to evaluate flood damages using risk-based analysis. Damages were reported at the index location for each of the 264 study area reaches for which a structure inventory had been conducted. A range of possible values, with a maximum and a minimum value for each economic variable (first floor elevation, structure and content values, and depth-damage relationships), was entered into the HEC-FDA model to calculate the uncertainty or error surrounding the elevation-damage, or stage-damage, relationships. The model also used the number of years that stages were recorded at a given gage to determine the hydrologic uncertainty surrounding the stage-probability relationships. Fragility curves for the non-Federal levees and top of levee elevations and exterior/interior stage relationships for Federal levees were entered into the levee features section of the model.

The possible occurrences of each variable were derived through the use of Monte Carlo simulation, which used randomly selected numbers to simulate the values of the selected variables from within the established ranges and distributions. For each variable, a sampling technique was used to select from within the range of possible values. With each sample, or iteration, a different value was selected. The number of iterations performed affects the simulation execution time and the quality and accuracy of the results. This process was conducted simultaneously for each economic and hydrologic variable. The resulting mean value and probability distributions formed a comprehensive picture of all possible outcomes.

**Stage-Damage Relationships with Uncertainty**. The HEC-FDA model used the economic inputs to generate a stage-damage relationship for each structure category in each study area reach under existing (2010) and future (2024, 2035, and 2085) conditions. The possible occurrences of each economic variable were derived through the use of Monte Carlo simulation. A total of 1,000 iterations were executed by the model for the Morganza evaluation. The sum of all sampled values was divided by the number of samples to yield the expected value for a specific simulation. A mean and standard deviation was automatically calculated for the damages at each stage.

**Stage-Probability Relationships with Uncertainty**. The HEC-FDA model used an equivalent record length (50 years) for each study area reach to generate a stage-probability relationship with uncertainty for the without-project and the with-project alternatives under existing (2010) and future (2024, 2035, and 2085) conditions through the use of graphical analysis. The model used the eight stage-probability events together with the equivalent record length to define the full range of the stage-probability or stage-probability functions by interpolating between the data points. Confidence bands surrounding the stages for each of the probability events were also provided.

**Without-Project Expected Annual Damages**. The model used Monte Carlo simulation to sample from the stage-probability curve with uncertainty. For each of the iterations within the simulation, stages were simultaneously selected for the entire range of probability events. For the study area reaches without a non-Federal levee system, the Monte Carlo simulation then selects a corresponding damage value for each of the stages from the stage-damage relationships with uncertainty. For the study area reaches with a non-Federal levee system, the Monte Carlo simulation also selects a failure probability from the fragility curve developed for the non-Federal levee. If the selected stages from the stage-probability curve are below the height of the non-Federal levee, then the fragility curve is used to determine if there is levee failure. If the levee fails, then a damage estimate is sampled from the stage-damage relationship. However, if the levee does not fail, then zero damages will be selected for that iteration. If the selected stages are equal to or above the height of the non-Federal levee and the levee fails, then the Monte Carlo simulation will select a damage value from the stage-damage relationship with uncertainty for that iteration. In general, the top of the non-Federal levee elevations were set at an elevation between the stages associated with the 10% ACE (10-year) event and the 4% ACE (25-year) event. There are no exterior-interior stage probability relationships under the without-project conditions.

The sum of all damage values divided by the number of iterations run by the model yielded the expected value, or mean damage value, with confidence bands for each probability event. The probability-damage relationships are integrated by weighting the damages corresponding to each magnitude of flooding (stage) by the percentage chance of exceedance (probability). From these weighted damages, the model determined the expected annual damages (EAD) with confidence bands (uncertainty). For the without-project alternative, the expected annual damages (EAD) were totaled for each study area reach to obtain the total without-project EAD under existing (2010) and future (2024, 2035, and 2085) conditions.

**Adjusted Without-Project Expected Annual Damages.** The without-project expected annual damages calculated as part of the economic analysis do not consider the behavior of property owners whose structures have incurred repetitive flood losses. The HEC-FDA model implicitly assumes that all damaged assets will be restored to their prior market value completely and instantaneously after each storm event. However, property owners could also opt to have their structures raised in place, floodproof and/or retrofit their structures, relocate within the floodplain, or permanently evacuate from the study area. The course of action selected by an individual property owner following repetitive flood losses depends upon many factors, including the degree of aversion to future anticipated flood risk by that property owner.

As shown in Table 16, unadjusted without-project expected annual damages increase approximately 184 percent between 2010 and 2085. Approximately 6 percent of this percentage increase is attributable to future development, while the remaining 178 percent is attributable to the projected rise in relative sea level. A breakdown of expected annual damages revealed that there were a significant number of structures with damage exposure from relatively frequent events. Table 17 shows that approximately 7,500 residential and non-residential structures incur flood damages from a 10% ACE (10-year) storm event in the year 2035, and Table 18 shows that approximately 1,700 residential structures would incur damages greater than or equal to 50 percent of the structural value at the 10% ACE (10-year) event. Given the number of structures at risk from frequent flooding, the magnitude of these damages, and the increased frequency which residential and non-residential structures would be exposed to flooding, adjustments to the implicit assumptions of the HEC-FDA model were deemed necessary.

*Historical Response to Flood Events.* The Morganza study area experienced numerous flood events during the past several decades. Historical data show that the post-flood response of property owners to the flood events prior to 2005 did not result in significant outmigration from the study area. Data from the 2000 Census show that approximately 65 percent of residents in the Lafourche and Terrebonne Parishes lived in the same housing unit as they had in 1995. This percentage ranged from a high of 81 percent in Dulac (southern portion of the study area) to a low of 54 percent in Thibodaux (northern portion of the study area). In comparison, the national percentage of the population residing in the same house in 2000 as in 1995 was 54 percent.

According to local officials, residents in low-lying communities began relocating to areas in the northern parts of the study area after Hurricanes Katrina and Rita impacted the area in 2005. Reasons for this intra-parish shift were a combination of weariness on the part of residents of having to deal with repeat flooding and the more stringent requirements to obtain permits for rebuilding after homes were damaged. In order to rebuild, residents had to incur the cost of building to higher elevations. The ability to secure insurance at a reasonable price was also cited as a reason for the exodus.

The rate of retreat from the southern communities slowed around 2008 after Hurricane Ike impacted the area due to federal assistance, as well as the construction of local levees, which reduced damages to the area. In addition, the two parishes have also implemented elevation programs designed to raise the structures in flood-prone areas. The elevation costs have been offset by state and Federal funding and, in the case of properties with flood insurance, supplemental support in the form of FEMA Increased Cost of Compliance Grants. These programs have made structure elevation more affordable for residents.

Local officials also stated that residents prefer to remain due to the culture of the residents and the economy of the area. The economy of Terrebonne Parish is closely tied to its abundant natural resources, and many of the residents in the small communities outside of Houma are shrimpers, oystermen, crabbers, fishermen, and trappers. In Lafourche Parish, the economy is strongly tied to the production and distribution of natural gas and oil, commercial fishing, and sugar cane.

Historical data show that recent flood events have not resulted in significant outmigration from the study area, and the post-flood response of property owners in the past has been consistent with the HEC-FDA assumption that the structure inventory will remain in place throughout the period of analysis. Although the HEC-FDA certified model is a probability-based, and not an event-driven, model, the assumption that structures will be completely and immediately repaired, is rarely the case for major flood events. While it may require considerable time (months to years) to fully complete repairs, past population trends nevertheless indicate that residents and the structures in which they live have not been permanently removed from the study area. However, the manner in which property owners have responded in the past may or may not be representative of how they will respond in the future to more repetitive and more severe flood events. The more frequent and damaging that flood events become due to sea level rise, the less time property owners have to repair damaged structures prior to the next flood. Thus, adjustments were made to the 2024, 2035, and 2085 structure inventories to account for the projected rise in relative sea level.

*Structure Inventory Adjustments.* The adjustments were made to the structure inventory before executing the HEC-FDA model to more accurately reflect the most likely future without-project and with-project conditions. For the 2024 residential structure inventory, all properties with a first floor elevation less than or equal to the 2010 10% ACE (10-year) water surface elevation exterior to the non-Federal levee, if it exists, within each study area reach were raised to the 2010 1% ACE (100-year) plus 2 feet to account for the sea level rise projected to occur during the period of analysis. This would also ensure that the structures would not be raised more than once during the period of analysis. For the 2035 residential structure inventory, all properties with a first floor elevation less than or equal to the 2024 10% ACE (10-year) water surface elevation exterior to the non-Federal levee were raised to the 2010 1% ACE (100-year) plus 2 feet. For the 2085 residential structure inventory, all properties with a first floor elevation less than or equal to the 2035 10% ACE (10-year) water surface elevation exterior to the non-Federal levee were raised to the 2010 1% ACE (100-year) plus 2 feet.

The non-residential structure inventory was also adjusted for repetitive flooding based on the 10% ACE (10-year) water surface elevation exterior to the non-Federal levee. If the total value of the structures in a non-residential structure category (except warehouses) was greater than or equal to 15 percent of the total value within a study area reach, then all of the structures in that category were raised based on the same criteria used for the residential structure inventory. If the total value was less than 15 percent, then the structures in that non-residential structure category were not adjusted for repetitive flooding due to their limited exposure. Warehouses were assumed to remain at their initial first floor elevation throughout the period of analysis. These structures would be difficult to elevate given the size and nature of their operations. Floodproofing measures were also not considered the most likely course of action for the owners of warehouses and other non-residential properties since these measures were deemed problematic and difficult to identify for storm surge flooding events.

The adjustments to the residential and non-residential structure inventory were made using the module feature of the HEC-FDA model. The adjusted first-floor elevations were used for the without-project inventory for the years 2024, 2035, and 2085 and for the 2024 with-project structure inventory. A separate module was created for the with-project structure inventories for the years 2035 and 2085. Since partial risk reduction will be provided by each of the project alternatives beginning in the year 2024, the first-floor elevations in these years were not adjusted under with-project conditions. It should be noted that the structures that were elevated between the years 2010 and 2024 are the only structures that were adjusted during the period of analysis under the with-project conditions.

*Rationale for the Adjustments.* The adjustments made to the 2024, 2035, and 2085 structure inventory were designed to account for the future behavior of property owners whose structures incur repetitive flooding. Beyond the dollar damage and disruptions associated with a flood event, a variety of considerations influence individual property owner rebuild decisions. Significant among these considerations are FEMA requirements for participation in the flood insurance program and the local permitting rules adopted by communities.

FEMA rules require that a structure located within the 1% ACE (100-year) receiving 50 percent or more structural damage from an individual flood event must elevate if it is to be rebuilt/repaired at the original location. Additionally, FEMA has requirements in place to address repetitively damaged properties. FEMA defines a repetitive flood loss property as one that incurs flood damages greater than $1,000 two or more times during a

10-year period. FEMA defines a severe repetitively flooded property as one that incurs flood damage two or more times during a ten-year period with the cumulative value of these damages exceeding the value of the structure, or one that has four claims exceeding a specifically defined amount over the same period. Thus, to be compliant with FEMA rules, severely repetitively flooded properties experiencing such damages would have to be elevated to the 1% ACE (100-year) event level. Property owners could also choose to implement an equivalent mitigation measure or face a significant increase in flood insurance premiums. Finally, the parish could enforce its own elevation requirements for properties in the high-risk flood zones that are severely damaged or are identified as repetitive flood properties, even if the owners are not National Flood Insurance Program policy holders.

As shown in Tables 17 and 18 there is a significant increase in the number of structures incurring flood damages between the 10% ACE (10-year) event and the 4% ACE (25-year) event. The inundation profiles displayed in Tables 17 and 18, along with the probabilities of repetitive flood events for individual structures, provide the basis for identifying a range of structure elevation values to be considered as the decision rule for making an adjustment the structure inventory. Evaluating repetitive flooding probabilities reveals that structures with first flood elevations at or below the 10% ACE (10-year) event have approximately a 26 percent change of being inundated two or more times over a 10-year period. For structures with first floor elevations at or below the 6.7% ACE (15-year) event and 4% ACE (25-year) event, the corresponding inundation chances fall to 14 percent and 6 percent, respectively. Note that selection of a 10-year period for computing multiple flood event probabilities should not be viewed as a definitive value for purposes of this investigation. The value of computing repetitive flooding probabilities is to provide insight regarding the decision rule for making an adjustment the structure inventory. Selection of alternative period lengths would result in different likelihoods of structures experiencing multiple flood events, but the basic relationship of probabilities across ACE events would not change. Ultimately, the adopted decision rule for structure inventory adjustment was based on the distribution of structures across ACE events, FEMA rules for rebuilding, and the expectation that the higher frequency of repetitive flooding associated with being located at the 10% ACE (10-year) event could strongly motivate property owners to take actions to reduce their exposure to flood risk and constitute the most accurate description of the most likely future.

As previously described, the structure inventory was adjusted for repetitive flooding based on the 10% ACE (10-year) water surface elevation exterior to the non-Federal levee. While non-Federal levees provide risk reduction up to the elevation associated with the 6.7% ACE (15-year) event to 5% ACE (20-year) event for approximately 60 percent of the structure inventory, these levees were not considered in this evaluation. However, as long as the non-Federal levees do not fail, structures located in the 6.7% ACE to 5% ACE (15-year to 20-year) floodplain are provided some level of risk reduction above the 10% ACE (10-year) event. This fact contributes to the rationale for using the first floor structure elevations associated with the 10% ACE (10-year) event as the adjustment point for the structure inventory.

Regarding the rationale for timing of the structure inventory adjustments, the following should be noted. Because residents are neither likely to anticipate the increase in relative sea level that is projected to occur between the years 2010 and 2024 nor take proactive mitigation measures in response, the 2024 structure inventory was adjusted based on the 10% ACE (10-year) event for the year 2010. Similarly, the 2035 structure inventory was adjusted based on the 10% ACE (10-year) event for the year 2024, and the 2085 structure inventory was adjusted based on the 10% ACE (10-year) event for the year 2035.

**With-Project Expected Annual Damages**. The with-project stage probability curves with uncertainty relate the stages on the exterior of the Federal levee system to each probability event. An exterior-interior stage relationship was also entered into the HEC-FDA model for each study area reach. The exterior-interior stage curve relates the stages on the outside of the Federal levee system to the stages on the inside of the Federal levee system for each study area reach. For the Morganza evaluation, the exterior stages were set equal to the water surface profiles from the with-project stage probability relationships for each reach, and the interior stages were set equal to the water surface profiles from the without-project stage-probability relationships. Additionally, since fragility curves were not developed for the Federal levee system, a top of the levee elevation was assigned and entered into the model for each study area reach. This elevation is below the actual top of the levee elevation to account for wave action above the still water stages. At stages below the top of the levee elevation, there is a 100 percent chance that the Federal levee will not fail. At stages equal to or greater than the top of the levee elevation, there is a 100 percent chance that the levee will fail.

The HEC-FDA model used Monte Carlo simulation to sample from the with-project stage-probability relationships with uncertainty for each iteration run by the model. The exterior stage randomly selected by the model was then compared to the top of the Federal levee elevation for each study area reach. If the exterior stage was below the top of the levee elevation, a zero damage value was assigned to that exterior stage. If the exterior stage selected by the model was equal to or above the height of the Federal levee, the related interior stage was used to calculate the damages from the stage-damage relationships with uncertainty. In this case, the with-project interior damages would be equal to the without-project damages for that probability event.

The sum of all damage values divided by the number of iterations run by the model yielded the expected value, or mean damage value, with confidence bands for each probability event. The probability-damage relationships were integrated by weighting the damages corresponding to each magnitude of flooding (stage) by the percentage chance of exceedance (probability). From these weighted damages, the model determined the expected annual damages (EAD) with confidence bands (uncertainty). For the with-project alternative, the expected annual damages (EAD) were totaled for each study area reach to obtain the total with-project EAD under existing (2010) and future (2024, 2035, and 2085) conditions.

Damages resulting from waves overtopping Federal levees were not calculated in this draft of the analysis. Since the top of levee elevations specified in the HEC-FDA model are less than the design top of the Federal levee, wave action above the still water stage has been incorporated into levee performance. Also, the study area reaches south of the city of Houma contain marshland that function as storage area for any excess storm surges attributable to residual wave overtopping. The exclusion of the potential damages from overtopping are not expected to be significant and does not affect plan formulation.

The performance of non-Federal levees was also not included in the calculation of with-project damages for study area reaches that are inside the Federal levee system. If the storm surge overtops the Federal levees, then it is expected that it will also overtop the non-Federal levees. The HEC-FDA model currently does not have the capability to analyze the performance of two levees simultaneously. The exclusion of non-Federal levee performance under the with-project conditions is not considered to have a significant impact on with-project damages.

For those reaches exterior to the Federal levee, the same process was used to calculate damages as was discussed under the without-project conditions. If a non-Federal levee was present in the reach, then a non-Federal levee fragility curve was used along with the with-project stage-damage relationships with uncertainty to calculate damages. If a non-Federal levee was not present in the reach, then the with-project stage-probability curves were used along with the stage-damage relationships with uncertainty to calculate damages. The with-project stages for the exterior reaches could be higher than the without-project stages for a range of probability events. The Federal levee reduces the impact of the storm surge on the interior reaches, but it elevates the stages and induces damages in all exterior reaches.

**Induced Damages.** The twelve study area reaches located below the proposed Federal levee system incur higher stages for various ACE storm events with the project in place for the years 2024, 2035, and 2085. The HEC-FDA model station numbers associated with these reaches are 163, 169, 175, 235, 256, 316, 340, 490, 496, 508, 604, and 631. Since these reaches experience induced damages as a direct result of the project alternatives, all of the properties in the impacted reaches, which includes 1,010 residential and non-residential structures, would be acquired and the approximately 2,500 residents would be relocated to areas outside the 100-year floodplain. The with-project induced damages, which included damages to residential and non-residential structures, their contents, and vehicles, as well as the debris removal and cleanup costs and damages to streets and highways, were removed for each of these reaches from the total damages for each of the project alternatives. The use of modules was utilized in the HEC-FDA model to remove the induced damages in the affected study area reaches. The cost of the property acquisition totaled $305 million including $249 million for residential structures and $56 million for non-residential structures. The property acquisition and relocation costs were added to the total project costs for the 3% AEP alternative and the 1% AEP alternative. A map of the impacted reaches and a more detailed discussion of the acquisition option can be found in the main report of this evaluation.

**Expected Annual Inundation Reduction Benefits**. The HEC-FDA model compared the without-project damages with uncertainty to the with-project damages with uncertainty to calculate the expected, benefits with uncertainty for each of the project alternatives. Benefits were calculated for the first year of partial risk reduction (2024), the project base year (2035), and future conditions (2085). Table 19 shows the expected annual without-project damages, with-project damages, and benefits for the years 2024, 2035, and 2085 for the residential and non-residential structures. The tables also show the expected annual benefits at the 25, 50, and 75 percentiles. These percentiles reflect the percentage chance that the benefits will be greater than or equal to the indicated amount.

**Benefits During Construction**. Construction of both the 3% AEP and 1% AEP alternatives is expected to begin in the year 2014. A closed system with all of the control structures and with at least the first levee lift in place, depending on the levee reach, is scheduled to be completed by the year 2024 for the 3% AEP alternative. A closed system with all control structures and with the first and a significant number of second levee lifts in place is scheduled to be completed by the year 2024 for the 1% AEP alternative. The construction of the 3% AEP storm damage risk reduction system is scheduled to achieve the full design elevation and full project performance in the year 2026, while the construction of the 1% AEP storm risk reduction systems is scheduled to achieve the full design elevation and full project performance in the year 2035. Completion of the initial lift of levee reaches, along with control structures, will provide partial risk reduction for the entire evaluation area. For both the 3% AEP and the 1% AEP alternatives, benefits during construction would accrue for the period 2024 to 2034. The base year for both alternatives has been designated as 2035.

Engineering inputs, which include without-project and with-project water surface profiles, fragility curves for non-Federal levees, top of Federal levee elevation and exterior-interior stage relationships for each study area reach, were developed for the year 2024. The engineering and economic inputs incorporating uncertainty were used in the HEC-FDA model to calculate the without-project and with-project damages for the two project alternatives during the period of construction. The interim benefits that begin in the year 2024 after the completion of the initial lift of levee reaches, associated locks, and floodgates were computed by comparing the expected annual without-project damages to the with-project damages for each of the alternatives. The annual without and with-project damages were adjusted so that the benefits for each of the alternatives could remain constant through 2035, the base year, for each of the alternatives.

The benefits during construction were compounded forward to the base year, totaled, and then amortized over the 50-year period of analysis using the Federal discount rate of 3.75 percent. The calculation of the benefits during construction claimed for the 3% and 1% AEP alternatives is shown in Tables 20 and 21, respectively.

**Equivalent Annual Damages and Benefits**. Damages and benefits for each of the years during the period of analysis were computed by linear interpolation between 2024 and 2084 for both the 3% AEP and the 1% AEP alternative. The FY 2012 Federal interest rate of 3.75 percent was used to compound the stream of expected annual damages and benefits before the project base year and to discount the stream of expected annual damages and benefits occurring after the base year to calculate the total present value of the damages and benefits over the period of analysis. The present value of the expected annual damages and benefits was then amortized over the period of analysis using the Federal discount rate to calculate the equivalent annual benefits. Tables 20 and 21 show the calculation of equivalent annual damages and benefits for each of the project alternatives.

Table 22 shows the equivalent annual residential and non-residential without-project damages, with-project damages, and benefits for each project alternative. Table 23 shows the equivalent annual without-project damages, with-project damages, and benefits for each project alternative for the 24 industrial properties. The tables also show the equivalent annual benefits at the 25, 50, and 75 percentiles. These percentiles reflect the percentage chance that the benefits will be greater than or equal to the indicated values.

## OTHER NED BENEFIT CATEGORIES

**General.** In addition to the physical damages to structures, contents, and vehicles, there are five other categories of NED benefits that are attributable to the Morganza alternatives: avoidance of structure-raising costs, emergency cost reductions, agricultural benefits, safe harbor of large commercial and recreational boat fleets, and municipal water supply benefits. These benefit categories account for less than 10 percent of the total benefits associated with the project alternatives.

**Avoidance of Structure-Raising Costs.** Typically, property owners in areas that incur repetitive flooding have three options for reducing their flood risk: raise their structures in place, floodproof/retrofit their structures, or relocate to other areas. For purposes of this evaluation, only structure-raising measures were considered to represent the most likely response under future without-project conditions. The avoidance of structure-raising costs by owners of residential and non-residential structures that could incur repetitive flooding and the temporary relocation of the residents can be considered benefits attributable to the project alternatives.

As shown in Table 24, there were 3,092 structures in the evaluation area that have the potential for repetitive flood losses and were elevated during the period of analysis. The cost per square foot to elevate these structures was based on data obtained during interviews conducted by Corps personnel in 2008 with representatives of three shoring firms in the Metropolitan New Orleans area that specialize in the elevation of structures. An average elevation cost per square foot was derived for each one-foot increment from the original elevation of the structure for slab and pier foundation 1-story and 2-story residential structures and mobile homes. The cost of elevating a 1-story slab foundation residential structure was used for all non-residential structures. These costs were updated to October 2011 price levels using Civil Works Construction Costs Index (CWCCIS). Table 25 shows the costs per square foot of elevating each structure type for each one-foot increment of elevation up to 13 feet.

The total cost for the temporary relocation of residents during the two-month elevation process includes lodging, the labor costs associated moving personal property into and out of a POD, and the storage of these contents. The average furnished apartment rental in the Houma area was determined to be $1,200 per month based on advertised rental properties. The average POD rental, which includes pick-up and delivery, was determined to be $700 for the two-month period. The average labor cost for moving personal property into and out of the POD was determined to be $650 based on the quote from the POD company. The temporary relocation cost using October 2011 price levels totaled $3,750 for each elevated structure.

The elevation cost per square foot, based on the type of structure, number of stories, foundation type, and the number of feet elevated, was multiplied by the square footage of the footprint of each raised structure obtained from the structure inventory collected in 2009 for the evaluation area. The temporary relocation cost per structure was added to the elevation cost to derive the total structure raising cost. Table 26 shows the number of structures elevated, the average height that the structures were elevated, the total cost of elevating these structures, and the average elevation cost per structure.

The total cost of raising 703 structures between the years 2010 and 2024 was calculated to be approximately $108.3 million. The average elevation cost per year during this period was $7.2 million. The cost of raising 464 structures between the years 2025 and 2035 totaled approximately $94.9 million with an average cost per year of $8.6 million, and the cost of raising 1,855 structures between the years 2036 and 2085 totaled $238.2 million with an average cost per year of $4.8 million. The present value of these annual average costs was totaled and then amortized over the period of analysis (2024 through 2084) using the current Federal discount rate of 3.75 percent.

**Emergency Cost Reduction.** The NED costs associated with each of the emergency activities conducted by the public and private sectors before, during, and after storm events, and infrastructure damage to roads and utilities were estimated based on data obtained during interviews with professionals who are familiar with emergency activities and infrastructure inundation impacts. More than 100 organizations and over 150 individuals were contacted as part of the interview process, and responses were obtained from 39 experts. The interviews were conducted between December 2009 and March 2010. The information compiled as part of the interview process was used to develop depth-emergency cost and depth-infrastructure damage relationships for the Morganza evaluation area. The results can be found in the final report dated March 2012 entitled, *Development of Depth-Emergency Costs and Infrastructure Damage Relationships for Selected South Louisiana Parishes.*

The emergency costs in the report were divided into six groups: evacuation activities (evacuation, subsistence, and reoccupation), debris removal and cleanup, public utilities, infrastructure, public services patronized, and public services produced. The public utilities group was divided into five subcategories: natural gas, electricity, telecommunications, sewage and wastewater treatment, and water supply. The infrastructure group was divided into seven subcategories: streets and highways, bridges, railroads, ports, airports, land-based pipelines, and petroleum wells. The public services patronized group was divided into six subcategories: education, libraries, indoor recreation facilities, medical, eldercare, and daycare. The public services produced group was divided into five subcategories: police, fire, incarceration, judicial, and government administrative.

The damage relationships for each subcategory were generated for two flood event scenarios, along with three depths of flooding for each scenario: freshwater short duration (less than two days) and saltwater long duration (two days or more), and flooding depths of 2 feet, 5 feet, and 12 feet. However, only the saltwater long duration depth-damage relationships were applied in this analysis. The flooding event was assumed to affect a typical area occupied by 3,800 households or 10,000 residents. An individual questionnaire was developed for each of the emergency cost groups and subcategories. The experts were asked to provide a minimum, most likely, and maximum estimate for a variety of parameters required to compute the costs/damages for each of the subcategories. The experts were instructed that the range between the minimum and maximum values was not expected to represent absolute minimum and maximum values, but rather the 90th percentile of the possible outcomes.

The responses from the experts for each estimated parameter were combined and averaged to generate aggregated minimum, most likely, and maximum values. These aggregated values were used to specify a triangular probability distribution. The triangular distributions were used as inputs in an @Risk (Version 5) spreadsheet constructed to produce a distribution of results representing the cost/damage for the subcategory. The distribution fitting feature of @Risk was used to identify the probability distribution functional form that best fit the output of the @Risk spreadsheet based on the Chi-Squared statistic. In all cases the normal distribution was found to represent the best fit. (In identifying the best fit functional form, the normal and triangular distributions were considered.) Consideration was limited to these two because the ultimate use of this information was input as depth-damage functions into HEC-FDA, which is limited to these two functional forms.

The mean dollar damages at each of the three depths of flooding were converted to a percentage of the total cost/damage estimate at the 12 feet depth of flooding. In addition to the three estimated depth of flooding points, a zero damage point was also specified at 1.9 feet of flooding. (This forced damage to begin at 2 feet of flooding.) Once expressed as a percentage, mean values the four depth of flooding data points are structured in the conventional manner that is employed with HEC-FDA. The standard deviation at each depth of flooding was handled in a similar manner as the mean value, with each of the dollar value standard deviations expressed as a percentage of the mean cost/damage dollar value at 12 feet.

The cost/damage depth-damage relationships were entered into the HEC-FDA model, along with information about the structures and infrastructure obtained from an inventory compiled for the study area, including structure type, study area reach, and foundation height, and the engineering inputs (stage-probability relationships and levee fragility curves) to determine the emergency cost reduction benefits attributable to each of the project alternatives. The cost/damage value at 12 feet of flooding was used as the emergency cost or infrastructure value for each "structure inventory" record in the HEC-FDA model.

For this evaluation, only the debris removal and cleanup of the residential and non-residential structures, and the physical damages to streets and highways were quantified and included in the net benefit analysis for the project alternatives. The evacuation, subsistence, and reoccupation costs and the police and fire department relocation costs were quantified, but were not included in the net benefit analysis. These emergency cost categories were quantified in the March 2012 report. The depth-damage results can be found in Chapter 6 of the March 2012 report. The responses to the questionnaires can be found in Attachment 2 of the report.

*Debris Removal and Cleanup.* Immediately after the floodwaters from a tropical event subside, the public and private sectors of the flooded community must begin the cleanup process. The first activities that typically take place include the removal of debris from roads and yards. The streets must be made accessible for use by emergency vehicles and for residents to return to their homes. Most of this type of debris is either vegetative or sediment debris left after the floodwaters subside. While these categories of debris could be a significant part of the cleanup process, they are not addressed in this analysis. This analysis has included the collection, processing, and proper disposal of the debris material from the inside of the inundated structures, which varies according to residential or non-residential occupancy type of the structure. This type of debris includes content-related debris, white goods, electronics, and hazardous waste (paints, oil, household chemicals, poisons, etc.). Hazardous debris must be properly disposed of so as to minimize the existing and future threats to human health and the environment.

Interviews were conducted with four experts in the fields of debris collection, processing, and disposal. The questionnaires used in the interview process were designed to elicit information from the experts regarding the cost of each stage of the debris cleanup process by structure occupancy type. The experts were asked to provide a minimum, most likely, and maximum estimate for the cleanup costs associated with the 2 feet, 5 feet, and 12 feet depths of flooding. A prototypical structure size in square feet was used for each of the five residential occupancy categories and for each of the eight non-residential occupancy categories. The experts were asked to estimate the percentage of the total cleanup caused by floodwater and to exclude any cleanup that was required by high winds.

The total amount of content-related debris estimated for each structure occupancy type was expressed in cubic yards per structure. The white goods were expressed in units per structure, and the electronics and hazardous materials were expressed in pounds of debris per structure. A minimum, most likely, and maximum cost estimate was provided for the collecting and processing of each cubic yard of content-related debris, each white goods unit, and each pound of electronics and hazardous waste for the saltwater long duration flood scenario. A minimum, most likely, and maximum cost estimate was also provided for the removal, hauling away, and disposal of the debris. The minimum, most likely, and maximum estimates from each expert were converted into aggregated values (as previously described) for each structure occupancy type and were entered into the @Risk spreadsheet as triangular distributions. Fitting of the @Risk spreadsheet output to a probability distribution functional form and conversion of the probability distribution information into HEC-FDA depth-damage input was accomplished as previously described. The mean debris removal and cleanup costs and the standard deviations for each of the three depths of flooding are shown by structure occupancy type in Table 27.

The cost/depth-damage relationships for each structure occupancy category were converted to percentages and entered into the HEC-FDA model, along with the debris and cleanup structure records (cost/damage value at 12 feet of flooding was used as the emergency cost or infrastructure value) and engineering inputs (stage-probability relationships and levee fragility curves) to calculate the expected annual without-project and with-project debris removal and cleanup costs for the years 2024, 2035, and 2085. The expected annual costs were converted to equivalent annual values using the current Federal discount rate of 3.75 percent and a 50-year period of analysis. Since the costs were initially expressed in 2010 price levels, the equivalent annual without-project and with-project values were updated to October 2011 price levels and are shown in Table 28. It should be noted that the adjusted structure inventory for repetitive flooding was used to calculate the reduction in debris removal and cleanup costs.

*Damages to Infrastructure.* The reduction of potential flood damages to the infrastructure (streets and highways, bridges, railroads, ports, airports, land-based pipelines, and petroleum wells) in an evaluation area can form a significant category of benefits attributable to a project alternative. For purposes of this analysis, only the damages to streets and highways were considered. Streets are defined as roadways with two lanes with relatively lower volumes of traffic and access, while major and secondary highways are defined as roadways with four lanes with relatively higher volumes of traffic and access.

GIS data were used to determine the number of miles of streets and highways in each of the study area reaches in the Morganza evaluation area. Within each study area reach, a grid was used to create individual HEC-FDA structure records. Each structure record was equal to one 1,000 feet x 1,000 feet grid unit. The NAVTEQ, Inc. database was then used to obtain the number of miles of streets and highways within each grid unit. A mean ground elevation was assigned to the grids based on LIDAR data.

Interviews were conducted with an expert in street and highway construction to determine the cost of repairing each mile of roadway. Costs were provided for three roadway components. The components of streets include street surface, street base, and street curb, while the components of major and secondary highways include road surface, road base, and road shoulder. A minimum, most likely, and maximum replacement value per mile, which included materials and labor, was assigned to each component. The expert was then asked to provide an estimate of the depreciation that has taken place in each roadway based on the age of the roadway. The value of each mile of roadway component was discounted by the estimated depreciation percentage. Finally, the expert was asked to estimate the percentage of the road components that would be damaged at the 2-feet, 5-feet, and 12-feet depths of flooding.

The damage to the streets and highways per mile was calculated by multiplying the cost of the materials and labor to replace each infrastructural component by the inverse of the depreciation percentage by the percentage damage to each component. The minimum, most likely, and maximum damages for each roadway component were used to develop a range of values for the total cost of the infrastructural damages for each mile of roadway. The triangular probability distributions were input to the @Risk model, and the probability distribution fitting feature was used to find the distribution that best fit the output. The normal distribution was found to fit the infrastructural damage outputs better than the triangular distribution. The mean value for the damages per mile and standard deviations for each of the three depths of flooding are shown for major and secondary highways and streets in Table 29.

The depth-damage relationships for major and secondary highways and streets were converted to percentages and entered into the HEC-FDA model, along with the major and secondary highways and streets structure records (damage value at 12 feet of flooding was used as the infrastructure value) and engineering inputs (stage-probability relationships and levee fragility curves) to calculate the expected annual without-project and with-project major and secondary highways and streets for the years 2024, 2035, and 2085. The expected annual costs were converted to equivalent annual values using the current Federal discount rate of 3.75 percent and a 50-year period of analysis. Since the costs were initially expressed in 2010 price levels, the equivalent annual without-project and with-project values were updated to October 2011 price levels and are shown in Table 30.

**Agricultural Benefits**. An economic analysis of the agricultural lands in the study area was conducted to determine the number of acres impacted in the study area. The

National Agricultural Statistical Service (NASS) geo-spatial information system for the year 2010 data were used to identify the agricultural land and crop distribution in each of the study area reaches. Agricultural activity was found in 35 of the Morganza study area reaches. The relationships for the without-project (2010, 2035, and 2085) conditions and for the with-project alternatives (2035 and 2085) conditions were used with the top of levee elevation for the non-Federal and Federal levees to determine the average annual flooded acres. Table 31 shows the average annual flooded agricultural acres by study area reach under the without-project conditions for the years 2010, 2035, and 2085 and under the with-project alternatives conditions for the years 2035 and 2085. Even if a high estimate of the net revenue generated by an average annual acre was used in the analysis, the total agricultural benefits would only equal approximately one percent of the total inundation reduction benefits to structures, contents, and vehicles for each of the project alternatives. Thus, estimates of agricultural benefits were not included in the net benefit computations.

**Safe Harbor Benefits for Boat Fleets**. In addition to the HNC, five bayous located in the coastal portion of the study area are used as navigational routes to and from the Gulf of Mexico: Bayous DuLarge, Grand Caillou, Petit Caillou, Terrebonne, and Pointe aux Chenes. Large commercial and recreational vessels dock along these waterways because of the proximity to the Gulf of Mexico and other fishing grounds, but these vessels must be moved upstream to safer harbors during tropical events. Storm surges could cause physical damages to moored vessels by tossing them into adjacent vessels or docks, pushing debris into the vessels, or washing them up on land. Since the project alternatives would reduce the impact that storm surges have on the waterways, vessels would not have to be moved to sheltered locations. The reduction in physical damages to the large commercial and recreational boat fleet and the reduction in the costs of moving these vessels inland to safer waterways are considered benefits attributable to the project. However, the physical damages were not quantified in this analysis.

According to data obtained from the Louisiana Department of Wildlife and Fisheries (LDWF) and the U.S. Coast Guard (USCG), there were 1,574 motorized vessels greater than 25 feet in length registered in Terrebonne Parish in 2009. These vessels were grouped into five categories: 949 were classified as commercial fishing vessels, 361 were classified as recreational boats, 140 were classified as oil and gas crew boats, 33 were used as commercial passenger vessels, and 91 were designated as other commercial vessels. Vessels less than 26 feet in length were not included in the analysis because they are typically removed from the water in advance of an approaching storm and would not benefit from the construction of the project.

*Projections for the Motorized Vessel Fleet.* The number of vessels in the commercial fishing and recreational fleets was projected for the years 2024, 2035, and 2085. The projections were based on both historic trends in boat registrations and economic growth patterns, and they were made for median, high growth, and low growth scenarios. The number of oil and gas related vessels was not projected because the project alternatives would not have an impact on these vessels. According to industry representatives, oil and gas related vessels are used to evacuate crewmen from offshore oil rigs prior to tropical events, and these vessels typically leave for other ports outside of the evaluation area. The number of vessels in the commercial passenger fleet and the other vessel fleet was projected to remain constant throughout the evaluation period. Projections for the commercial fishing, recreational vessel, and commercial passenger fleets were obtained from the draft report entitled *Economic Benefits of Protecting the Large Recreational and Commercial Boat Fleets* dated March 2012.

*Commercial Fishing Vessels*. The commercial fishing fleet consists primarily of shrimp boats, but it also includes vessels used to harvest oysters and finfish. The number of commercial fishing vessels registered with the LDWF has been declining since the late 1990s due to an industry trend toward larger, but fewer, vessels. While the number of vessels less than 26 feet in length decreased 18.5 percent from 1,115 in 1999 to 909 in 2008, the number of vessels in the 40 to 65 feet range increased over 400 percent from 46 in 1998 to 236 in 2008. The overall number of registered commercial fishing vessels decreased 10.8 percent from 1,757 in 1997 to 1,568 in 2008, which is an average annual decline of 0.44 percent.

The projections for the commercial fishing fleet were based on the annual brown and white shrimp catch for the state of Louisiana during the 13-year period 1997 through 2009. During this period, Terrebonne Parish contributed approximately 30 percent of the total shrimp catch in the state. The Terrebonne shrimp catch totaled 25.9 million pounds in 2009 and averaged 32.9 million pounds annually between 1997 and 2009. The average catch size for the 13-year period was used as the median value in the projections. The low estimate of 21.5 million pounds was calculated by subtracting two standard deviations from the median value. The high estimate of 44.3 million pounds was calculated by adding two standard deviations to the median value.

Historical trends were used to determine the percentage of the total shrimp catch caught by vessels in each of the size categories. The percentage caught by the smaller crafts was projected to decrease through the year 2040, while the percentage caught by the larger crafts was projected to increase through the year 2040. After the year 2040, these percentages were projected to remain constant. Table 32 shows the percentage of the total shrimp catch caught by each vessel size for the years 2009, 2024, 2035, and 2085.

The 2002 LDWF report was used to calculate the median catch for each vessel size. Table 33 displays the median shrimp catch for each vessel size.

The projected number of vessels in each size category for the low, median, and high growth scenarios in the years 2024, 2035, and 2085 is shown in Table 34. These numbers are based on the annual shrimp catch, the percentage of the total catch by vessel size, and the median catch for each vessel size. As an example, the projected number of vessels over 65 feet in length for the high scenario in the year 2024 was calculated by multiplying 44.3 million pounds (the high estimate of the total shrimp catch) by 15.9 percent (the percentage of the total catch for vessels over 60 feet in length from Table 32). This product was then divided by 69,050 (the median shrimp catch for vessels over 60 feet in length from Table 33) to estimate that there will be 102 vessels over 60 feet in length in the year 2024 under the high growth scenario.

*Recreational Vessels.* The large recreational vessel fleet experienced an average annual growth rate of 2.0 percent between 1999 and 2009 and an average annual growth rate of 2.9 percent between 2002 and 2009. This growth can be attributed to population growth and rising median income. Table 35 shows the annual growth in the number of recreational vessels by vessel size for the years 1999 to 2009 and 2002 to 2009.

In the median forecast, the average 10-year annual growth rate was extended through the year 2040, and a slower growth rate was used for the period between 2040 and 2085. In the low growth estimate, the size of the recreational vessel fleet is projected to remain constant during the year 2085. In the high growth estimate, the size of the recreational vessel fleet is based on the 2002 through 2009 growth rate. Table 36 shows the forecasted growth rates by vessel size for the median and high growth scenarios. Table 37 shows the projected number of recreational vessels for the years 2024, 2035, and 2085 under the low growth, median, and high growth scenarios.

*Commercial Passenger Vessels.* The commercial passenger fleet consists of charter fishing vessels that are similar to recreational vessels but with a different type of ownership. While commercial passenger fleet in Terrebonne Parish declined 2.9 percent annually from 68 vessels in 1997 to 56 vessels in 2003, the fleet increased 5.9 percent annually from 56 vessels in 2004 to 79 vessels in 2009. Overall, the number of commercial passenger vessels grew at an average annual growth rate of 1.2 percent. Due to the fluctuations in the number of vessels during the 13-year period, the median commercial passenger fleet was projected to remain constant at 33 vessels for the years 2024, 2035, and 2085. Of this total, 21 vessels were between 26 feet and 40 feet in length, 9 vessels were between 40 feet and 65 feet in length, and 3 vessels were over 65 feet in length. The low estimate is based on an annual decrease of 1.0 percent through the year 2040 and an annual decrease of 0.5 percent from the year 2040 through the year 2085. The high estimate is based on a 1.0 percent annual increase through the year 2040 and a 0.5 percent annual increase from the year 2040 through the year 2085. The projected number of commercial passenger vessels for the years 2024, 2035, and 2085 for the low growth, median, and high growth scenarios is shown in Table 38.

*Evacuation Travel Distances.* The homeports of the motorized vessel fleet under the without-project condition were determined based on interviews with experts in the Terrebonne Parish maritime industry. As shown in Table 39, 60 percent of the vessels dock along Bayous Petit Caillou and Grand Caillou, and 30 percent dock along Bayous DuLarge and Terrebonne. The remaining 10 percent dock along the HNC and Bayou Pointe aux Chenes. The homeport of 78 percent of the vessels is located above the project alternatives, while the homeport of 22 percent of the vessels is located below the project alternatives.

The distribution of the vessel fleet along the six waterways was used to estimate the average number of nautical miles that a vessel would travel to evacuate from storms more intense than the 10% ACE (10-year) event. Under the without-project condition, all vessels would have to travel north of their homeport to seek shelter during tropical events. Under the with-project conditions, only the vessels with homeports below the proposed alternatives would have to evacuate to safer locations. The weighted average number of nautical miles each vessel would have to travel in advance of an approaching storm event was determined to be 10.94 nautical miles under without-project conditions and 1.14 nautical miles with the proposed alternatives in place. The distances traveled to flee an approaching storm under without and with-project conditions are shown in Table 40. The total distances traveled to flee approaching storms were calculated under the without-project and the with-project conditions by multiplying the number of vessels in each vessel type and size category by the weighted average travel distances.

*Travel Costs per Nautical Mile*. The cost per nautical mile by vessel size category for commercial fishing, recreational/commercial passenger (charter fishing), and other commercial vessels was estimated using fuel and crew costs. The average speed and fuel consumption for each size category by vessel type was determined based on the characteristics of used vessels available for sale on the websites www.MaritimeSales.com and www.YachtWorld.com. The cost of diesel fuel was based on the 3-year average of Gulf Coast monthly fuel costs during the period March 2009 through February 2012 from the U.S. Energy Information Agency (EIA). Crew costs were estimated at $15 per hour for crew members and $20 per hour for captains. Crew sizes varied by vessel type and size, with larger vessels requiring more manpower. Table 40 show the calculation of the travel costs per nautical mile for the commercial fishing vessels, recreational/commercial passenger vessels, and other vessels by size category.

Travel costs were calculated using October 2011 price levels for the without-project and the with-project conditions by multiplying the projected number of vessels in the fleet by the weighted average travel distance from by the average operating cost per nautical mile. Table 41 shows the without-project and with-project total vessel travel costs for each vessel size for the low growth, median, and high growth scenarios for the years 2024, 2035, and 2085. The difference between the without-project travel costs and the travel costs with the project alternatives in place is considered the travel cost reduction benefit attributable to the project alternatives.

*Expected Annual Travel Costs Reduction*. The without-project and with-project travel costs were integrated by weighting the travel costs by the percentage chance of exceedance (probability) for those ACE events equal to and more intense than the 10% ACE (10-year) event. From these weighted travel costs, the expected annual travel costs were calculated for the without-project and with-project conditions for the low growth, median, and high growth scenarios for the years 2024, 2035, and 2085. The difference between the without-project and the with-project expected annual travel costs is considered the benefit attributable to the project alternatives. The expected annual travel costs reductions are shown in Table 43.

*Expected Annual Physical Damage Reduction for the Vessel Fleet.* A depth-damage curve relating the height of the storm surge above normal sea level at one-foot increments to the percentage of the vessel damaged was developed for the vessel fleet as part of the draft report entitled *Economic Benefits of Protecting the Large Recreational and Commercial Boat Fleets* dated March 2012. The damage percentages were based on data collected in the Louisiana coastal region following Hurricanes Katrina and Rita. However, because sufficient documentation supporting the development of the depth-damage relationships was not available, physical damages to the vessel fleet were not calculated used in the net benefit analysis for the Morganza PAC Report.

**Municipal Water Supply Benefits.** The Terrebonne Water District Number 1 is responsible for supplying drinking water to the residents of Terrebonne Parish. The city of Houma and the town of Grand Caillou are served by a water treatment facility located at the confluence of the Houma Navigation Canal (HNC) and the Gulf Intracoastal Waterway (GIWW), which draws water from the GIWW. The remainder of Terrebonne Parish is served by the water treatment facility in Schriever that draws water from Bayou Lafourche. The Schriever plant is also periodically used to supplement the Houma water supply. Under existing conditions, above normal salinity levels occur each year during late summer and early fall in the GIWW, which impacts the Houma Water Treatment Plant (HWTP), and in the portion of Bayou Lafourche located between the Company Canal in Lafourche Parish and the GIWW, which impacts the Schriever Water Treatment Plant (SWTP). The HNC has been identified as the major conduit for the intrusion of saltwater from the Gulf of Mexico. During periods of high salinity levels, the HWTP and the SWTP must obtain water from the Bayou Black Reservoir in order to meet their municipal water supply demands.

Water for Lafourche Parish is provided by five water treatment facilities located along Bayou Lafourche. The Lockport facility, which is located on Bayou Lafourche downstream from the Company Canal, is the only plant in Lafourche Parish to have reported excessive salinity levels. Since the Lockport water treatment facility has no alternative water sources, the plant typically treats the saltwater and then sends out advisories to the residents of the area.

*Average Annual Number of Days of High Salinity.* Since the HNC was constructed in 1961, chloride concentrations at the Houma Water Treatment Plant (HWTP) have exceeded the State standard of 250 parts per million (ppm) an average of 37 days per year with a standard deviation of 25.6 days. The number of days of high salinity ranged from a high of 109 days in 1999 to a low of zero days in 1961, 1989, and 1993. The @Risk program was used to determine that a Gamma probability distribution would best fit these data for the period between 1961 through 2011. The Gamma probability distribution was then used to predict the number of days of high salinity for each year in the period of analysis (2012 through 2084). The expected value for the number of days of high salinity during the period is 31.2 days per year, not accounting for rising sea level. The distribution was truncated so as not to generate values below zero days of high salinity.

Construction of the lock-gate complex on the HNC, which is projected to be completed in the year 2019, will reduce the amount of saltwater intrusion into the evaluation area. The number of days with salinity greater than 250 ppm with the project in place depends on how the HNC and Bayou Grand Caillou navigational and environmental structures are operated. A system-wide salinity model was used by Engineering to assess the salinity at 78 locations throughout the project area. However, for purposes of this analysis, only the three locations closest to the HWTP were used to determine the reductions in salinity. Salinity levels were simulated in the model to compare the reduction in salinity levels under the without-project and with-project conditions for year 2004. Under the without-project condition, there were 53 days of salinity greater than 250 ppm. With the HNC floodgate closed and all other environmental and navigational structures open, the number of days of high salinity was reduced to 40 days, which is a decrease of 23.91 percent. With the HNC lock and the other structures open, the number of days was only reduced to 49 days. With the HNC lock open and all environmental structures closed, the number of days was only reduced to 50 days. For this analysis, the most likely operation is for the HNC gate to be closed and the other structures to be open.

*Additional Costs Associated with High Salinity Levels*. The expected annual number of days for each of the years in the period of analysis was then multiplied by the increase in chemical costs per million gallons (MG) per day using water from Bayou Black instead of the GIWW. Based on information provided by HWTP, the incremental treatment cost is $84.79 per MG. The incremental cost was then multiplied by the average number of gallons treated per day of 4.056 MG based on data from FY 2008-09 to determine the average daily increase in treatment cost. The average daily treatment cost was calculated to be $343.94. This cost was then multiplied by the average number of days of high salinity for each year to determine the average annual cost under the without-project conditions. The average daily treatment cost under the with-project conditions was determined by reducing the without-project cost by 23.91 percent beginning in the year 2019.

Additionally, granular activated carbon (GAC) must be added to water obtained from Bayou Black because the high level of total organic carbon (TOC) in the water decreases the life of the GAC in the water supply. The cost of each GAC treatment was estimated by the SWTP to be $275,000. Without the project in place, the GAC would need to be replaced every 3 years and with the project in place, the GAC would need to be replaced every 4 years. The reduction in the number of years in the GAC replacement cycle generates a cost savings during the period of analysis (2019 through 2084).

The project alternative would reduce the costs associated with the operation of the four gates located along Bayou Black (Water Proof Pump Station, Minors, Hanson, and Elliot Jones) to prevent saltwater intrusion. The power usage under the without-project condition costs $330 per year, while the power usage with the project in place costs $251 per year. The reduced power usage leads to an estimated cost savings of $79 per year.

The gates would no longer need to be refurbished every 20 years at a cost of $135,000 and replaced every 40 years at a cost of $1 million. Thus, the project would create a cost savings of $2.27 million during the period of analysis. Finally, the Water Proof Pump Station would no longer need to be refurbished every 20 years at a cost of $135,000 and replaced every 40 years at a cost of $500,000. This would create a cost savings of $1,270,000 during the period of analysis (2019 through 2084).

*Annualized Cost Savings*. Table 44 shows the projected annual increase in the cost of supplying water that results from increased salinity under the without-project and with-project conditions in October 2011 price levels. The difference between the two total costs is the total cost savings attributable to the project alternative. The total cost savings were annualized over the period of analysis using the current Federal discount rate of 3.75 percent to determine the average annual cost savings or benefits associated with the project alternative.

# PART 4: LIFE CYCLE COSTS OF THE PROJECT ALTERNATIVES

## CONSTRUCTION OF THE PROJECT ALTERNATIVES

**Construction Schedule**. Construction of each of the project alternatives is scheduled to begin in the year 2014 and will continue through the year 2070 for the 3% AEP alternative and through the year 2071 for the 1% AEP alternative. The authorized levee alignment for each of the alternatives will be constructed utilizing the existing non-Federal levee systems throughout the area whenever possible and will be constructed in phases due to the relatively poor foundation conditions and the absence of quality burrow material. The 3% AEP alternative requires one or two levee lifts, depending on the levee reach, to achieve the design elevation by the year 2026. Two additional levee lifts are scheduled after the year 2026 to maintain the design elevation. The 1% AEP alternative requires two or three levee lifts, depending on the levee reach, to achieve the design elevation by the year 2035. Three additional levee lifts are scheduled after the year 2035 to maintain the design elevation. The first levee lifts will be overbuilt and allowed to settle for several years before the later levee lifts are added. The later lifts will account for the relative sea-level rise and subsidence that is projected to occur throughout the period of analysis. The life cycle costs also include the construction of sector gates and a lock structure on the Houma Navigation Canal and the major periodic rehabilitation cost of these navigation structures.

**Average Annual Costs**. Life cycle cost estimates were provided for both the 3% AEP and the 1% AEP alternatives in October 2011 price levels. The first costs, along with the schedule of expenditures, were used to determine the interest during construction and gross investment cost at the end of the installation period (2035 for the 3% AEP alternative and the 1% AEP alternative). The current Federal discount rate of 3.75 percent was used to discount the costs to the base year and then amortize the costs over the 50-year period of analysis. After the average annual construction costs were calculated, the annual operations and maintenance costs were added.

Tables 45 and 46 provide the life cycle costs for each of the project alternatives, the average annual construction costs, the annual operation and maintenance costs, and the total average annual costs.

## PART 5: RESULTS OF THE ECONOMIC ANALYSIS

## NET BENEFIT ANALYSIS

**Calculation of Net Benefits.** The expected annual benefits attributable to each of the project alternatives for each of the benefit categories were converted to an equivalent time frame by using the current Federal discount rate of 3.75 percent. The base year for this conversion is the year 2035 for the 3% AEP alternative and the 1% AEP alternative. The equivalent annual benefits were then compared to the average annual costs to develop a benefit-to-cost ratio for each alternative. The net benefits for each alternative were calculated by subtracting the average annual costs from the equivalent annual benefits. The net benefits were used to determine the economic justification of each of the project alternatives.

**Comparison of Net Benefits for the Project Alternatives.** Tables 47 and 48 summarize the equivalent annual damages and benefits, total annual costs, benefit-to-cost ratio, and equivalent annual net benefits for the 3% AEP and the 1% AEP alternatives. Tables 49 and 50 show the net benefits for the project alternatives using only the existing condition (2010) structure inventory for the 3% and 1% AEP alternatives.

**Sensitivity Analysis.** The purpose of this sensitivity analysis was to investigate the impact that a change in depth-damage relationships from an adjacent area would have on the net benefits and benefit-to-cost ratios of the 3% AEP alternative and the 1% AEP alternative. The saltwater long-duration depth-damage relationships developed by a panel of experts as part of the Donaldsonville to the Gulf evaluation were applied to the residential and non-residential structures, contents, and vehicles in the Morganza evaluation area. The depth-damage relationships developed for the Donaldsonville evaluation are shown in Table 51. The net benefits and benefit-to-cost ratios calculated for the two project alternatives using the Donaldsonville to the Gulf depth-damage relationships are shown in Tables 52 and 53.

In addition to the sensitivity analysis performed by applying the depth-damage relationships for the Donaldsonville to the Gulf of Mexico evaluation, sensitivity analysis was also performed to determine the impacts of changes in sea level rise and subsidence and changes in the project interest rate on the damages, benefits and costs for each of the project alternatives.

The difference in stages across all probability events for all study area reaches under without-project conditions between 2035 and 2085 averaged approximately 1.6 feet. This increase in water surface elevations reflects the sea level rise and subsidence projected to occur in the evaluation area during the period. To estimate the sensitivity of damages and benefits to changes in sea level rise and subsidence for the project alternatives, damages were held constant between the years 2035 and 2085. This resulted in a 21 percent decrease in without-project damages between 2035 and 2085, and a 17 percent decrease in benefits for the 3 % AEP and 1% AEP alternatives over the period of analysis (2024-2085). The average annual cost of the project alternatives declined 0.9 percent because the height of the flood risk management structures was lowered without projected sea level rise and subsidence. The adjustments for the 3% AEP alternative resulted in a 64 percent decline in the net benefits and a decrease in the benefit-to-cost ratio from 1.34 to 1.12. The adjustments resulted in a 72 percent reduction in net benefits and a decrease in the benefit-to-cost ratio from 1.30 to 1.08 for the 1% AEP alternative.

Sensitivity analysis was also performed to determine the sensitivity of damages, benefits and costs to changes in the project interest rate used in the economic analysis. When the interest rate used in the analysis is increased from the current rate of 3.75 percent to 5.0 percent, the benefit-to-cost ratio decreases to approximately 1.0 for both the 1% AEP alternative and the 3% AEP alternative. The project alternatives would not be economically justified at any interest rate above 5 percent.

**Update to 2012 Price Level.** The damages, benefits, and costs values were updated to a 2012 price level and are shown in Table 54 for the 3% AEP alternative and Table 55 for the 1% AEP alternative. The following indexes were used to update the benefit categories from 2011 to 2012: the Construction Index developed by the Bureau of Labor Statistics was used for residential and non-residential benefit categories, including the industrial benefit category, and the avoided structure-raising costs category; the National

Highway Construction Cost Index was used for the highway and streets benefit categories; the Remediation Services Index developed by the Bureau of Labor Statistics was used for the debris removal and cleanup benefit category and the Diesel Fuel Price Index developed by the Energy Information Administration was used for boat fleets benefit category. Project costs were estimated to reflect 2012 prices.

## RISK ANALYSIS AND PROJECT PERFORMANCE

**Benefit Exceedance Probability Relationship.** The HEC-FDA model used the uncertainty surrounding the economic and engineering inputs to generate results that can be used to assess the performance of the two project alternatives. A spreadsheet was developed using the expected annual damage and benefit results from the HEC-FDA model to calculate the equivalent annual without-project and with-project damages and the damages reduced for each of the project alternatives. Table 56 shows the equivalent annual benefits at the 75, 50, and 25 percentiles. These percentiles reflect the percentage chance that the benefits will be greater than or equal to the indicated values. A trend function was applied to estimate the forecasted damage reduction above the 75 percentile for each of the project alternatives. The benefit exceedance probability relationship for each of the project alternatives can be compared to the point estimate of the average annual costs for each of the project alternatives. The table and graphs for each of the project alternatives shows the percent chance that the benefit-to-cost ratio will be greater than one and the net benefits will be positive.

**Residual Risk**. Residual risk is the flood risk that remains in the floodplain after a proposed flood risk management alternative is implemented. It includes the consequence of capacity exceedance as well as consideration of project performance. Table 57 shows the number of structures damaged and the structural damages in dollars under the without-project conditions for each of the eight ACE events, the residual damages in dollars under the with-project conditions for the 2% ACE (50-year),1% ACE (100-year), 0.5% ACE (200-year), and 0.2% ACE (500-year) events, and the percentage of the total number of structures including automobiles, residential structures, commercial structures, and mobile homes damaged by each of the four ACE events for the year 2035. All three ACE events exceed the design of the 3% AEP alternative, while only the 0.5 % ACE (200-year) event and 0.2% ACE (500-year) event exceeds the design of the 1% AEP (100-year) alternative. The residual damages in each of these cases are higher than the without-project damages because structures below the 10% ACE (10-year) event are elevated to above the 1% ACE (100-year) event to account for the response of residents to repetitive flood losses beginning in the year 2024. Finally, the table shows the minimum and maximum flood depths under the without-project conditions, which assumes that the non-Federal levees will fail, for each of the four ACE events.

Table 58 shows the number and the percentage of the total structures in the study area that would be inundated at three-foot increments of flooding at the under the without project conditions in the year 2035. The residual damages with the proposed Federal alternatives would be higher due to structures being elevated under the without-project condition to account for the response of residents to repetitive flooding, but not elevated with the project alternatives in place. For example, 19 percent of the structures would not be inundated, 12 percent of the structures would receive between 0 and 3 feet of flooding, and approximately 36 percent would have a depth of flooding between 3 and 6 feet above the first floor elevation.

**AEP by Reach for the Years of Analysis.** The results from the HEC-FDA model were also used to calculate the long-term annual exceedance probability (AEP) and the conditional non-exceedance probability, or assurance, for various probability storm events. The model provided a target stage to assess project performance for each study area reach under both existing (2010) and future (2024, 2035, and 2085) without-project and with-project conditions. For study area reaches without Federal or non-Federal levees, the target stage was set by default at the elevation where the model calculated five percent residual damages for the 1% ACE (100-year) event. For levees without geotechnical failure, which includes the Federal levees in the Morganza analysis, the target stage was set equal to the assigned top of the Federal levee elevation. For levees with geotechnical failure, which includes the non-Federal levees in the Morganza analysis, the target stage was computed based on the joint probability of annual exceedance and probability of geotechnical failure.

The model calculated a target stage AEP with a median and expected value that reflected the likelihood that the target stages will be exceeded in a given year. The median value was calculated using point estimates, while the expected value was calculated using Monte Carlo simulation. The results also show the long-term risk or the probability of a target stage being exceeded over 10-year, 30-year, and 50-year periods. Finally, the model results show the conditional non-exceedance probability or the likelihood that a target stage will not be exceeded by the 10% ACE (10 year), the 4% ACE (25-year), the 2% ACE (50-year), the 1% ACE (100-year), the 0.4% ACE (250-year), and the 0.2% ACE (500-year) events.

Table 59 displays the project performance results for four high damage study area reaches, 11BW79, 11BW5, 1-5, and BL89, which correspond to HEC-FDA model station numbers 64, 58, 82, and 298, under existing (2010) and future (2024, 2035, and 2085) without-project and with-project conditions. Study area reaches 11BW79 an 11BW5 are both located in the northern portion of the city of Houma, study area reach 1-5 is located south and east of the city of Houma, and study area reach BL89 is north and east of the city of Houma and south of Bayou Lafourche. The location of these four high damage study area reaches can be found on the 11 x 17 maps containing the study area reaches in the main report. The project performance information for the remaining 260 study area reaches follows the same logic and format, but is not displayed in the table.

As an example, the target stage for study area reach 11BW79 under existing and future without project conditions shown in the table is based on the joint probability of an annual exceedance event and geotechnical failure since there is a non-Federal levee with geotechnical failure entered into the model. The target stages for the 3% AEP and 1% AEP are shown as the assigned top of Federal levee elevation since geotechnical failure was not entered into the model. Using the year 2035 as an example, the median AEP is 0.1196 (without risk), and the expected AEP is 0.1190 (with risk) and the return interval is 8.4 years under without-project conditions. The median and expected AEP for the 3% AEP alternative is 0.0237 and 0.0256 with a return interval of 39.1 years, respectively. The median and expected AEP for the 1% AEP alternative is 0.004 and 0.072, respectively.

The long term risk is the likelihood that the target stage will be exceeded during a multi-year time window (10, 25, or 50 years). The long term risk of the target stage being exceeded is 71.8 percent for a 10-year period, 95.8 percent for a 30-year period, and 99.8 percent for a 50-year period under without project conditions for 2035. For the 3% AEP alternative, the long term risk of the target stage being exceeded is 22.9 percent for a 10-year period, 47.7 percent for a 30-year period, and 72.7 percent for a 50-year period. For the 1% AEP alternative, the long term risk of the target stage being exceeded is 7.0 percent for a 10-year period, 16.5 percent for a 30-year period, and 30.3 percent for a 50-year period. The output also shows the assurance or conditional non-exceedance for various probability events. This is the likelihood that a target stage will not be exceeded by a specified event. For this reach, there is a 79.6 percent chance that the stage associated with the 10% ACE (10-year) event will not exceed the target stage, 17.4 percent for the 4% ACE (25-year), 5.0 percent for the 2% ACE (50-year), 2.1 percent for the 1% ACE (100-year), 1.1 percent for the 0.4% (250-year), and 0.007 percent for the 0.2% (500-year) under without project conditions. For the 3% AEP alternative, there is a 99.8-percent for the 10% ACE (10-year), 79.6 percent for the 4% ACE (25-year), 41.3 percent for the 2% ACE (50-year), 20.9 percent for the 1% (100-year), 11.1 percent for the 0.4% ACE (250-year), and 6.3 percent for the 0.2% ACE (500-year). For the 1% AEP alternative, there is a 99.9 percent for the 10% ACE (10-year), 99.8 percent for the 4% ACE (25-year), 91.6 percent for the 2% ACE (50-year), 71.5 percent for the 1% ACE (100-year), 49.8 percent for the 0.4% ACE (250-year), and 33.1 percent for the 0.2% ACE (500-year) events.

# Figure 1

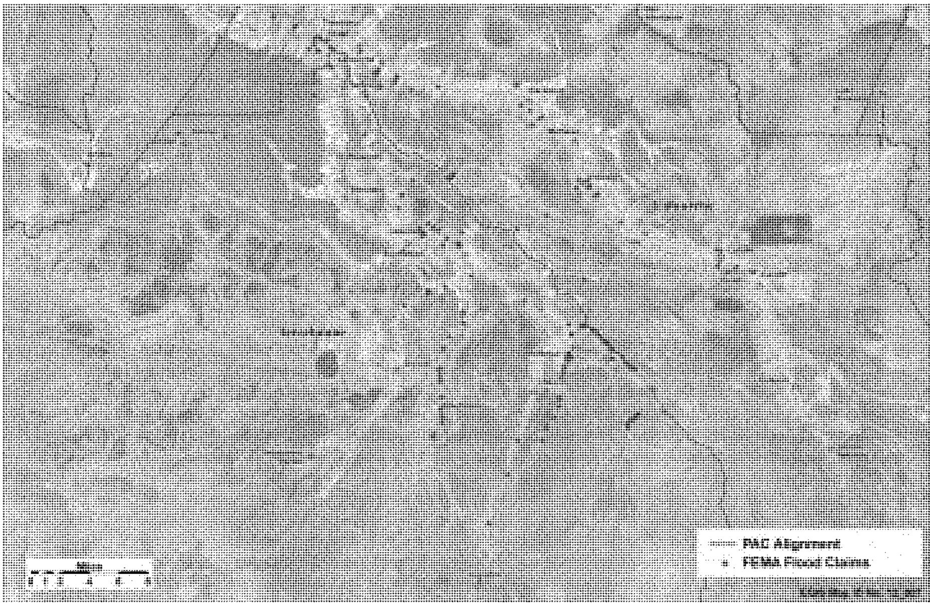



Figure 1. FEMA Repetitive Loss Properties – 1978-2010

## Figure 2

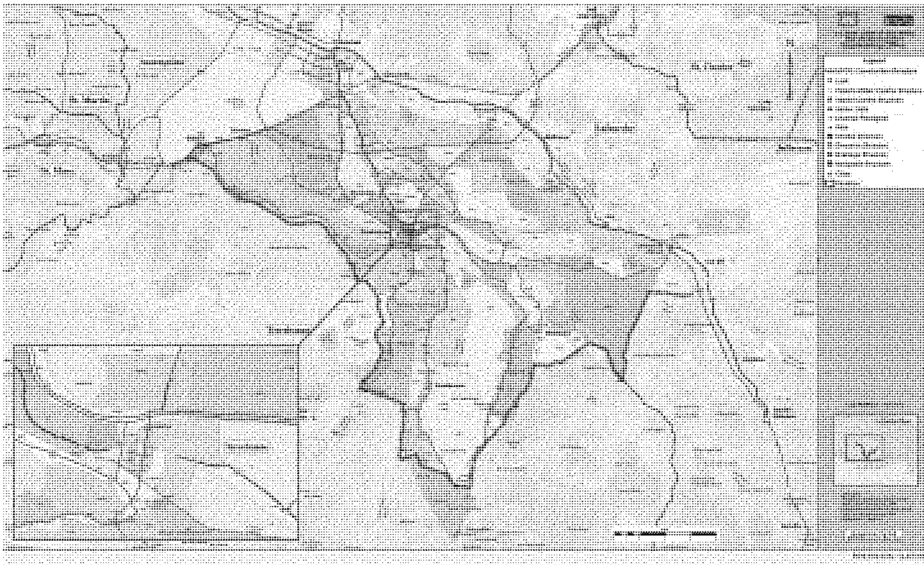


Figure 2. Study Area Reaches and Authorized Alignment

Table of Tables

Table 1
Land Use in the Study Area
(2009)
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Land Class Name | Acres | Percentage of Total |
|---|---|---|
| | | |
| **Developed land** | 38,798 | 8.7 |
| | | |
| **Agricultural Land** | | |
| Pasture/Hay | 46,544 | 10.5 |
| Sugarcane | 20,681 | 4.6 |
| Fallow/Idle Cropland | 8,606 | 1.9 |
| Soybeans | 425 | 0.1 |
| Rice | 1 | 0.0 |
| Subtotal | 76,257 | 17.1 |
| | | |
| **Undeveloped Land** | | |
| Barren/Wetlands | 289,737 | 65.1 |
| Shrubland | 1,758 | 0.4 |
| Grasslands | 347 | 0.1 |
| Forests | 41 | 0.1 |
| Open Space | 1,486 | 0.3 |
| Subtotal | 293,369 | 65.9 |
| | | |
| **Open Water** | 36,487 | 8.2 |
| | | |
| **Total** | 444,911 | 100.0 |

Source: National Agricultural Statistical Service

Table 2
Historical and Projected Parish Population
(1,000s)
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Parish | 1970 | 1980 | 1990 | 2000 | 2010 | 2035 | 2085 |
|---|---|---|---|---|---|---|---|
| Lafourche | 69.1 | 83.5 | 85.8 | 90.0 | 96.3 | 97.9 | 104.2 |
| Terrebonne | 76.2 | 95.1 | 97.0 | 104.5 | 112.0 | 120.9 | 142.8 |
| Total | 145.2 | 178.6 | 182.9 | 194.4 | 208.3 | 218.8 | 247.0 |

Source: U.S. Census data, Moody's County Forecast Database, and discussions with parish planning officials.

Table 3
Existing Condition and Projected Population
within Inventoried Study Area
(1,000s)
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Parish | 2010 | 2035 | 2085 |
|---|---|---|---|
| Lafourche | 28.8 | 29.3 | 31.2 |
| Terrebonne | 104.9 | 113.2 | 133.8 |
| Total | 133.7 | 142.5 | 165.0 |

Source: Moody's County Forecast Database and discussions with parish planning officials.

Table 4
Number of Households by Parish
(1,000s)
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Parish | 1970 | 1980 | 1990 | 2000 | 2010 | 2035 | 2085 |
|---|---|---|---|---|---|---|---|
| Lafourche | 18.0 | 25.7 | 28.8 | 32.1 | 33.7 | 36.3 | 38.1 |
| Terrebonne | 19.6 | 29.5 | 31.9 | 36.0 | 38.2 | 43.4 | 50.4 |
| Total | 37.6 | 55.2 | 60.7 | 68.1 | 71.9 | 79.7 | 88.5 |

Source: U.S. Census data, Moody's County Forecast Database, and discussions with parish planning officials.

Table 5
Per Capita Income
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Parish | 1990 | 2000 | 2005 | 2008 | 2009 |
|---|---|---|---|---|---|
| Lafourche | $ 13,070 | $ 23,039 | $ 30,422 | $ 42,613 | $ 42,205 |
| Terrebonne | $ 13,218 | $ 20,991 | $ 28,037 | $ 39,772 | $ 39,049 |

Source: Bureau of Economic Analysis

Table 6
Total Non-Farm Employment
(1,000s)
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Parish | 1970 | 1980 | 1990 | 2000 | 2010 | 2035 | 2085 |
|---|---|---|---|---|---|---|---|
| Lafourche | 15.1 | 24.4 | 22.1 | 30.4 | 37.5 | 40.7 | 44.2 |
| Terrebonne | 24.6 | 42.4 | 35.8 | 47.3 | 58.9 | 67.3 | 81.3 |
| Total | 39.7 | 66.8 | 57.9 | 77.7 | 96.4 | 108.0 | 125.5 |

Source: Based on Moody's County Forecast Database and discussions with parish planning officials.

Table 7
FEMA Flood Claims in Louisiana
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Event | Year | Number of Paid Claims | Total Amount Paid (1,000s) | Average Amount Paid (1,000s) |
|---|---|---|---|---|
| | | | | |
| Tropical Storm Juan | Oct-85 | 6,187 | $ 189,842 | $ 30.7 |
| Hurricane Andrew | Aug-92 | 5,589 | $ 270,791 | $ 48.5 |
| Tropical Storm Isadore | Sep-02 | 8,441 | $ 141,869 | $ 16.8 |
| Hurricane Lili | Oct-02 | 2,563 | $ 46,049 | $ 18.0 |
| Hurricane Katrina | Aug-05 | 167,099 | $ 18,556,254 | $ 111.0 |
| Hurricane Rita | Sep-05 | 9,507 | $ 539,086 | $ 56.7 |
| Hurricane Gustav | Sep-08 | 4,524 | $ 115,250 | $ 25.5 |
| Hurricane Ike | Sep-08 | 46,137 | $ 2,712,969 | $ 58.8 |

Source: Federal Emergency Management Agency (FEMA)
Note: Total amount paid and average amount paid have been updated to the Oct 2011 price level using the CPI for all urban consumers.

Table 8
FEMA Flood Claims by Parish
1978-2011
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Parish | Number of Policies September 2011 | Number of Claims |
|---|---|---|
| | | |
| Lafourche | 14,222 | 5,066 |
| Terrebonne | 20,044 | 12,780 |

Source: FEMA

Table 9
Number of Structures per Reach in the Existing Condition
(2010)
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Reach Name | HEC-FDA Station Number | Residential | Mobile Home | Non-Residential | Vehicle | Total |
|---|---|---|---|---|---|---|
| 1-1AB | 1 | 36 | 81 | 120 | 237 | 474 |
| 1-1AN | 4 | 1,090 | 415 | 217 | 1,925 | 3,647 |
| 11BE1 | 7 | 2 | 199 | - | 201 | 402 |
| 11BE2 | 10 | 159 | 37 | 14 | 217 | 427 |
| 11BE3 | 13 | 234 | 346 | 35 | 877 | 1,492 |
| 11BE4 | 16 | 163 | 109 | 67 | 272 | 611 |
| 11BE5 | 19 | 69 | 104 | 44 | 433 | 650 |
| 11BE6-E | 22 | - | 1 | 2 | 1 | 4 |
| 11BE6-W | 25 | 1 | 125 | 24 | 126 | 276 |
| 1-1BU3-U1 | 28 | - | - | - | - | - |
| 1-1BU3-U2 | 31 | - | - | - | - | - |
| 1-1BU3-U3 | 34 | - | - | - | - | - |
| 11BU4 | 37 | - | - | - | - | - |
| 11BW11 | 40 | 89 | 41 | 38 | 130 | 298 |
| 11BW2-W1 | 43 | 63 | 19 | 1 | 88 | 171 |
| 11BW2-W2 | 46 | 368 | 143 | 10 | 772 | 1,293 |
| 11BW4-W3 | 49 | 9 | 12 | 4 | 30 | 55 |
| 11BW4-W4 | 52 | 658 | 86 | 29 | 1,198 | 1,971 |
| 11BW4-W4A | 55 | 230 | 3 | 12 | 329 | 574 |
| 11BW5 | 58 | 1,565 | 1 | 54 | 4,721 | 6,341 |
| 11BW6 | 61 | 672 | 8 | 81 | 3,108 | 3,869 |
| 11BW79 | 64 | 1,567 | 35 | 89 | 1,996 | 3,687 |
| 11BW79-W7 | 67 | 767 | 67 | 120 | 1,916 | 2,870 |
| 1-2MID | 70 | - | - | 62 | - | 62 |
| 1-2N | 73 | 209 | 34 | 89 | 308 | 640 |
| 1-2S | 76 | - | - | 27 | - | 27 |
| 1-3 | 79 | 1,003 | 84 | 51 | 1,347 | 2,485 |
| 1-5 | 82 | 2,395 | 315 | 358 | 2,710 | 5,778 |
| 1-7_N3-4 | 85 | 16 | - | 2 | 28 | 46 |
| 1-7_N4-7 | 88 | 35 | - | 3 | 76 | 114 |
| 1-7_N7-10 | 91 | 68 | - | 3 | 80 | 151 |
| 1-7-N10-13 | 94 | 87 | 3 | 7 | 104 | 201 |
| 1-7N13-16 | 97 | 38 | 4 | 33 | 49 | 124 |
| 1-7N16-17 | 100 | - | - | 2 | - | 2 |

Table 9 (Cont.)
Number of Structures per Reach in the Existing Condition
(2010)
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Reach Name | HEC-FDA Station Number | Residential | Mobile Home | Non-Residential | Vehicle | Total |
|---|---|---|---|---|---|---|
| 1-7N17-24 | 103 | 43 | 1 | 36 | 56 | 136 |
| 1-7N24-28 | 106 | 217 | 4 | 22 | 296 | 539 |
| 1-8 | 109 | 336 | 44 | 221 | 710 | 1,311 |
| 2-1A2 | 112 | - | - | - | - | - |
| 2-1B2-MID | 115 | 6 | 1 | 2 | 7 | 16 |
| 2-1B2N | 118 | 37 | 2 | 6 | 39 | 84 |
| 2-1B2S | 121 | 1,032 | 19 | 218 | 1,211 | 2,480 |
| 3-1B | 124 | 250 | 31 | 19 | 281 | 581 |
| 3-1C | 127 | 72 | 19 | 6 | 91 | 188 |
| 4-1N | 130 | 169 | 35 | 12 | 204 | 420 |
| 4-1S | 133 | 162 | 88 | 10 | 250 | 510 |
| 4-2 | 136 | 449 | 99 | 10 | 548 | 1,106 |
| 4-2A | 139 | 323 | 289 | 23 | 612 | 1,247 |
| 4-2B | 142 | 114 | 112 | 11 | 226 | 463 |
| 4-2C | 145 | 98 | 30 | 5 | 128 | 261 |
| 4-7 | 148 | 195 | 29 | 15 | 224 | 463 |
| 4MGT | 151 | 192 | 74 | 8 | 315 | 589 |
| 5-1A | 154 | 858 | 188 | 40 | 1,364 | 2,450 |
| 5-1B | 157 | 496 | 105 | 37 | 601 | 1,239 |
| 6-1B1 | 160 | 3 | - | 2 | 3 | 8 |
| 6-1B1-B | 163 | 2 | 1 | - | 3 | 6 |
| 8-1N | 166 | 15 | 5 | 3 | 20 | 43 |
| 8-1N-B | 169 | 39 | 12 | 1 | 51 | 103 |
| 8-1S-B | 175 | 122 | 42 | 10 | 164 | 338 |
| 8-2C | 178 | - | - | 2 | - | 2 |
| 8-2D | 181 | 51 | 23 | 3 | 74 | 151 |
| 9-1AE | 184 | - | 2 | - | 2 | 4 |
| 9-1AMID | 187 | - | - | - | - | - |
| 9-1AW | 190 | - | 1 | - | 1 | 2 |
| 9-1BE | 193 | 4 | 1 | 2 | 5 | 12 |
| 9-1BMIDE | 196 | 1 | 2 | 2 | 3 | 8 |
| 9-1BMIDW | 199 | - | - | - | - | - |
| 9-1BW | 202 | 3 | 22 | 1 | 25 | 51 |
| A1 | 205 | 29 | 21 | 20 | 50 | 120 |
| B1 | 208 | 12 | 11 | 2 | 23 | 48 |
| BB1 | 211 | 141 | 1 | 8 | 267 | 417 |
| BB2 | 214 | 4 | - | 10 | 4 | 18 |
| BB3 | 217 | 16 | 3 | 49 | 39 | 107 |

Table 9 (Cont.)
Number of Structures per Reach in the Existing Condition
(2010)
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Reach Name | HEC-FDA Station Number | Residential | Mobile Home | Non-Residential | Vehicle | Total |
|---|---|---|---|---|---|---|
| BB4 | 220 | 6 | - | - | 6 | 12 |
| BB5 | 223 | 388 | - | 2 | 388 | 778 |
| BB6 | 226 | 8 | 5 | 3 | 13 | 29 |
| BB7 | 229 | 120 | 101 | 43 | 221 | 485 |
| BB8-B | 235 | - | 6 | 47 | 21 | 74 |
| BD1 | 238 | 54 | 18 | 4 | 72 | 148 |
| BDL0 | 241 | 14 | 51 | 1 | 65 | 131 |
| BDL1 | 244 | 21 | 7 | 5 | 28 | 61 |
| BDL2 | 247 | 4 | - | - | 4 | 8 |
| BDL3 | 250 | 82 | 27 | 5 | 109 | 223 |
| BDL4 | 253 | 65 | - | 3 | 65 | 133 |
| BDL4-B | 256 | 53 | 15 | 11 | 68 | 147 |
| BDL5 | 259 | 35 | 10 | 19 | 45 | 109 |
| BGC0 | 262 | 21 | 76 | 9 | 97 | 203 |
| BGC1 | 265 | 23 | 7 | 2 | 30 | 62 |
| BGC2 | 268 | 24 | 11 | 3 | 35 | 73 |
| BGC3 | 271 | 132 | 49 | 26 | 181 | 388 |
| BGC4 | 274 | 49 | 31 | 41 | 80 | 201 |
| BL1 | 277 | 1 | 10 | 7 | 11 | 29 |
| BL2 | 280 | 132 | 15 | 35 | 147 | 329 |
| BL3 | 283 | 66 | 13 | 24 | 79 | 182 |
| BL4 | 286 | 58 | 33 | 21 | 91 | 203 |
| BL5 | 289 | 379 | 197 | 125 | 576 | 1,277 |
| BL6 | 292 | 1,382 | 397 | 140 | 1,839 | 3,758 |
| BL7 | 295 | 1,465 | 146 | 225 | 2,322 | 4,158 |
| BL89 | 298 | 1,897 | 523 | 239 | 3,758 | 6,417 |
| BPC1 | 301 | 339 | 12 | 2 | 351 | 704 |
| BPC2 | 304 | 54 | 35 | 7 | 89 | 185 |
| BPC3 | 307 | 112 | 58 | 13 | 170 | 353 |
| BPC4 | 310 | 55 | 21 | 18 | 76 | 170 |
| BPC5 | 313 | 250 | 34 | 9 | 284 | 577 |
| BPC5-B | 316 | 198 | 23 | 39 | 221 | 481 |
| BT1 | 319 | 485 | 45 | 118 | 592 | 1,240 |
| BT10 | 322 | - | - | - | - | - |
| BT2 | 325 | 107 | 27 | 3 | 134 | 271 |
| BT3 | 328 | 17 | 3 | 6 | 20 | 46 |
| BT4 | 331 | 97 | 68 | 15 | 165 | 345 |
| BT4-SA | 334 | 55 | 6 | 3 | 61 | 125 |
| BT5 | 337 | 10 | - | 4 | 10 | 24 |
| BT5-B | 340 | 10 | - | - | 10 | 20 |
| BT6 | 343 | 395 | 25 | 239 | 792 | 1,451 |

Table 9 (Cont.)
Number of Structures per Reach in the Existing Condition
(2010)
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Reach Name | HEC-FDA Station Number | Residential | Mobile Home | Non-Residential | Vehicle | Total |
|---|---|---|---|---|---|---|
| BT6A | 346 | 275 | 62 | 162 | 419 | 918 |
| BT7 | 349 | 146 | 58 | 69 | 381 | 654 |
| BT8 | 352 | 16 | 7 | 22 | 23 | 68 |
| BT9 | 355 | - | - | - | - | - |
| C1 | 358 | 22 | 9 | 5 | 31 | 67 |
| C1-LF | 361 | 7 | 1 | 2 | 8 | 18 |
| CC1 | 364 | 50 | 67 | 7 | 117 | 241 |
| D-01 | 367 | 21 | 11 | - | 32 | 64 |
| D-06 | 370 | 25 | 9 | 1 | 34 | 69 |
| D10 | 373 | 28 | 12 | 4 | 40 | 84 |
| D-16N | 376 | 37 | 30 | 7 | 67 | 141 |
| D-16S | 379 | 147 | 119 | 8 | 266 | 540 |
| D-1732 | 382 | 119 | 86 | 13 | 205 | 423 |
| D1A | 385 | - | - | - | - | - |
| D1B | 388 | - | - | - | - | - |
| D1b-LF | 391 | 2 | 1 | 4 | 3 | 10 |
| D1C | 394 | 12 | 9 | 10 | 21 | 52 |
| D1c-LF1 | 397 | 180 | 108 | 29 | 404 | 721 |
| D1c-LF2 | 400 | 150 | 65 | 20 | 215 | 450 |
| D1c-LF3 | 403 | 5 | 1 | 4 | 6 | 16 |
| D-25 | 406 | 116 | 29 | 24 | 154 | 323 |
| D-25-B | 409 | - | - | - | - | - |
| D-26 | 412 | 47 | 2 | 2 | 49 | 100 |
| D-28 | 415 | 20 | 20 | 4 | 40 | 84 |
| D-29 | 418 | 1,391 | - | 50 | 1,471 | 2,912 |
| D-30 | 421 | 32 | 2 | 1 | 34 | 69 |
| D-31 | 424 | 12 | 6 | 3 | 18 | 39 |
| D-34N | 427 | 16 | - | 5 | 16 | 37 |
| D-34S | 430 | 4 | 1 | 2 | 5 | 12 |
| D-35 | 433 | 7 | - | 2 | 7 | 16 |
| D-36 | 436 | 133 | 99 | 6 | 232 | 470 |
| D-37 | 439 | 62 | - | - | 62 | 124 |
| D-38 | 442 | 273 | - | 22 | 734 | 1,029 |
| D-39-1 | 445 | 300 | 14 | 30 | 314 | 658 |
| D-39-2 | 448 | 66 | 1 | 22 | 274 | 363 |
| D-39-3 | 451 | 184 | 3 | 70 | 329 | 586 |
| D-42 | 454 | 24 | 29 | 3 | 53 | 109 |
| D-43 | 457 | 152 | 50 | 12 | 202 | 416 |
| D-44 | 460 | 3 | 71 | 6 | 94 | 174 |
| D-45 | 463 | 4 | - | - | 4 | 8 |
| D-48 | 466 | 8 | 3 | - | 11 | 22 |

Table 9 (Cont.)
Number of Structures per Reach in the Existing Condition
(2010)
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Reach Name | HEC-FDA Station Number | Residential | Mobile Home | Non-Residential | Vehicle | Total |
|---|---|---|---|---|---|---|
| D-49 | 469 | - | 5 | - | 5 | 10 |
| D-50 | 472 | 30 | 34 | 5 | 142 | 211 |
| D-51 | 475 | 47 | 1 | 2 | 48 | 98 |
| D-53 | 478 | 84 | - | 5 | 84 | 173 |
| D-56 | 481 | 65 | 11 | 5 | 76 | 157 |
| D-60 | 484 | - | 370 | 2 | 370 | 742 |
| D-61 | 487 | 44 | 28 | 1 | 72 | 145 |
| D-61-B | 490 | 6 | - | - | 6 | 12 |
| D-62-B | 496 | 58 | 4 | 2 | 62 | 126 |
| D-64 | 499 | 93 | - | - | 93 | 186 |
| E1 | 502 | 2 | 18 | 14 | 20 | 54 |
| E1-LF | 505 | - | 1 | - | 1 | 2 |
| E1-LF-B | 508 | - | - | 8 | - | 8 |
| E2 | 511 | - | - | 1 | - | 1 |
| E2-B | 514 | - | - | 4 | - | 4 |
| E2-LF | 517 | 133 | 72 | 75 | 205 | 485 |
| E2-LF-B | 520 | - | - | - | - | - |
| FC | 523 | - | - | 1 | - | 1 |
| GW10 | 526 | 434 | 4 | 35 | 474 | 947 |
| GW11 | 529 | 54 | - | 14 | 54 | 122 |
| GW12 | 532 | 977 | 48 | 147 | 2,276 | 3,448 |
| GW13 | 535 | 288 | 478 | 64 | 776 | 1,606 |
| GW14 | 538 | 817 | 37 | 114 | 2,673 | 3,641 |
| GW14-1 | 541 | 32 | 13 | 12 | 45 | 102 |
| GW15 | 544 | 129 | 145 | 22 | 274 | 570 |
| GW16 | 547 | 28 | 64 | 7 | 92 | 191 |
| GW17 | 550 | - | - | 13 | - | 13 |
| GW18 | 553 | 44 | - | 1 | 44 | 89 |
| GW18-B | 556 | - | 1 | - | 1 | 2 |
| GW2 | 559 | 21 | 8 | 1 | 29 | 59 |
| GW3 | 562 | 21 | 24 | 12 | 45 | 102 |
| GW4 | 565 | - | 4 | 1 | 4 | 9 |
| GW5 | 568 | - | 4 | - | 4 | 8 |
| GW6 | 571 | - | 10 | - | 10 | 20 |
| GW7 | 574 | - | 4 | - | 4 | 8 |
| GW8 | 577 | - | 2 | - | 2 | 4 |
| GW9 | 580 | 24 | 7 | 16 | 31 | 78 |
| HC1 | 583 | 100 | 120 | 19 | 220 | 459 |
| HC2 | 586 | - | - | 2 | - | 2 |
| HC3 | 589 | 28 | 50 | 9 | 78 | 165 |
| HC4 | 592 | 7 | - | 3 | 7 | 17 |

Table 9 (Cont.)
Number of Structures per Reach in the Existing Condition
(2010)
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Reach Name | HEC-FDA Station Number | Residential | Mobile Home | Non-Residential | Vehicle | Total |
|---|---|---|---|---|---|---|
| HNC0 | 595 | 2 | 3 | 75 | 5 | 85 |
| HNC1 | 598 | 25 | 10 | 10 | 35 | 80 |
| HNC10 | 601 | 14 | 3 | 1 | 17 | 35 |
| HNC10-B | 604 | 89 | 26 | 9 | 115 | 239 |
| HNC2 | 607 | 129 | 55 | 22 | 184 | 390 |
| HNC3 | 610 | 58 | 36 | 13 | 94 | 201 |
| HNC4 | 613 | 27 | 8 | 1 | 35 | 71 |
| HNC5 | 616 | 60 | 110 | 5 | 170 | 345 |
| HNC6 | 619 | - | 9 | 51 | 9 | 69 |
| HNC7 | 622 | 33 | 9 | 253 | 42 | 337 |
| HNC8 | 625 | 60 | 3 | 13 | 63 | 139 |
| HNC9 | 628 | - | - | - | - | - |
| HNC9-B | 631 | 142 | 29 | 7 | 171 | 349 |
| HNC9-E | 634 | 6 | 9 | - | 15 | 30 |
| HNC9-W | 637 | 7 | 4 | 6 | 11 | 28 |
| LB1 | 640 | - | - | - | - | - |
| LB2 | 643 | 9 | 15 | 7 | 24 | 55 |
| LB3 | 646 | - | - | 3 | - | 3 |
| LB4 | 649 | 31 | 264 | 17 | 295 | 607 |
| LB5 | 652 | 30 | 19 | 12 | 49 | 110 |
| LBB2 | 655 | 3 | - | 2 | 3 | 8 |
| LBB3 | 658 | 51 | 9 | 7 | 60 | 127 |
| LBB4 | 661 | 99 | 3 | 139 | 105 | 346 |
| LBB5 | 664 | 610 | - | 28 | 610 | 1,248 |
| LBB6 | 667 | 88 | - | 35 | 88 | 211 |
| LBC1 | 670 | - | - | 2 | - | 2 |
| LBC2 | 673 | - | - | 3 | - | 3 |
| LF1 | 676 | 24 | - | 11 | 24 | 59 |
| LF2 | 679 | 13 | 1 | 4 | 14 | 32 |
| LF-GB | 682 | - | 5 | 9 | 5 | 19 |
| LL1 | 685 | 3 | - | - | 3 | 6 |
| LL2 | 688 | - | - | - | - | - |
| LL3 | 691 | - | 1 | - | 1 | 2 |
| MC1 | 694 | - | - | - | - | - |
| OB1 | 697 | - | - | - | - | - |
| OB2 | 700 | 40 | 74 | 5 | 114 | 233 |
| OB3 | 703 | 18 | 12 | 10 | 150 | 190 |
| OB4 | 706 | 55 | - | 2 | 55 | 112 |
| PAC1 | 709 | 3 | 2 | 7 | 5 | 17 |
| SL1 | 712 | 54 | 55 | 10 | 109 | 228 |
| SL2 | 715 | 20 | - | 2 | 20 | 42 |

Table 9 (Cont.)
Number of Structures per Reach in the Existing Condition
(2010)
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Reach Name | HEC-FDA Station Number | Residential | Mobile Home | Non-Residential | Vehicle | Total |
|---|---|---|---|---|---|---|
| SL3 | 718 | 140 | 54 | 8 | 194 | 396 |
| TS1 | 721 | - | - | - | - | - |
| TS10 | 724 | - | - | - | - | - |
| TS11 | 727 | 77 | - | 18 | 77 | 172 |
| TS12 | 730 | 19 | 25 | 23 | 44 | 111 |
| TS13 | 733 | 13 | 6 | 4 | 19 | 42 |
| TS14 | 736 | - | 3 | - | 3 | 6 |
| TS15 | 739 | - | - | - | - | - |
| TS16 | 742 | 123 | 177 | 5 | 300 | 605 |
| TS17 | 745 | 30 | 8 | 2 | 38 | 78 |
| TS18 | 748 | 12 | - | - | 12 | 24 |
| TS19 | 751 | 401 | 195 | 31 | 750 | 1,377 |
| TS2 | 754 | - | - | - | - | - |
| TS20 | 757 | 1 | - | - | 1 | 2 |
| TS21 | 760 | - | - | - | - | - |
| TS22 | 763 | 228 | 205 | 46 | 433 | 912 |
| TS3 | 766 | - | - | - | - | - |
| TS4 | 769 | 37 | 3 | 14 | 40 | 94 |
| TS5 | 772 | 82 | 57 | 39 | 139 | 317 |
| TS6 | 775 | 226 | 48 | 56 | 274 | 604 |
| TS7 | 778 | - | - | - | - | - |
| TS9 | 781 | 80 | 57 | 20 | 137 | 294 |
| US1 | 784 | - | - | 2 | - | 2 |
| GW11-B | 787 | - | - | - | - | - |
| E1-B | 790 | - | - | - | - | - |
| BB7-B | 793 | - | - | - | - | - |
| BD1-B | 796 | - | - | - | - | - |
| BC | 799 | - | - | - | - | - |
| Total | | 36,681 | 9,858 | 6,227 | 64,365 | 117,131 |

Note: Industrial Structures were modeled as a separate category and therefore are not included in the above structure inventory.

Table 10
Residential and Non-Residential Structure Inventory
Existing Conditions (2010)
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Structure Category | Number | Average Depreciated Replacement Value |
|---|---|---|
| *Residential* | | |
| One-Story Slab | 21,693 | $ 168,000 |
| One-Story Pier | 12,717 | $ 92,000 |
| Two-Story Slab | 1,656 | $ 232,000 |
| Two-Story Pier | 615 | $ 148,000 |
| Mobile Home | 9,858 | $ 10,000 |
| **Total Residential** | **46,539** | |
| *Non-Residential* | | |
| Eating and Recreation | 297 | $ 348,000 |
| Professional | 1,167 | $ 555,000 |
| Public and Semi-Public | 642 | $ 813,000 |
| Repair and Home Use | 148 | $ 175,000 |
| Retail and Personal Services | 586 | $ 572,000 |
| Warehouse | 2,932 | $ 181,000 |
| Grocery and Gas Station | 146 | $ 359,000 |
| Multi-Family Occupancy | 309 | $ 431,000 |
| Industrial | 24 | $ 1,854,000 |
| **Total Non-Residential** | **6,251** | |

Source: Based on *Morganza to the Gulf Post Authorization Change Report: Residential and Non-residential Structure Inventory and Nonresidential Surveys Final Report* dated May 2009

Table 11
Number of Projected Residential and Non-Residential Structures
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Future Conditions (2010-2035) | |
|---|---|
| Structure Category | Number |
| *Residential* | |
| One-Story Slab | 3,522 |
| One-Story Pier | 1,924 |
| Two-Story Slab | 204 |
| Two-Story Pier | 91 |
| Mobile Home | 1,579 |
| **Total Residential** | **7,320** |
| *Non-Residential* | |
| Eating and Recreation | 137 |
| Professional | 286 |
| Public and Semi-Public | 92 |
| Repair and Home Use | 32 |
| Retail and Personal Services | 122 |
| Warehouse | 620 |
| Grocery and Gas Station | 30 |
| Multi-Family Occupancy | 0 |
| Industrial | 0 |
| **Total Non-Residential** | **1,319** |
| Future Conditions (2035-2085) | |
| Structure Category | Number |
| *Residential* | |
| One-Story Slab | 4,344 |
| One-Story Pier | 2,328 |
| Two-Story Slab | 263 |
| Two-Story Pier | 111 |
| Mobile Home | 1,866 |
| **Total Residential** | **8,912** |
| *Non-Residential* | |
| Eating and Recreation | 537 |
| Professional | 484 |
| Public and Semi-Public | 91 |
| Repair and Home Use | 66 |
| Retail and Personal Services | 251 |
| Warehouse | 1,850 |
| Grocery and Gas Station | 63 |
| Multi-Family Occupancy | 0 |
| Industrial | 0 |
| **Total Non-Residential** | **3,342** |

Source: Based on *Projections of Future Development and Land Usage Morganza to the Gulf Feasibility Evaluation Final Report* dated February 2011

Table 12

Content-to-Structure Value Ratios (CSVRs) and Standard Deviations (SDs)
by Structure Category
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Structure Category | | (CSVR, SD) |
|---|---|---|
| Residential | One-story | (0.71, 0.23) |
| | Two-story | (0.50, 0.27) |
| | Mobile home | (1.48, 0.68) |
| | | |
| Non-Residential | Eating and Recreation | (3.05, 4.48) |
| | Groceries and Gas Stations | (1.28, 0.96) |
| | Professional Buildings | (0.78, 0.70) |
| | Public and Semi-Public Buildings | (0.81, 1.03) |
| | Multi-Family Buildings | (0.23, 0.13) |
| | Repair and Home Use | (2.51, 2.08) |
| | Retail and Personal Services | (1.48, 1.13) |
| | Warehouses and Contractor Services | (3.73, 4.81) |

Table 13
Depth-Damage Relationships for Structures, Contents and Vehicles
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Occupancy Type | Category Name | Damage Type | Parameter | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1STY-PIER | Residential | | Stage | -1.1 | -1.0 | -0.5 | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 |
| | | Structure | Mean % | 0.0 | 1.1 | 12.2 | 15.2 | 49.4 | 50.1 | 66.7 | 70.2 | 71.2 | 97.5 | 97.5 | 97.5 | 97.5 | 97.5 | 97.5 | 97.5 | 97.5 | 97.5 | 97.5 | 97.5 |
| | | | Lower % | 0.0 | 1.0 | 11.9 | 13.7 | 44.4 | 45.1 | 60.0 | 63.2 | 64.1 | 87.7 | 87.7 | 87.7 | 87.7 | 87.7 | 87.7 | 87.7 | 87.7 | 87.7 | 87.7 | 87.7 |
| | | | Upper % | 0.0 | 1.7 | 18.3 | 22.8 | 74.0 | 75.1 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| | | Contents | Mean % | 0.0 | 0.0 | 0.0 | 0.0 | 95.0 | 95.0 | 95.0 | 95.0 | 98.0 | 98.0 | 98.0 | 98.0 | 98.0 | 98.0 | 98.0 | 98.0 | 98.0 | 98.0 | 98.0 | 98.0 |
| | | | Lower % | 0.0 | 0.0 | 0.0 | 0.0 | 90.0 | 90.0 | 95.0 | 95.0 | 98.0 | 98.0 | 98.0 | 98.0 | 98.0 | 98.0 | 98.0 | 98.0 | 98.0 | 98.0 | 98.0 | 98.0 |
| | | | Upper % | 0.0 | 0.0 | 0.0 | 0.0 | 98.0 | 98.0 | 98.0 | 98.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| 1STY-SLAB | Residential | | Stage | -1.0 | -0.5 | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 |
| | | Structure | Mean % | 0.0 | 1.1 | 1.1 | 23.3 | 23.3 | 37.2 | 41.9 | 45.3 | 92.0 | 92.0 | 92.0 | 92.0 | 92.0 | 92.0 | 92.0 | 92.0 | 92.0 | 92.0 | 92.0 | 92.0 |
| | | | Lower % | 0.0 | 1.0 | 1.0 | 21.0 | 21.0 | 35.5 | 37.7 | 40.8 | 82.8 | 82.8 | 82.8 | 82.8 | 82.8 | 82.8 | 82.8 | 82.8 | 82.8 | 82.8 | 82.8 | 82.8 |
| | | | Upper % | 0.0 | 1.7 | 1.7 | 35.0 | 35.0 | 55.9 | 62.9 | 68.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| | | Contents | Mean % | 0.0 | 0.0 | 0.0 | 0.0 | 95.0 | 95.0 | 95.0 | 95.0 | 98.0 | 98.0 | 98.0 | 98.0 | 98.0 | 98.0 | 98.0 | 98.0 | 98.0 | 98.0 | 98.0 | 98.0 |
| | | | Lower % | 0.0 | 0.0 | 0.0 | 0.0 | 90.0 | 90.0 | 95.0 | 95.0 | 98.0 | 98.0 | 98.0 | 98.0 | 98.0 | 98.0 | 98.0 | 98.0 | 98.0 | 98.0 | 98.0 | 98.0 |
| | | | Upper % | 0.0 | 0.0 | 0.0 | 0.0 | 98.0 | 98.0 | 98.0 | 98.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| | | | Struct | N | | 0.3 | | N | | 12.2 | | N | 71.0 | 23.0 | | | -901.0 | | | | | | |
| 2STY-PIER | Residential | | Stage | -1.1 | -1.0 | -0.5 | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 |
| | | Structure | Mean % | 0.0 | 1.4 | 2.2 | 6.4 | 19.0 | 19.0 | 31.9 | 32.6 | 33.3 | 93.4 | 93.4 | 93.4 | 93.4 | 93.4 | 93.4 | 93.6 | 93.6 | 93.6 | 93.6 | 93.6 |
| | | | Lower % | 0.0 | 1.2 | 2.0 | 5.8 | 17.1 | 17.1 | 28.7 | 29.3 | 30.0 | 84.0 | 84.0 | 84.0 | 84.0 | 84.0 | 84.0 | 84.0 | 84.0 | 84.0 | 84.0 | 84.0 |
| | | | Upper % | 0.0 | 2.1 | 3.3 | 9.6 | 28.5 | 28.5 | 47.9 | 48.9 | 49.9 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| | | Contents | Mean % | 0.0 | 0.0 | 0.0 | 0.0 | 69.6 | 74.7 | 74.7 | 78.5 | 79.9 | 83.2 | 83.2 | 83.2 | 83.2 | 83.2 | 83.2 | 97.5 | 97.8 | 98.5 | 98.5 | 98.5 |
| | | | Lower % | 0.0 | 0.0 | 0.0 | 0.0 | 66.2 | 70.9 | 70.9 | 74.6 | 75.9 | 79.0 | 79.0 | 79.0 | 79.0 | 79.0 | 79.0 | 92.6 | 92.9 | 93.6 | 93.6 | 93.6 |
| | | | Upper % | 0.0 | 0.0 | 0.0 | 0.0 | 73.1 | 78.4 | 78.4 | 82.5 | 83.9 | 87.3 | 87.3 | 87.3 | 87.3 | 87.3 | 87.3 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| 2STY-SLAB | Residential | | Stage | -1.1 | -1.0 | -0.5 | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 |
| | | Structure | Mean % | 0.0 | 1.2 | 1.2 | 16.1 | 16.1 | 26.1 | 27.1 | 28.5 | 80.0 | 80.0 | 80.0 | 80.0 | 80.0 | 80.0 | 80.3 | 80.3 | 80.3 | 83.2 | 83.2 | 83.2 |
| | | | Lower % | 0.0 | 1.1 | 1.1 | 14.5 | 14.5 | 23.5 | 24.4 | 25.7 | 72.0 | 72.0 | 72.0 | 72.0 | 72.0 | 72.0 | 72.0 | 72.0 | 72.0 | 72.0 | 72.0 | 72.0 |
| | | | Upper % | 0.0 | 1.8 | 1.8 | 24.2 | 24.2 | 39.1 | 40.7 | 42.8 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| | | | Stage | -1.0 | -0.5 | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 |
| | | Contents | Mean % | 0.0 | 0.0 | 0.0 | 0.0 | 69.6 | 74.7 | 74.7 | 78.5 | 79.9 | 83.2 | 83.2 | 83.2 | 83.2 | 83.2 | 83.2 | 97.5 | 97.8 | 98.5 | 98.5 | 98.5 |
| | | | Lower % | 0.0 | 0.0 | 0.0 | 0.0 | 66.2 | 70.9 | 70.9 | 74.6 | 75.9 | 79.0 | 79.0 | 79.0 | 79.0 | 79.0 | 79.0 | 92.6 | 92.9 | 93.6 | 93.6 | 93.6 |
| | | | Upper % | 0.0 | 0.0 | 0.0 | 0.0 | 73.1 | 78.4 | 78.4 | 82.5 | 83.9 | 87.3 | 87.3 | 87.3 | 87.3 | 87.3 | 87.3 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| AUTO | AUTO | | Stage | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 | 16.0 | 17.0 |
| | | Structure | Mean % | 0.0 | 0.0 | 3.7 | 13.0 | 46.7 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| | | | Lower % | 0.0 | 0.0 | 2.3 | 12.0 | 44.7 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| | | | Upper % | 0.0 | 0.0 | 4.7 | 15.0 | 45.3 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

Table 13 (Cont)
Depth-Damage Relationships for Structures, Contents and Vehicles
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Occupancy Type | Category Name | Damage Type | Parameter | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EAT | COM | | Stage | -1.0 | -0.5 | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 |
| | | Structure | Mean % | 0.0 | 0.0 | 6.6 | 19.8 | 19.8 | 24.5 | 24.5 | 29.6 | 34.7 | 37.9 | 37.9 | 37.9 | 63.3 | 63.3 | 63.3 | 63.3 | 63.3 | 63.3 | 63.3 | 63.3 |
| | | | Lower % | 0.0 | 0.0 | 6.2 | 18.4 | 18.4 | 22.8 | 22.8 | 26.6 | 31.2 | 34.1 | 34.1 | 34.1 | 57.0 | 57.0 | 57.0 | 57.0 | 57.0 | 57.0 | 57.0 | 57.0 |
| | | | Upper % | 0.0 | 0.0 | 7.6 | 22.8 | 22.8 | 28.2 | 28.2 | 37.0 | 43.4 | 47.4 | 47.4 | 47.4 | 79.2 | 79.2 | 79.2 | 79.2 | 79.2 | 79.2 | 79.2 | 79.2 |
| | | Contents | Mean % | 0.0 | 0.0 | 0.0 | 41.2 | 45.6 | 73.3 | 74.8 | 92.4 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| | | | Lower % | 0.0 | 0.0 | 0.0 | 39.2 | 43.3 | 69.6 | 71.1 | 87.8 | 95.0 | 95.0 | 95.0 | 95.0 | 95.0 | 95.0 | 95.0 | 95.0 | 95.0 | 95.0 | 95.0 | 95.0 |
| | | | Upper % | 0.0 | 0.0 | 0.0 | 51.5 | 57.0 | 91.6 | 93.5 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| GROC | COM | | Stage | -1.0 | -0.5 | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 |
| | | Structure | Mean % | 0.0 | 0.0 | 6.6 | 19.8 | 19.8 | 24.5 | 24.5 | 29.6 | 34.7 | 37.9 | 37.9 | 37.9 | 63.3 | 63.3 | 63.3 | 63.3 | 63.3 | 63.3 | 63.3 | 63.3 |
| | | | Lower % | 0.0 | 0.0 | 6.2 | 18.4 | 18.4 | 22.8 | 22.8 | 26.6 | 31.2 | 34.1 | 34.1 | 34.1 | 57.0 | 57.0 | 57.0 | 57.0 | 57.0 | 57.0 | 57.0 | 57.0 |
| | | | Upper % | 0.0 | 0.0 | 7.6 | 22.8 | 22.8 | 28.2 | 28.2 | 37.0 | 43.4 | 47.4 | 47.4 | 47.4 | 79.2 | 79.2 | 79.2 | 79.2 | 79.2 | 79.2 | 79.2 | 79.2 |
| | | Contents | Mean % | 0.0 | 0.0 | 0.0 | 99.1 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| | | | Lower % | 0.0 | 0.0 | 0.0 | 94.1 | 95.0 | 95.0 | 95.0 | 95.0 | 95.0 | 95.0 | 95.0 | 95.0 | 95.0 | 95.0 | 95.0 | 95.0 | 95.0 | 95.0 | 95.0 | 95.0 |
| | | | Upper % | 0.0 | 0.0 | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| MOBHOM | MOBHOME | | Stage | -1.1 | -1.0 | -0.5 | 0.0 | 0.5 | 1.0 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 |
| | | Structure | Mean % | 0.0 | 6.4 | 7.3 | 9.9 | 43.4 | 44.7 | 97.6 | 97.6 | 97.6 | 97.6 | 97.6 | 97.6 | 97.6 | 97.6 | 97.6 | 97.6 | 97.6 | 97.6 | 97.6 | 97.6 |
| | | | Lower % | 0.0 | 6.1 | 6.9 | 9.4 | 41.2 | 42.5 | 92.7 | 92.7 | 92.7 | 92.7 | 92.7 | 92.7 | 92.7 | 92.7 | 92.7 | 92.7 | 92.7 | 92.7 | 92.7 | 92.7 |
| | | | Upper % | 0.0 | 8.6 | 9.8 | 13.4 | 58.6 | 60.3 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| | | Contents | Mean % | 0.0 | 0.0 | 0.0 | 95.0 | 96.0 | 97.0 | 98.0 | 99.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| | | | Lower % | 0.0 | 0.0 | 0.0 | 90.0 | 92.0 | 94.0 | 96.0 | 98.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| | | | Upper % | 0.0 | 0.0 | 0.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| MULT | COM | | Stage | -1.0 | -0.5 | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 |
| | | Structure | Mean % | 0.0 | 0.0 | 6.6 | 19.8 | 19.8 | 24.5 | 24.5 | 29.6 | 34.7 | 37.9 | 37.9 | 37.9 | 63.3 | 63.3 | 63.3 | 63.3 | 63.3 | 63.3 | 63.3 | 63.3 |
| | | | Lower % | 0.0 | 0.0 | 6.2 | 18.4 | 18.4 | 22.8 | 22.8 | 26.6 | 31.2 | 34.1 | 34.1 | 34.1 | 57.0 | 57.0 | 57.0 | 57.0 | 57.0 | 57.0 | 57.0 | 57.0 |
| | | | Upper % | 0.0 | 0.0 | 7.6 | 22.8 | 22.8 | 28.2 | 28.2 | 37.0 | 43.4 | 47.4 | 47.4 | 47.4 | 79.2 | 79.2 | 79.2 | 79.2 | 79.2 | 79.2 | 79.2 | 79.2 |
| | | Contents | Mean % | 0.0 | 0.0 | 0.0 | 20.1 | 26.2 | 33.5 | 42.4 | 49.8 | 51.7 | 51.7 | 51.7 | 51.7 | 51.7 | 51.7 | 71.8 | 85.2 | 100.0 | 100.0 | 100.0 | 100.0 |
| | | | Lower % | 0.0 | 0.0 | 0.0 | 15.8 | 22.4 | 31.2 | 40.5 | 46.6 | 50.3 | 50.3 | 50.3 | 50.3 | 50.3 | 50.3 | 56.4 | 79.6 | 93.5 | 97.1 | 97.1 | 97.1 |
| | | | Upper % | 0.0 | 0.0 | 0.0 | 22.2 | 28.7 | 35.2 | 46.2 | 51.4 | 53.0 | 53.1 | 54.6 | 54.6 | 54.6 | 54.6 | 79.3 | 89.5 | 100.0 | 100.0 | 100.0 | 100.0 |
| PROF | COM | | Stage | -1.0 | -0.5 | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 |
| | | Structure | Mean % | 0.0 | 0.0 | 6.6 | 19.8 | 19.8 | 24.5 | 24.5 | 29.6 | 34.7 | 37.9 | 37.9 | 37.9 | 63.3 | 63.3 | 63.3 | 63.3 | 63.3 | 63.3 | 63.3 | 63.3 |
| | | | Lower % | 0.0 | 0.0 | 6.2 | 18.4 | 18.4 | 22.8 | 22.8 | 26.6 | 31.2 | 34.1 | 34.1 | 34.1 | 57.0 | 57.0 | 57.0 | 57.0 | 57.0 | 57.0 | 57.0 | 57.0 |
| | | | Upper % | 0.0 | 0.0 | 7.6 | 22.8 | 22.8 | 28.2 | 28.2 | 37.0 | 43.4 | 47.4 | 47.4 | 47.4 | 79.2 | 79.2 | 79.2 | 79.2 | 79.2 | 79.2 | 79.2 | 79.2 |
| | | Contents | Mean % | 0.0 | 0.0 | 0.0 | 35.0 | 43.3 | 56.7 | 63.9 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| | | | Lower % | 0.0 | 0.0 | 0.0 | 30.0 | 37.1 | 48.6 | 54.8 | 85.7 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| | | | Upper % | 0.0 | 0.0 | 0.0 | 50.0 | 61.8 | 81.0 | 91.3 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

Table 13 (Cont)
Depth-Damage Relationships for Structures, Contents and Vehicles
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PUBL | COM | | Stage | -1.0 | -0.5 | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 |
| | | Structure | Mean % | 0.0 | 0.0 | 1.1 | 22.3 | 23.7 | 25.8 | 32.7 | 34.4 | 79.1 | 79.1 | 79.1 | 79.1 | 79.1 | 79.1 | 79.1 | 79.1 | 80.5 | 80.5 | 80.5 | 80.5 |
| | | | Lower % | 0.0 | 0.0 | 1.1 | 20.8 | 22.1 | 24.0 | 29.5 | 31.0 | 71.2 | 71.2 | 71.2 | 71.2 | 71.2 | 71.2 | 71.2 | 71.2 | 72.4 | 72.4 | 72.4 | 72.4 |
| | | | Upper % | 0.0 | 0.0 | 1.3 | 25.7 | 27.3 | 29.7 | 39.3 | 43.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| | | Contents | Mean % | 0.0 | 0.0 | 0.0 | 80.0 | 85.0 | 85.7 | 86.6 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| | | | Lower % | 0.0 | 0.0 | 0.0 | 60.0 | 63.8 | 64.3 | 65.0 | 75.0 | 75.0 | 75.0 | 75.0 | 75.0 | 75.0 | 75.0 | 75.0 | 75.0 | 75.0 | 75.0 | 75.0 | 75.0 |
| | | | Upper % | 0.0 | 0.0 | 0.0 | 88.0 | 93.5 | 94.2 | 95.3 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| REPA | COM | | Stage | -1.0 | -0.5 | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 |
| | | Structure | Mean % | 0.0 | 0.0 | 1.1 | 22.3 | 23.7 | 25.8 | 32.7 | 34.4 | 79.1 | 79.1 | 79.1 | 79.1 | 79.1 | 79.1 | 79.1 | 79.1 | 80.5 | 80.5 | 80.5 | 80.5 |
| | | | Lower % | 0.0 | 0.0 | 1.1 | 20.8 | 22.1 | 24.0 | 29.5 | 31.0 | 71.2 | 71.2 | 71.2 | 71.2 | 71.2 | 71.2 | 71.2 | 71.2 | 72.4 | 72.4 | 72.4 | 72.4 |
| | | | Upper % | 0.0 | 0.0 | 1.3 | 25.7 | 27.3 | 29.7 | 39.3 | 43.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| | | Contents | Mean % | 0.0 | 0.0 | 0.0 | 33.3 | 34.3 | 34.3 | 69.2 | 70.6 | 72.1 | 80.6 | 83.7 | 83.7 | 83.7 | 83.7 | 83.7 | 83.7 | 83.7 | 83.7 | 83.7 | 83.7 |
| | | | Lower % | 0.0 | 0.0 | 0.0 | 31.7 | 32.6 | 32.6 | 65.7 | 67.1 | 68.5 | 76.6 | 79.6 | 79.6 | 79.6 | 79.6 | 79.6 | 79.6 | 79.6 | 79.6 | 79.6 | 79.6 |
| | | | Upper % | 0.0 | 0.0 | 0.0 | 41.7 | 42.9 | 42.9 | 86.5 | 88.3 | 90.2 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| RETA | COM | | Stage | -1.0 | -0.5 | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 |
| | | Structure | Mean % | 0.0 | 0.0 | 1.1 | 22.3 | 23.7 | 25.8 | 32.7 | 34.4 | 79.1 | 79.1 | 79.1 | 79.1 | 79.1 | 79.1 | 79.1 | 79.1 | 80.5 | 80.5 | 80.5 | 80.5 |
| | | | Lower % | 0.0 | 0.0 | 1.1 | 20.8 | 22.1 | 24.0 | 29.5 | 31.0 | 71.2 | 71.2 | 71.2 | 71.2 | 71.2 | 71.2 | 71.2 | 71.2 | 72.4 | 72.4 | 72.4 | 72.4 |
| | | | Upper % | 0.0 | 0.0 | 1.3 | 25.7 | 27.3 | 29.7 | 39.3 | 43.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| | | | Stage | -1.0 | -0.5 | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 |
| | | Contents | Mean % | 0.0 | 0.0 | 0.0 | 36.6 | 60.5 | 60.5 | 75.4 | 85.1 | 94.5 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| | | | Lower % | 0.0 | 0.0 | 0.0 | 34.8 | 57.5 | 57.5 | 71.6 | 80.8 | 89.7 | 95.0 | 95.0 | 95.0 | 95.0 | 95.0 | 95.0 | 95.0 | 95.0 | 95.0 | 95.0 | 95.0 |
| | | | Upper % | 0.0 | 0.0 | 0.0 | 45.7 | 75.7 | 75.7 | 94.2 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| WARE | COM | | Stage | -1.0 | -0.5 | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 |
| | | Structure | Mean % | 0.0 | 0.0 | 1.1 | 22.3 | 23.7 | 25.8 | 32.7 | 34.4 | 79.1 | 79.1 | 79.1 | 79.1 | 79.1 | 79.1 | 79.1 | 79.1 | 80.5 | 80.5 | 80.5 | 80.5 |
| | | | Lower % | 0.0 | 0.0 | 1.1 | 20.8 | 22.1 | 24.0 | 29.5 | 31.0 | 71.2 | 71.2 | 71.2 | 71.2 | 71.2 | 71.2 | 71.2 | 71.2 | 72.4 | 72.4 | 72.4 | 72.4 |
| | | | Upper % | 0.0 | 0.0 | 1.3 | 25.7 | 27.3 | 29.7 | 39.3 | 43.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| | | | Stage | -1.0 | -0.5 | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 |
| | | Contents | Mean % | 0.0 | 0.0 | 0.0 | 17.6 | 22.1 | 22.1 | 29.2 | 34.0 | 42.8 | 50.8 | 58.7 | 66.7 | 74.6 | 79.7 | 79.7 | 79.7 | 79.7 | 79.7 | 79.7 | 79.7 |
| | | | Lower % | 0.0 | 0.0 | 0.0 | 16.8 | 21.0 | 21.0 | 27.8 | 32.3 | 40.7 | 48.3 | 55.8 | 63.4 | 70.9 | 75.7 | 75.7 | 75.7 | 75.7 | 75.7 | 75.7 | 75.7 |
| | | | Upper % | 0.0 | 0.0 | 0.0 | 22.0 | 27.7 | 27.7 | 36.6 | 42.5 | 53.6 | 63.5 | 73.4 | 83.4 | 93.3 | 99.6 | 99.6 | 99.6 | 99.6 | 99.6 | 99.6 | 99.6 |

Source: Based on *Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-to-Structure Value Ratios (CSVRs) in Support of the Lower Atchafalaya and Morganza to the Gulf, Louisiana, Feasibility Study Final Report* dated May 1997

Table 14
Non-Federal Levee Fragility Curve
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| | | Stage (ft.) associated w/Probability of Failure | | | | Top of Levee |
|---|---|---|---|---|---|---|
| Reach Name | Station | 0% | 10% | 45% | 95% | (ft.) |
| 1-1AB | 1 | 2.0 | 3.8 | 4.4 | 4.7 | 5.0 |
| 1-1AN | 4 | 2.0 | 3.8 | 4.4 | 4.7 | 5.0 |
| 11BE4 | 16 | 2.0 | 4.5 | 5.3 | 5.6 | 6.0 |
| 11BE5 | 19 | 2.0 | 3.0 | 3.5 | 3.7 | 4.0 |
| 11BE6-W | 25 | 2.0 | 4.5 | 5.3 | 5.6 | 6.0 |
| 11BW11 | 40 | 2.0 | 2.3 | 2.6 | 2.8 | 3.0 |
| 11BW5 | 58 | 2.0 | 4.1 | 4.8 | 5.1 | 5.5 |
| 11BW6 | 61 | 2.0 | 4.1 | 4.8 | 5.1 | 5.5 |
| 11BW79 | 64 | 2.0 | 4.5 | 5.3 | 5.6 | 6.0 |
| 11BW79-W7 | 67 | 2.0 | 4.1 | 4.8 | 5.1 | 5.5 |
| 1-2S | 76 | 2.0 | 3.0 | 3.5 | 3.7 | 4.0 |
| 1-3 | 79 | 2.0 | 4.9 | 5.7 | 6.0 | 6.5 |
| 1-5 | 82 | 2.0 | 2.3 | 2.6 | 2.8 | 3.0 |
| 1-7_N3-4 | 85 | 2.0 | 4.1 | 4.8 | 5.1 | 5.5 |
| 1-7_N4-7 | 88 | 2.0 | 4.1 | 4.8 | 5.1 | 5.5 |
| 1-7_N7-10 | 91 | 2.0 | 4.1 | 4.8 | 5.1 | 5.5 |
| 1-7-N10-13 | 94 | 2.0 | 4.1 | 4.8 | 5.1 | 5.5 |
| 1-7N13-16 | 97 | 2.0 | 4.1 | 4.8 | 5.1 | 5.5 |
| 1-7N16-17 | 100 | 2.0 | 4.1 | 4.8 | 5.1 | 5.5 |
| 1-7N17-24 | 103 | 2.0 | 4.1 | 4.8 | 5.1 | 5.5 |
| 1-7N24-28 | 106 | 2.0 | 4.1 | 4.8 | 5.1 | 5.5 |
| 3-1B | 124 | 2.0 | 7.1 | 8.4 | 8.8 | 9.5 |
| 3-1C | 127 | 2.0 | 4.5 | 5.3 | 5.6 | 6.0 |
| 4-1N | 130 | 2.0 | 3.0 | 3.5 | 3.7 | 4.0 |
| 4-1S | 133 | 2.0 | 5.3 | 6.2 | 6.5 | 7.0 |
| 4-2 | 136 | 2.0 | 3.0 | 3.5 | 3.7 | 4.0 |
| 4-2A | 139 | 2.0 | 4.5 | 5.3 | 5.6 | 6.0 |
| 4-2B | 142 | 2.0 | 4.5 | 5.3 | 5.6 | 6.0 |
| 4-2C | 145 | 2.0 | 4.5 | 5.3 | 5.6 | 6.0 |
| 4-7 | 148 | 2.0 | 4.5 | 5.3 | 5.6 | 6.0 |
| 4MGT | 151 | 2.0 | 4.5 | 5.3 | 5.6 | 6.0 |
| 5-1A | 154 | 2.0 | 4.5 | 5.3 | 5.6 | 6.0 |
| 5-1B | 157 | 2.0 | 4.5 | 5.3 | 5.6 | 6.0 |
| 6-1B1 | 160 | 2.0 | 4.5 | 5.3 | 5.6 | 6.0 |
| 6-1B1-B | 163 | 2.0 | 4.5 | 5.3 | 5.6 | 6.0 |
| 8-1N | 166 | 2.0 | 3.0 | 3.5 | 3.7 | 4.0 |

Table 14 (Cont.)
Non-Federal Levee Fragility Curve
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| | | Stage (ft.) associated w/Probability of Failure | | | | Top of Levee |
|---|---|---|---|---|---|---|
| Reach Name | Station | 0% | 10% | 45% | 95% | (ft.) |
| 8-1N-B | 169.0 | 2.0 | 3.0 | 3.5 | 3.7 | 4.0 |
| 8-1S-B | 175.0 | 2.0 | 3.0 | 3.5 | 3.7 | 4.0 |
| 8-2C | 178.0 | 2.0 | 4.5 | 5.3 | 5.6 | 6.0 |
| 8-2D | 181.0 | 2.0 | 4.5 | 5.3 | 5.6 | 6.0 |
| 9-1AE | 184.0 | 2.0 | 6.0 | 7.0 | 7.4 | 8.0 |
| 9-1AMID | 187.0 | 2.0 | 6.0 | 7.0 | 7.4 | 8.0 |
| 9-1AW | 190.0 | 2.0 | 6.0 | 7.0 | 7.4 | 8.0 |
| 9-1BMIDE | 196.0 | 2.0 | 6.0 | 7.0 | 7.4 | 8.0 |
| 9-1BMIDW | 199.0 | 2.0 | 6.0 | 7.0 | 7.4 | 8.0 |
| 9-1BW | 202.0 | 2.0 | 6.0 | 7.0 | 7.4 | 8.0 |
| BL2 | 280.0 | 2.0 | 4.5 | 5.3 | 5.6 | 6.0 |
| BL3 | 283.0 | 2.0 | 4.5 | 5.3 | 5.6 | 6.0 |
| BL4 | 286.0 | 2.0 | 3.8 | 4.4 | 4.7 | 5.0 |
| BL5 | 289.0 | 2.0 | 3.8 | 4.4 | 4.7 | 5.0 |
| BL6 | 292.0 | 2.0 | 3.8 | 4.4 | 4.7 | 5.0 |
| BL7 | 295.0 | 2.0 | 4.5 | 5.3 | 5.6 | 6.0 |
| BL89 | 298.0 | 2.0 | 3.8 | 4.4 | 4.7 | 5.0 |
| BPC3 | 307.0 | 2.0 | 4.5 | 5.3 | 5.6 | 6.0 |
| BPC4 | 310.0 | 2.0 | 4.5 | 5.3 | 5.6 | 6.0 |
| BT4 | 331.0 | 2.0 | 4.5 | 5.3 | 5.6 | 6.0 |
| BT4-SA | 334.0 | 2.0 | 5.3 | 6.2 | 6.5 | 7.0 |
| D-01 | 367.0 | 2.0 | 7.5 | 8.8 | 9.3 | 10.0 |
| D10 | 373.0 | 2.0 | 4.5 | 5.3 | 5.6 | 6.0 |
| D-16S | 379.0 | 2.0 | 3.0 | 3.5 | 3.7 | 4.0 |
| D-25 | 406.0 | 2.0 | 5.3 | 6.2 | 6.5 | 7.0 |
| D-29 | 418.0 | 2.0 | 4.9 | 5.7 | 6.0 | 6.5 |
| D-30 | 421.0 | 2.0 | 3.0 | 3.5 | 3.7 | 4.0 |
| D-36 | 436.0 | 2.0 | 7.1 | 8.4 | 8.8 | 9.5 |
| D-48 | 466.0 | 2.0 | 3.0 | 3.5 | 3.7 | 4.0 |
| D-53 | 478.0 | 2.0 | 3.8 | 4.4 | 4.7 | 5.0 |
| D-56 | 481.0 | 2.0 | 4.5 | 5.3 | 5.6 | 6.0 |
| D-60 | 484.0 | 2.0 | 4.5 | 5.3 | 5.6 | 6.0 |
| D-61 | 487.0 | 2.0 | 4.5 | 5.3 | 5.6 | 6.0 |
| D-61-B | 490.0 | 2.0 | 4.5 | 5.3 | 5.6 | 6.0 |
| D-62-B | 496.0 | 2.0 | 4.5 | 5.3 | 5.6 | 6.0 |
| D-64 | 499.0 | 2.0 | 3.8 | 4.4 | 4.7 | 5.0 |
| E2-LF | 517.0 | 2.0 | 4.0 | 4.7 | 5.0 | 5.4 |
| E2-LF-B | 520.0 | 2.0 | 4.0 | 4.7 | 5.0 | 5.4 |
| LBC1 | 670.0 | 2.0 | 4.5 | 5.3 | 5.6 | 6.0 |
| LBC2 | 673.0 | 2.0 | 4.5 | 5.3 | 5.6 | 6.0 |
| PAC1 | 709.0 | 2.0 | 7.5 | 8.8 | 9.3 | 10.0 |
| SL3 | 718.0 | 2.0 | 7.5 | 8.8 | 9.3 | 10.0 |

Table 15
Still Water Stage Associated with Federal Levee Failure by Levee Reach
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Federal Levee Reach | Levee Failure Still Water Stage (ft.) | | | | | |
|---|---|---|---|---|---|---|
| | 2024 | | 2035 | | 2085 | |
| | 3% AEP | 1% AEP | 3% AEP | 1% AEP | 3% AEP | 1% AEP |
| A | 9.4 | 13.6 | 10.5 | 15.9 | 11.2 | 18.3 |
| B | 11.1 | 15.5 | 10.8 | 16.5 | 11.5 | 17.7 |
| E | 13.2 | 13.3 | 14.2 | 19.8 | 13.5 | 20.8 |
| F | 13.0 | 13.2 | 13.3 | 20.6 | 13.5 | 20.8 |
| G | 12.9 | 14.5 | 13.1 | 19.5 | 13.6 | 19.6 |
| H | 14.8 | 17.2 | 16.2 | 20.5 | 15.8 | 21.8 |
| I | 14.9 | 18.2 | 15.1 | 20.5 | 15.8 | 21.8 |
| J | 15.3 | 18.5 | 15.5 | 20.9 | 15.8 | 21.8 |
| K | 14.0 | 17.8 | 15.1 | 21.0 | 14.4 | 21.8 |
| L | 14.7 | 17.3 | 15.1 | 20.3 | 14.4 | 21.8 |

Note: The Federal levee heights associated with failure of the 3% AEP do not uniformally rise across the selected years due to the estimated settlement that occurs relative to the levee lift schedule.

Table 16
Expected Annual Damages (1,000's)
Structures, Contents, and Vehicles
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Analysis Year | Unadjusted Without-Project Damages | Percent Increase from 2010 |
|---|---|---|
| 2010 | $ 515,000 | |
| 2024 | $ 591,000 | 15 |
| 2035 | $ 726,000 | 41 |
| 2085 | $ 1,462,000 | 184 |

Note: Without-project damages before adjusting the structure inventories for repetitive flood losses after the year 2010.

Table 17
Number of Structures Receiving Damages By Probability Event in 2035
Residential, Commercial, and Mobile Homes
Unadjusted Without-Project Condition
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Annual Chance Exceedance Event (ACE) | Residential | Non-Residential | Mobile Home | Total |
|---|---|---|---|---|
| 0.99 (1 yr) | 1,114 | 371 | 211 | 1,696 |
| 0.20 (5 yr) | 1,905 | 586 | 400 | 2,891 |
| 0.10 (10 yr) | 5,240 | 1,117 | 1,178 | 7,535 |
| 0.04 (25 yr) | 26,442 | 3,848 | 6,603 | 36,893 |
| 0.02 (50 yr) | 35,072 | 6,054 | 9,185 | 50,311 |
| 0.01 (100 yr) | 41,801 | 7,562 | 11,252 | 60,615 |
| 0.005 (200 yr) | 42,147 | 7,591 | 11,428 | 61,166 |
| 0.002 (500 yr) | 42,356 | 7,594 | 11,437 | 61,387 |

Note: The table reflects the number of structures damaged by ACE event before adjustments were made to the structure inventory for repetitive flooding. In contrast, Table 55 shows the number of structures damaged by ACE event in Table 55 after the adjustments have been made for repetitive flooding. It should be noted that this table uses damages below their first floor elevation as a criteria for being damaged by an ACE event.

Table 18

Number of Structures Receiving 50% or Greater Damages By Probability Event in 2035
Residential and Mobile Homes
Without-Project Condition
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Annual Chance Exceedance (ACE) Event | Residential Structures Receiving Greater Than 50% Damage |
|---|---|
| 0.99 (1 yr) | 95 |
| 0.20 (5 yr) | 341 |
| 0.10 (10 yr) | 1,702 |
| 0.04 (25 yr) | 17,316 |
| 0.02 (50 yr) | 30,830 |
| 0.01 (100 yr) | 34,045 |
| 0.005 (200 yr) | 40,692 |
| 0.002 (500 yr) | 41,460 |

Notes: Calculations do not include performance of non-Federal levees.

Calculations include mobile homes.

Calculations are based on 50% damage to structure value not including damage to contents.

Records containing multiple structures were only counted once.

Table 19
Expected Annual Damages and Benefits (1000's)
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| 2010 | | | | | | |
|---|---|---|---|---|---|---|
| | Expected Annual Damage | | | Probability Damage Reduced Exceeds Indicated Values | | |
| Plan Name | Total Without-Project | Total With-Project | Damages Reduced | 0.75 | 0.50 | 0.25 |
| Without | $ 485,766 | $ - | $ - | $ - | $ - | $ - |
| **2024** | | | | | | |
| | Expected Annual Damage | | | Probability Damage Reduced Exceeds Indicated Values | | |
| Plan Name | Total Without-Project | Total With-Project | Damages Reduced | 0.75 | 0.50 | 0.25 |
| Without | $ 538,070 | $ 538,070 | $ - | $ - | $ - | $ - |
| Alt 3% | $ 538,070 | $ 299,936 | $ 238,134 | $ 229,960 | $ 304,649 | $ 386,288 |
| Alt 1% | $ 538,070 | $ 158,762 | $ 379,308 | $ 339,305 | $ 531,108 | $ 709,097 |
| **2035** | | | | | | |
| | Expected Annual Damage | | | Probability Damage Reduced Exceeds Indicated Values | | |
| Plan Name | Total Without-Project | Total With-Project | Damages Reduced | 0.75 | 0.50 | 0.25 |
| Without | $ 642,259 | $ 642,259 | $ - | $ - | $ - | $ - |
| Alt 3% | $ 642,259 | $ 334,582 | $ 307,677 | $ 229,960 | $ 304,649 | $ 386,288 |
| Alt 1% | $ 642,259 | $ 111,291 | $ 530,968 | $ 339,305 | $ 531,108 | $ 709,097 |
| **2085** | | | | | | |
| | Expected Annual Damage | | | Probability Damage Reduced Exceeds Indicated Values | | |
| Plan Name | Total Without-Project | Total With-Project | Damages Reduced | 0.75 | 0.50 | 0.25 |
| Without | $ 1,156,553 | $ 1,156,553 | $ - | $ - | $ - | $ - |
| Alt 3% | $ 1,156,553 | $ 553,116 | $ 603,437 | $ 464,706 | $ 606,124 | $ 743,005 |
| Alt 1% | $ 1,156,553 | $ 146,304 | $ 1,010,249 | $ 687,360 | $ 1,003,295 | $ 1,317,193 |

Note : Damage values based on HEC-FDA model executions for structures, their contents, and vehicles only.

Table 20
3% AEP Calculation of Equivalent Annual Damages and Benefits (1000's)
Base Year 2035
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Year | Years from Base Year | PV Factor | Expected Annual Without-Project Damages | Expected Annual With Project Damages | Present Value (PV) Expected Annual Damages/Benefits: Expected Annual Without- Project Damages | Expected Annual With-Project Damages | Expected Annual Benefits |
|---|---|---|---|---|---|---|---|
| 2010-12 | -22 | 2.370 | $ 485,766 | - | - | - | |
| 2013 | -21 | 2.279 | - | - | - | - | |
| 2014 | -20 | 2.191 | - | - | - | - | |
| 2015 | -19 | 2.107 | - | - | - | - | |
| 2016 | -18 | 2.026 | - | - | - | - | |
| 2017 | -17 | 1.948 | - | - | - | - | |
| 2018 | -16 | 1.873 | - | - | - | - | |
| 2019 | -15 | 1.801 | - | - | - | - | |
| 2020 | -14 | 1.732 | - | - | - | - | |
| 2021 | -13 | 1.665 | - | - | - | - | |
| 2022 | -12 | 1.601 | - | - | - | - | |
| 2023 | -11 | 1.539 | - | - | - | - | |
| 2024 | -10 | 1.480 | $ 538,070 | $ 299,936 | $ 777,535 | $ 433,420 | $ 344,115 |
| 2025 | -9 | 1.423 | $ 547,542 | $ 309,407 | $ 762,624 | $ 430,947 | $ 331,677 |
| 2026 | -8 | 1.369 | $ 557,014 | $ 249,336 | $ 747,774 | $ 334,727 | $ 413,048 |
| 2027 | -7 | 1.316 | $ 566,485 | $ 258,808 | $ 733,002 | $ 334,884 | $ 398,118 |
| 2028 | -6 | 1.265 | $ 575,957 | $ 268,280 | $ 718,321 | $ 334,593 | $ 383,729 |
| 2029 | -5 | 1.217 | $ 585,429 | $ 277,751 | $ 703,744 | $ 333,885 | $ 369,859 |
| 2030 | -4 | 1.170 | $ 594,900 | $ 287,223 | $ 689,282 | $ 332,791 | $ 356,490 |
| 2031 | -3 | 1.125 | $ 604,372 | $ 296,695 | $ 674,945 | $ 331,340 | $ 343,605 |
| 2032 | -2 | 1.082 | $ 613,844 | $ 306,166 | $ 660,745 | $ 329,559 | $ 331,186 |
| 2033 | -1 | 1.040 | $ 623,315 | $ 315,638 | $ 646,690 | $ 327,475 | $ 319,215 |
| 2034 | 0 | 1.000 | $ 632,787 | $ 325,110 | $ 632,787 | $ 325,110 | $ 307,677 |
| 2035 | 1 | 0.962 | $ 642,259 | $ 334,582 | $ 619,045 | $ 322,488 | $ 296,556 |
| 2036 | 2 | 0.925 | $ 652,545 | $ 338,952 | $ 606,225 | $ 314,892 | $ 291,333 |
| 2037 | 3 | 0.889 | $ 662,831 | $ 343,323 | $ 593,524 | $ 307,424 | $ 286,099 |
| 2038 | 4 | 0.855 | $ 673,116 | $ 347,694 | $ 580,949 | $ 300,085 | $ 280,864 |
| 2039 | 5 | 0.822 | $ 683,402 | $ 352,064 | $ 568,507 | $ 292,874 | $ 275,633 |
| 2040 | 6 | 0.790 | $ 693,688 | $ 356,435 | $ 556,206 | $ 285,793 | $ 270,413 |
| 2041 | 7 | 0.760 | $ 703,974 | $ 360,806 | $ 544,051 | $ 278,841 | $ 265,211 |
| 2042 | 8 | 0.731 | $ 714,260 | $ 365,176 | $ 532,049 | $ 272,018 | $ 260,031 |
| 2043 | 9 | 0.703 | $ 724,546 | $ 369,547 | $ 520,203 | $ 265,324 | $ 254,879 |
| 2044 | 10 | 0.676 | $ 734,832 | $ 373,918 | $ 508,519 | $ 258,759 | $ 249,760 |
| 2045 | 11 | 0.650 | $ 745,118 | $ 378,288 | $ 496,999 | $ 252,321 | $ 244,678 |
| 2046 | 12 | 0.625 | $ 755,404 | $ 382,659 | $ 485,648 | $ 246,011 | $ 239,637 |
| 2047 | 13 | 0.601 | $ 765,690 | $ 387,030 | $ 474,468 | $ 239,827 | $ 234,641 |
| 2048 | 14 | 0.577 | $ 775,975 | $ 391,400 | $ 463,462 | $ 233,769 | $ 229,693 |
| 2049 | 15 | 0.555 | $ 786,261 | $ 395,771 | $ 452,632 | $ 227,836 | $ 224,796 |
| 2050 | 16 | 0.534 | $ 796,547 | $ 400,142 | $ 441,979 | $ 222,026 | $ 219,953 |
| 2051 | 17 | 0.513 | $ 806,833 | $ 404,512 | $ 431,505 | $ 216,339 | $ 215,166 |
| 2052 | 18 | 0.494 | $ 817,119 | $ 408,883 | $ 421,211 | $ 210,772 | $ 210,439 |

Table 20 (Cont.)
3% AEP Calculation of Equivalent Annual Damages and Benefits (1000's)
Base Year 2035
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Year | Years from Base Year | PV Factor | Expected Annual Without-Project Damages | Expected Annual With Project Damages | Present Value (PV) Expected Annual Damages/Benefits: Expected Annual Without-Project Damages | Present Value (PV) Expected Annual Damages/Benefits: Expected Annual With-Project Damages | Present Value (PV) Expected Annual Damages/Benefits: Expected Annual Benefits |
|---|---|---|---|---|---|---|---|
| 2053 | 19 | 0.475 | $ 827,405 | $ 413,254 | $ 411,097 | $ 205,325 | $ 205,771 |
| 2054 | 20 | 0.456 | $ 837,691 | $ 417,625 | $ 401,164 | $ 199,997 | $ 201,167 |
| 2055 | 21 | 0.439 | $ 847,977 | $ 421,995 | $ 391,412 | $ 194,786 | $ 196,626 |
| 2056 | 22 | 0.422 | $ 858,263 | $ 426,366 | $ 381,840 | $ 189,690 | $ 192,150 |
| 2057 | 23 | 0.406 | $ 868,548 | $ 430,737 | $ 372,450 | $ 184,708 | $ 187,742 |
| 2058 | 24 | 0.390 | $ 878,834 | $ 435,107 | $ 363,239 | $ 179,838 | $ 183,401 |
| 2059 | 25 | 0.375 | $ 889,120 | $ 439,478 | $ 354,208 | $ 175,079 | $ 179,128 |
| 2060 | 26 | 0.361 | $ 899,406 | $ 443,849 | $ 345,354 | $ 170,429 | $ 174,925 |
| 2061 | 27 | 0.347 | $ 909,692 | $ 448,219 | $ 336,679 | $ 165,887 | $ 170,792 |
| 2062 | 28 | 0.333 | $ 919,978 | $ 452,590 | $ 328,179 | $ 161,450 | $ 166,729 |
| 2063 | 29 | 0.321 | $ 930,264 | $ 456,961 | $ 319,853 | $ 157,117 | $ 162,736 |
| 2064 | 30 | 0.308 | $ 940,550 | $ 461,331 | $ 311,701 | $ 152,887 | $ 158,815 |
| 2065 | 31 | 0.296 | $ 950,836 | $ 465,702 | $ 303,721 | $ 148,757 | $ 154,964 |
| 2066 | 32 | 0.285 | $ 961,121 | $ 470,073 | $ 295,909 | $ 144,726 | $ 151,184 |
| 2067 | 33 | 0.274 | $ 971,407 | $ 474,443 | $ 288,266 | $ 140,792 | $ 147,475 |
| 2068 | 34 | 0.264 | $ 981,693 | $ 478,814 | $ 280,789 | $ 136,953 | $ 143,836 |
| 2069 | 35 | 0.253 | $ 991,979 | $ 483,185 | $ 273,476 | $ 133,208 | $ 140,268 |
| 2070 | 36 | 0.244 | $ 1,002,265 | $ 487,555 | $ 266,324 | $ 129,554 | $ 136,770 |
| 2071 | 37 | 0.234 | $ 1,012,551 | $ 491,926 | $ 259,333 | $ 125,991 | $ 133,341 |
| 2072 | 38 | 0.225 | $ 1,022,837 | $ 496,297 | $ 252,498 | $ 122,516 | $ 129,982 |
| 2073 | 39 | 0.217 | $ 1,033,123 | $ 500,668 | $ 245,819 | $ 119,128 | $ 126,691 |
| 2074 | 40 | 0.208 | $ 1,043,409 | $ 505,038 | $ 239,293 | $ 115,824 | $ 123,469 |
| 2075 | 41 | 0.200 | $ 1,053,694 | $ 509,409 | $ 232,918 | $ 112,604 | $ 120,314 |
| 2076 | 42 | 0.193 | $ 1,063,980 | $ 513,780 | $ 226,690 | $ 109,465 | $ 117,225 |
| 2077 | 43 | 0.185 | $ 1,074,266 | $ 518,150 | $ 220,609 | $ 106,406 | $ 114,203 |
| 2078 | 44 | 0.178 | $ 1,084,552 | $ 522,521 | $ 214,671 | $ 103,425 | $ 111,246 |
| 2079 | 45 | 0.171 | $ 1,094,838 | $ 526,892 | $ 208,874 | $ 100,521 | $ 108,353 |
| 2080 | 46 | 0.165 | $ 1,105,124 | $ 531,262 | $ 203,216 | $ 97,691 | $ 105,525 |
| 2081 | 47 | 0.158 | $ 1,115,410 | $ 535,633 | $ 197,694 | $ 94,935 | $ 102,759 |
| 2082 | 48 | 0.152 | $ 1,125,696 | $ 540,004 | $ 192,306 | $ 92,250 | $ 100,055 |
| 2083 | 49 | 0.146 | $ 1,135,982 | $ 544,374 | $ 187,048 | $ 89,636 | $ 97,413 |
| 2084 | 50 | 0.141 | $ 1,146,267 | $ 548,745 | $ 181,920 | $ 87,089 | $ 94,831 |
| | | | | | | | |
| | | | | | W/O | With | Benefit |
| | | | | Amortization Factor | 0.04457 | 0.04457 | 0.04457 |
| | | | | Equivalent Annual (2024-2084) | 1,164,866 | 581,462 | 583,405 |
| | | | | Equivalent Annual (2035-2084) | 819,530 | 409,908 | 409,622 |
| | | | | Equivalent Annual (2024-2034) | 345,336 | 171,554 | 173,782 |

Note: Present value and amortization factors are based on the fiscal year 2012 Federal discount rate of 3.75 percent.

| | 3 % AEP |
|---|---|
| Partial Performance begins in: | 2024 |
| Full Performance begins in: | 2035 |
| Base Year | 2035 |

Table 21
1% AEP Calculation of Equivalent Annual Damages and Benefits (1000's)
Base Year 2035
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Year | Years from Base Year | PV Factor | Expected Annual Without- Project Damages | Expected Annual With-Project Damages | Present Value (PV) Expected Annual Damages/Benefits: Expected Annual Without-Project Damages | Present Value (PV) Expected Annual Damages/Benefits: Expected Annual With-Project Damages | Present Value (PV) Expected Annual Damages/Benefits: Expected Annual Benefits |
|---|---|---|---|---|---|---|---|
| 2010-12 | -22 | 2.370 | $ 485,766 | - | - | - | - |
| 2013 | -21 | 2.279 | - | - | - | - | - |
| 2014 | -20 | 2.191 | - | - | - | - | - |
| 2015 | -19 | 2.107 | - | - | - | - | - |
| 2016 | -18 | 2.026 | - | - | - | - | - |
| 2017 | -17 | 1.948 | - | - | - | - | - |
| 2018 | -16 | 1.873 | - | - | - | - | - |
| 2019 | -15 | 1.801 | - | - | - | - | - |
| 2020 | -14 | 1.732 | - | - | - | - | - |
| 2021 | -13 | 1.665 | - | - | - | - | - |
| 2022 | -12 | 1.601 | - | - | - | - | - |
| 2023 | -11 | 1.539 | - | - | - | - | - |
| 2024 | -10 | 1.480 | $ 538,070 | $ 145,647 | $ 777,535 | $ 229,418 | $ 548,117 |
| 2025 | -9 | 1.423 | $ 547,542 | $ 154,162 | $ 762,624 | $ 234,318 | $ 528,306 |
| 2026 | -8 | 1.369 | $ 557,014 | $ 162,676 | $ 747,774 | $ 238,564 | $ 509,211 |
| 2027 | -7 | 1.316 | $ 566,485 | $ 171,191 | $ 733,002 | $ 242,197 | $ 490,805 |
| 2028 | -6 | 1.265 | $ 575,957 | $ 179,706 | $ 718,321 | $ 245,256 | $ 473,065 |
| 2029 | -5 | 1.217 | $ 585,429 | $ 188,221 | $ 703,744 | $ 247,777 | $ 455,967 |
| 2030 | -4 | 1.170 | $ 594,900 | $ 196,735 | $ 689,282 | $ 249,796 | $ 439,486 |
| 2031 | -3 | 1.125 | $ 604,372 | $ 205,250 | $ 674,945 | $ 251,345 | $ 423,601 |
| 2032 | -2 | 1.082 | $ 613,844 | $ 213,765 | $ 660,745 | $ 252,455 | $ 408,290 |
| 2033 | -1 | 1.040 | $ 623,315 | $ 222,279 | $ 646,690 | $ 253,157 | $ 393,533 |
| 2034 | 0 | 1.000 | $ 632,787 | $ 230,794 | $ 632,787 | $ 253,479 | $ 379,308 |
| 2035 | 1 | 0.962 | $ 642,259 | $ 102,896 | $ 619,045 | $ 107,269 | $ 511,776 |
| 2036 | 2 | 0.925 | $ 652,545 | $ 103,534 | $ 606,225 | $ 104,042 | $ 502,183 |
| 2037 | 3 | 0.889 | $ 662,831 | $ 104,172 | $ 593,524 | $ 100,908 | $ 492,615 |
| 2038 | 4 | 0.855 | $ 673,116 | $ 104,810 | $ 580,949 | $ 97,866 | $ 483,083 |
| 2039 | 5 | 0.822 | $ 683,402 | $ 105,447 | $ 568,507 | $ 94,911 | $ 473,596 |
| 2040 | 6 | 0.790 | $ 693,688 | $ 106,085 | $ 556,206 | $ 92,042 | $ 464,164 |
| 2041 | 7 | 0.760 | $ 703,974 | $ 106,723 | $ 544,051 | $ 89,256 | $ 454,795 |
| 2042 | 8 | 0.731 | $ 714,260 | $ 107,361 | $ 532,049 | $ 86,552 | $ 445,497 |
| 2043 | 9 | 0.703 | $ 724,546 | $ 107,998 | $ 520,203 | $ 83,926 | $ 436,277 |
| 2044 | 10 | 0.676 | $ 734,832 | $ 108,636 | $ 508,519 | $ 81,377 | $ 427,142 |
| 2045 | 11 | 0.650 | $ 745,118 | $ 109,274 | $ 496,999 | $ 78,903 | $ 418,096 |
| 2046 | 12 | 0.625 | $ 755,404 | $ 109,912 | $ 485,648 | $ 76,501 | $ 409,147 |
| 2047 | 13 | 0.601 | $ 765,690 | $ 110,550 | $ 474,468 | $ 74,170 | $ 400,298 |
| 2048 | 14 | 0.577 | $ 775,975 | $ 111,187 | $ 463,462 | $ 71,907 | $ 391,555 |
| 2049 | 15 | 0.555 | $ 786,261 | $ 111,825 | $ 452,632 | $ 69,711 | $ 382,921 |
| 2050 | 16 | 0.534 | $ 796,547 | $ 112,463 | $ 441,979 | $ 67,580 | $ 374,399 |
| 2051 | 17 | 0.513 | $ 806,833 | $ 113,101 | $ 431,505 | $ 65,512 | $ 365,993 |
| 2052 | 18 | 0.494 | $ 817,119 | $ 113,738 | $ 421,211 | $ 63,505 | $ 357,705 |
| 2053 | 19 | 0.475 | $ 827,405 | $ 114,376 | $ 411,097 | $ 61,558 | $ 349,539 |
| 2054 | 20 | 0.456 | $ 837,691 | $ 115,014 | $ 401,164 | $ 59,668 | $ 341,496 |
| 2055 | 21 | 0.439 | $ 847,977 | $ 115,652 | $ 391,412 | $ 57,835 | $ 333,577 |
| 2056 | 22 | 0.422 | $ 858,263 | $ 116,290 | $ 381,840 | $ 56,056 | $ 325,785 |
| 2057 | 23 | 0.406 | $ 868,548 | $ 116,927 | $ 372,450 | $ 54,330 | $ 318,120 |
| 2058 | 24 | 0.390 | $ 878,834 | $ 117,565 | $ 363,239 | $ 52,656 | $ 310,583 |
| 2059 | 25 | 0.375 | $ 889,120 | $ 118,203 | $ 354,208 | $ 51,031 | $ 303,176 |
| 2060 | 26 | 0.361 | $ 899,406 | $ 118,841 | $ 345,354 | $ 49,456 | $ 295,899 |
| 2061 | 27 | 0.347 | $ 909,692 | $ 119,478 | $ 336,679 | $ 47,927 | $ 288,751 |
| 2062 | 28 | 0.333 | $ 919,978 | $ 120,116 | $ 328,179 | $ 46,445 | $ 281,734 |
| 2063 | 29 | 0.321 | $ 930,264 | $ 120,754 | $ 319,853 | $ 45,007 | $ 274,846 |

Table 21 (Cont.)
1% AEP Calculation of Equivalent Annual Damages and Benefits (1000's)
Base Year 2035
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Year | Years from Base Year | PV Factor | Expected Annual Without- Project Damages | Expected Annual With-Project Damages | Present Value (PV) Expected Annual Damages/Benefits: Expected Annual Without-Project Damages | Expected Annual With-Project Damages | Expected Annual Benefits |
|---|---|---|---|---|---|---|---|
| 2064 | 30 | 0.308 | $ 940,550 | $ 131,599 | $ 311,701 | $ 43,612 | $ 268,089 |
| 2065 | 31 | 0.296 | $ 950,836 | $ 132,299 | $ 303,721 | $ 42,260 | $ 261,461 |
| 2066 | 32 | 0.285 | $ 961,121 | $ 132,999 | $ 295,909 | $ 40,948 | $ 254,962 |
| 2067 | 33 | 0.274 | $ 971,407 | $ 133,700 | $ 288,266 | $ 39,676 | $ 248,591 |
| 2068 | 34 | 0.264 | $ 981,693 | $ 134,400 | $ 280,789 | $ 38,442 | $ 242,347 |
| 2069 | 35 | 0.253 | $ 991,979 | $ 135,100 | $ 273,476 | $ 37,245 | $ 236,230 |
| 2070 | 36 | 0.244 | $ 1,002,265 | $ 135,800 | $ 266,324 | $ 36,085 | $ 230,239 |
| 2071 | 37 | 0.234 | $ 1,012,551 | $ 136,501 | $ 259,333 | $ 34,960 | $ 224,372 |
| 2072 | 38 | 0.225 | $ 1,022,837 | $ 137,201 | $ 252,498 | $ 33,870 | $ 218,629 |
| 2073 | 39 | 0.217 | $ 1,033,123 | $ 137,901 | $ 245,819 | $ 32,812 | $ 213,007 |
| 2074 | 40 | 0.208 | $ 1,043,409 | $ 138,601 | $ 239,293 | $ 31,787 | $ 207,507 |
| 2075 | 41 | 0.200 | $ 1,053,694 | $ 139,302 | $ 232,918 | $ 30,792 | $ 202,125 |
| 2076 | 42 | 0.193 | $ 1,063,980 | $ 140,002 | $ 226,690 | $ 29,829 | $ 196,862 |
| 2077 | 43 | 0.185 | $ 1,074,266 | $ 140,702 | $ 220,609 | $ 28,894 | $ 191,715 |
| 2078 | 44 | 0.178 | $ 1,084,552 | $ 141,403 | $ 214,671 | $ 27,989 | $ 186,683 |
| 2079 | 45 | 0.171 | $ 1,094,838 | $ 142,103 | $ 208,874 | $ 27,111 | $ 181,764 |
| 2080 | 46 | 0.165 | $ 1,105,124 | $ 142,803 | $ 203,216 | $ 26,259 | $ 176,957 |
| 2081 | 47 | 0.158 | $ 1,115,410 | $ 143,503 | $ 197,694 | $ 25,434 | $ 172,260 |
| 2082 | 48 | 0.152 | $ 1,125,696 | $ 144,204 | $ 192,306 | $ 24,635 | $ 167,671 |
| 2083 | 49 | 0.146 | $ 1,135,982 | $ 144,904 | $ 187,048 | $ 23,860 | $ 163,189 |
| 2084 | 50 | 0.141 | $ 1,146,267 | $ 145,604 | $ 181,920 | $ 23,108 | $ 158,812 |
| | | | | | | | |

| | W/O | With | Benefit |
|---|---|---|---|
| Amortization Factor | 0.04457 | 0.04457 | 0.04457 |
| Equivalent Annual (2024-2084) | 1,064,961 | 223,725 | 841,236 |
| Equivalent Annual (2035-2084) | 747,898 | 113,888 | 634,010 |
| Equivalent Annual (2024-2034) | 317,063 | 109,837 | 207,226 |

Note: Present value and amortization factors are based on the fiscal year 2012 Federal discount rate of 3.75 percen

| | 1% AEP |
|---|---|
| Partial Performance begins in: | 2024 |
| Full Performance begins in: | 2035 |
| Base Year | 2035 |

Table 22
Equivalent Annual Damages and Benefits to Residential and Non-Residential Categories (1000's)
(2024-2085)
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| | Equivalent Annual Damage | | | Probability Damage Reduced Exceeds Indicated Values | | |
|---|---|---|---|---|---|---|
| Plan Name | Without Project | With Project | Damages Reduced | 0.75 | 0.50 | 0.25 |
| Alt 3% | $ 1,064,961 | $ 540,054 | $ 524,907 | $ 183,350 | $ 503,018 | $ 653,719 |
| Alt 1% | $ 1,064,961 | $ 223,725 | $ 841,236 | $ 563,796 | $ 886,158 | $ 1,171,757 |

Note: Expected annual damages for structures, their contents, and vehicles were calculated for the years 2024, 2035, and 2085 and converted to equivalent annual values.

Table 23

Equivalent Annual Damages and Benefits for Industrial Properties Category (1000's)

(2024-2085)

Morganza to the Gulf of Mexico, LA

Post-Authorization Change Report

| | Equivalent Annual Damage | | | Probability Damage Reduced Exceeds Indicated Values | | |
|---|---|---|---|---|---|---|
| Plan Name | Without-Project | With Project | Damages Reduced | 0.75 | 0.50 | 0.25 |
| Alt 3% | $ 24,252 | $ 9,566 | $ 14,686 | $ 6,315 | $ 15,670 | $ 20,406 |
| Alt 1% | $ 24,252 | $ 3,695 | $ 20,557 | $ 14,322 | $ 21,939 | $ 28,564 |

Note: Expected annual damages for industrial properties for the years 2024, 2035, and 2085, were converted to equivalent annual values.

Table 24
Number of Structures Elevated by Analysis Year
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Analysis Year | Residential | Non-Residential |
|---|---|---|
| 2024 | 707 | 66 |
| 2035 | 417 | 47 |
| 2085 | 1,789 | 66 |
| Total | 2,913 | 179 |

Table 25
Structure-Raising Costs
(Dollars per Square Foot in 2011 price level)
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Ft. Raised | 1-Sty Slab | 2-Sty Slab | 1-Sty Pier | 2-Sty Pier | Mobile Home |
|---|---|---|---|---|---|
| 1.0 | 74.52 | 82.62 | 65.88 | 72.90 | 36.72 |
| 2.0 | 74.52 | 82.62 | 65.88 | 72.90 | 36.72 |
| 3.0 | 76.14 | 84.24 | 68.58 | 75.60 | 36.72 |
| 4.0 | 78.84 | 89.64 | 68.58 | 75.60 | 36.72 |
| 5.0 | 78.84 | 89.64 | 68.58 | 75.60 | 44.82 |
| 6.0 | 80.46 | 91.26 | 70.20 | 77.22 | 44.82 |
| 7.0 | 80.46 | 91.26 | 70.20 | 77.22 | 44.82 |
| 8.0 | 83.16 | 93.96 | 71.82 | 78.84 | 44.82 |
| 9.0 | 83.16 | 93.96 | 71.82 | 78.84 | 44.82 |
| 10.0 | 83.16 | 93.96 | 71.82 | 78.84 | 44.82 |
| 11.0 | 83.16 | 93.96 | 71.82 | 78.84 | 44.82 |
| 12.0 | 83.16 | 93.96 | 71.82 | 78.84 | 44.82 |
| 13.0 | 85.86 | 99.36 | 73.44 | 80.46 | 44.82 |

Source: Based on interviews with three major shoring companies in the Metropolitan New Orleans area
Note: Temporary Relocation costs equal to $3,750 were also applied to the elevated structures.

Table 26
Structure-Raising Costs Avoided
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Time Period | Total No. of Structures | Average No. of Feet Raised | Total Cost (in Millions) | Average Cost (in Thousands) |
|---|---|---|---|---|
| 2010 to 2024 | 773 | 11 | $ 108 | $ 140 |
| 2025 to 2035 | 464 | 12 | $ 95 | $ 205 |
| 2036 to 2085 | 1855 | 11 | $ 238 | $ 128 |

Table 27
Depth-Damage Relationships for Debris Removal and Cleanup Cost
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Occupancy Type | Parameter | Stage in Feet | | | | |
|---|---|---|---|---|---|---|
| 1STY-PIER | Stage | 0.0 | 1.9 | 2.0 | 5.0 | 12.0 |
| | Percentage of Structure Damage | $ - | $ - | $ 4,957 | $ 5,354 | $ 5,828 |
| | Standard Deviation | $ - | $ - | $ 817 | $ 831 | $ 854 |
| 1STY-SLAB | Stage | 0.0 | 1.9 | 2.0 | 5.0 | 12.0 |
| | Percentage of Structure Damage | $ - | $ - | $ 4,956 | $ 5,353 | $ 5,748 |
| | Standard Deviation | $ - | $ - | $ 816 | $ 830 | $ 840 |
| 2STY-PIER | Stage | 0.0 | 1.9 | 2.0 | 5.0 | 12.0 |
| | Percentage of Structure Damage | $ - | $ - | $ 4,957 | $ 5,353 | $ 5,828 |
| | Standard Deviation | $ - | $ - | $ 817 | $ 830 | $ 851 |
| 2STY-SLAB | Stage | 0.0 | 1.9 | 2.0 | 5.0 | 12.0 |
| | Percentage of Structure Damage | $ - | $ - | $ 6,262 | $ 6,870 | $ 7,610 |
| | Standard Deviation | $ - | $ - | $ 855 | $ 881 | $ 916 |
| EAT | Stage | 0.0 | 1.9 | 2.0 | 5.0 | 12.0 |
| | Percentage of Structure Damage | $ - | $ - | $ 33,060 | $ 33,645 | $ 34,451 |
| | Standard Deviation | $ - | $ - | $ 7,740 | $ 7,744 | $ 7,748 |
| GROC | Stage | 0.0 | 1.9 | 2.0 | 5.0 | 12.0 |
| | Percentage of Structure Damage | $ - | $ - | $ 34,736 | $ 35,483 | $ 36,481 |
| | Standard Deviation | $ - | $ - | $ 7,757 | $ 7,756 | $ 7,766 |
| MOBHOM | Stage | 0.0 | 1.9 | 2.0 | 5.0 | 12.0 |
| | Percentage of Structure Damage | $ - | $ - | $ 4,822 | $ 5,252 | $ 5,860 |
| | Standard Deviation | $ - | $ - | $ 814 | $ 823 | $ 860 |
| MULT | Stage | 0.0 | 1.9 | 2.0 | 5.0 | 12.0 |
| | Percentage of Structure Damage | $ - | $ - | $ 7,955 | $ 8,581 | $ 10,277 |
| | Standard Deviation | $ - | $ - | $ 685 | $ 738 | $ 997 |
| PROF | Stage | 0.0 | 1.9 | 2.0 | 5.0 | 12.0 |
| | Percentage of Structure Damage | $ - | $ - | $ 33,799 | $ 34,294 | $ 35,643 |
| | Standard Deviation | $ - | $ - | $ 7,742 | $ 7,745 | $ 7,762 |
| PUBL | Stage | 0.0 | 1.9 | 2.0 | 5.0 | 12.0 |
| | Percentage of Structure Damage | $ - | $ - | $ 33,799 | $ 34,294 | $ 35,643 |
| | Standard Deviation | $ - | $ - | $ 7,742 | $ 7,746 | $ 7,763 |
| REPA | Stage | 0.0 | 1.9 | 2.0 | 5.0 | 12.0 |
| | Percentage of Structure Damage | $ - | $ - | $ 35,141 | $ 35,889 | $ 36,886 |
| | Standard Deviation | $ - | $ - | $ 7,757 | $ 7,758 | $ 7,768 |
| RETA | Stage | 0.0 | 1.9 | 2.0 | 5.0 | 12.0 |
| | Percentage of Structure Damage | $ - | $ - | $ 33,585 | $ 34,080 | $ 35,429 |
| | Standard Deviation | $ - | $ - | $ 7,741 | $ 7,745 | $ 7,762 |
| WARE | Stage | 0.0 | 1.9 | 2.0 | 5.0 | 12.0 |
| | Percentage of Structure Damage | $ - | $ - | $ 48,057 | $ 54,939 | $ 63,208 |
| | Standard Deviation | $ - | $ - | $ 8,283 | $ 8,541 | $ 8,929 |

Source: Based on *Development of Depth-Emergency Costs and Infrastructure Damage Relationships for Selected South Louisiana Parishes Final Report dated March 2012*

Table 28
Equivalent Annual Damages and Benefits for Debris Category (1000's)
(2024-2085)
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| | Equivalent Annual Damage | | | Probability Damage Reduced Exceeds Indicated Values | | |
|---|---|---|---|---|---|---|
| Plan Name | Without-Project | With-Project | Damages Reduced | 0.75 | 0.50 | 0.25 |
| Alt 3% | $ 36,905 | $ 17,908 | $ 18,997 | $ 14,108 | $ 18,460 | $ 23,377 |
| Alt 1% | $ 36,905 | $ 7,878 | $ 29,027 | $ 19,960 | $ 30,217 | $ 39,392 |

Note: Expected annual damages for the years 2024, 2035, and 2085 were converted to equivalent annual values.

Table 29
Depth-Damage Relationships for Major & Secondary Highways and Streets
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Occupancy Type | Parameter | Stage in Feet | | | | |
|---|---|---|---|---|---|---|
| STREETS | Stage | 0.0 | 1.9 | 2.0 | 5.0 | 12.0 |
| | Percentage of Structure Damage | $ - | $ - | $ 88,262 | $ 162,965 | $ 246,059 |
| | Standard Deviation | $ - | $ - | $ 22,441 | $ 27,017 | $ 37,795 |
| HIGHWAY | Stage | 0.0 | 1.9 | 2.0 | 5.0 | 12.0 |
| | Percentage of Structure Damage | $ - | $ - | $ 158,070 | $ 483,837 | $ 669,393 |

Source: Based on *Development of Depth-Emergency Costs and Infrastructure Damage Relationships for Selected South Louisiana Parishes Final Report dated March 2012*

Table 30
Equivalent Annual Damages and Benefits for Major & Secondary Highways and Streets (1000's)
(2024-2085)
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| | Equivalent Annual Damage | | | Probability Damage Reduced Exceeds Indicated Values | | |
|---|---|---|---|---|---|---|
| Plan Name | Without-Project | With-Project | Damages Reduced | 0.75 | 0.50 | 0.25 |
| Alt 3% | $ 31,476 | $ 14,326 | $ 17,151 | $ 10,291 | $ 15,779 | $ 19,895 |
| Alt 1% | $ 31,476 | $ 8,088 | $ 23,389 | $ 14,570 | $ 21,645 | $ 27,838 |

Note: Expected annual damages for the years 2024, 2035, and 2085 were converted to equivalent annual values.

Table 31
Average Annual Agricultural Acres Impacted
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Study Area Reaches | | 2010 | 2035 | | | | | 2085 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Without-Project | Without-Project | With 35 Yr | With 100 Yr | Benefits 35 Yr | Benefits 100 Yr | Without-Project | With 35 Yr | With 100 Yr | Benefits 35 Yr | Benefits 100 Yr |
| | | Acres | Acres | Acres | Acres | Acres | Acres | Acres | Acres | Acres | Acres | Acres |
| 1 | 1-5 | 77 | 138 | 5 | 0 | 133 | 138 | 317 | 10 | 2 | 307 | 314 |
| 2 | 2-1A2 | 19 | 23 | 10 | 1 | 13 | 22 | 23 | 10 | 1 | 13 | 22 |
| 3 | 2-1B2N | 53 | 61 | 30 | 4 | 31 | 57 | 68 | 31 | 4 | 38 | 65 |
| 4 | 4-7 | 11 | 17 | 1 | 0 | 16 | 17 | 47 | 1 | 0 | 46 | 47 |
| 5 | 9-1AE | 10 | 10 | 10 | 10 | 0 | 0 | 20 | 20 | 20 | 0 | 0 |
| 6 | 9-1AMID | 18 | 18 | 18 | 18 | 0 | 0 | 36 | 36 | 36 | 0 | 0 |
| 7 | 9-1AW | 9 | 9 | 9 | 9 | 0 | 0 | 18 | 18 | 18 | 0 | 0 |
| 8 | 9-1BE | 2 | 2 | 0 | 0 | 2 | 2 | 3 | 0 | 0 | 3 | 3 |
| 9 | 9-1BMIDE | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| 10 | 9-1BMIDW | 3 | 3 | 3 | 3 | 0 | 0 | 5 | 5 | 5 | 0 | 0 |
| 11 | 9-1BW | 10 | 11 | 11 | 11 | 0 | 0 | 21 | 21 | 21 | 0 | 0 |
| 12 | BL5 | 13 | 15 | 8 | 1 | 8 | 14 | 35 | 8 | 1 | 27 | 34 |
| 13 | BL6 | 1 | 2 | 0 | 0 | 2 | 2 | 6 | 1 | 0 | 5 | 6 |
| 14 | BL7 | 7 | 9 | 2 | 0 | 7 | 9 | 46 | 3 | 0 | 43 | 46 |
| 15 | BL89 | 14 | 22 | 4 | 1 | 18 | 21 | 75 | 8 | 1 | 67 | 74 |
| 16 | C1-LF | 27 | 27 | 12 | 1 | 15 | 26 | 31 | 12 | 1 | 20 | 30 |
| 17 | D1b-LF | 16 | 16 | 7 | 1 | 9 | 15 | 16 | 7 | 1 | 9 | 15 |
| 18 | D1c-LF2 | 19 | 25 | 10 | 1 | 15 | 24 | 86 | 10 | 1 | 76 | 85 |
| 19 | D1c-LF3 | 38 | 57 | 17 | 2 | 40 | 55 | 297 | 17 | 2 | 280 | 295 |
| 20 | D-28 | 18 | 20 | 9 | 1 | 11 | 19 | 21 | 10 | 1 | 11 | 20 |
| 21 | D-31 | 12 | 12 | 5 | 1 | 7 | 11 | 12 | 5 | 1 | 7 | 11 |
| 22 | E2-LF | 82 | 138 | 14 | 2 | 124 | 136 | 323 | 14 | 2 | 309 | 322 |
| 23 | GW14 | 8 | 8 | 2 | 0 | 6 | 8 | 19 | 4 | 0 | 15 | 18 |
| 24 | GW16 | 8 | 10 | 2 | 0 | 8 | 10 | 20 | 2 | 0 | 18 | 20 |
| 25 | GW2 | 36 | 68 | 2 | 1 | 66 | 67 | 139 | 5 | 1 | 134 | 139 |
| 26 | HNC6 | 16 | 24 | 1 | 0 | 23 | 24 | 43 | 2 | 0 | 41 | 43 |
| 27 | SL2 | 28 | 40 | 5 | 1 | 35 | 39 | 172 | 10 | 1 | 162 | 171 |
| 28 | TS1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 |
| 29 | TS10 | 8 | 11 | 8 | 1 | 3 | 10 | 18 | 8 | 1 | 10 | 17 |
| 30 | TS11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31 | TS2 | 3 | 3 | 3 | 1 | 0 | 2 | 6 | 6 | 1 | 0 | 4 |
| 32 | TS3 | 1 | 3 | 1 | 0 | 2 | 3 | 3 | 1 | 0 | 2 | 3 |
| 33 | TS5 | 9 | 10 | 6 | 1 | 4 | 9 | 12 | 6 | 1 | 6 | 12 |
| 34 | TS6 | 9 | 10 | 6 | 1 | 4 | 9 | 15 | 6 | 1 | 9 | 15 |
| 35 | TS7 | 5 | 7 | 5 | 1 | 2 | 6 | 10 | 5 | 1 | 5 | 9 |
| 36 | TS9 | 16 | 19 | 10 | 1 | 9 | 18 | 23 | 11 | 1 | 13 | 22 |
| **Total** | | **607** | **849** | **236** | **75** | **613** | **774** | **1989** | **312** | **128** | **1677** | **1861** |

Note: Agricultural acres in the eastern Federal levee tie-in areas north of Bayou Lafourche are not included in the table.

Table 32
Percent of Total Catch Caught by Vessel Size Category
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Length | 2009 | 2024 | 2035 | 2085 |
|---|---|---|---|---|
| Total <26' | 7.2% | 6.5% | 5.9% | 5.7% |
| 26' to < 40' | 23.2% | 20.9% | 19.3% | 18.5% |
| 40' to < 65' | 55.2% | 56.7% | 57.8% | 58.3% |
| 65' and over | 14.4% | 15.9% | 17.0% | 17.5% |

Source: *Economic Benefits of Protecting the Large Recreational and Commercial Boat Fleets Final Report* dated April 2012

Table 33
Median Catch by Vessel Size
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Length | Median Catch (lbs) |
|---|---|
| ≤20' | 3,000 |
| 21' to ≤ 40' | 20,300 |
| 41' to ≤ 60' | 47,653 |
| 60' and over | 69,050 |

Source: *Economic Benefits of Protecting the Large Recreational and Commercial Boat Fleets Final Report* dated April 2012

Table 34
Commercial Fishing Vessel Forecast
(2024-2085)
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| | Low | | | Median | | | High | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2024 | 2035 | 2085 | 2024 | 2035 | 2085 | 2024 | 2035 | 2085 |
| 26' to < 40' | 222 | 204 | 196 | 339 | 313 | 300 | 457 | 421 | 404 |
| 40' to < 65' | 256 | 261 | 263 | 391 | 399 | 402 | 527 | 537 | 542 |
| 65' and over | 50 | 53 | 55 | 76 | 81 | 83 | 102 | 109 | 112 |
| Total >=26 | 527 | 518 | 514 | 807 | 793 | 786 | 1,086 | 1,067 | 1,059 |

Source: *Economic Benefits of Protecting the Large Recreational and Commercial Boat Fleets Final Report* dated April 2012

Table 35
Recreational Fleet Historical Growth Rates
(1999-2009)
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Vessel Size | Annual Growth | |
|---|---|---|
| | 1999-2009 | 2002-2009 |
| 26' to < 40' | 1.8% | 2.5% |
| 40' to < 65' | 3.2% | 5.2% |
| 65' and over | 5.0% | 7.1% |
| Total ≥26 | 2.0% | 2.9% |

Source: *Economic Benefits of Protecting the Large Recreational and Commercial Boat Fleets Final Report* dated April 2012

Table 36
Recreational Fleet Growth Rates
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Vessel Size | Median | | High | |
|---|---|---|---|---|
| | To 2040 | To 2085 | To 2040 | To 2085 |
| 26' to < 40' | 1.0% | 0.5% | 2.0% | 0.7% |
| 40' to < 65' | 2.5% | 1.0% | 4.0% | 1.3% |
| 65' and over | 3.0% | 1.5% | 6.0% | 2.0% |

Source: *Economic Benefits of Protecting the Large Recreational and Commercial Boat Fleets Final Report* dated April 2012

Table 37
Number of Recreational Vessel Forecast
(2024-2085)
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| | Low | | | Median | | | High | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2024 | 2035 | 2085 | 2024 | 2035 | 2085 | 2024 | 2035 | 2085 |
| 26' to < 40' | 283 | 283 | 283 | 329 | 367 | 482 | 381 | 474 | 716 |
| 40' to < 65' | 67 | 67 | 67 | 97 | 127 | 225 | 121 | 186 | 404 |
| 65' and over | 11 | 11 | 11 | 17 | 24 | 54 | 26 | 50 | 163 |
| Total >=26 | 361 | 361 | 361 | 443 | 518 | 761 | 528 | 709 | 1,283 |

Source: *Economic Benefits of Protecting the Large Recreational and Commercial Boat Fleets Final Report* dated April 2012

Table 38
Commercial Passenger Vessel Forecast
(2024-2085)
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| | Low | | | Median | | | High | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2024 | 2035 | 2085 | 2024 | 2035 | 2085 | 2024 | 2035 | 2085 |
| 26' to < 40' | 18 | 16 | 11 | 21 | 21 | 21 | 24 | 26 | 33 |
| 40' to < 65' | 8 | 7 | 5 | 9 | 9 | 9 | 10 | 12 | 17 |
| 65' and over | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 4 | 5 |
| Total >=26 | 28 | 25 | 18 | 33 | 33 | 33 | 37 | 42 | 55 |

Source: *Economic Benefits of Protecting the Large Recreational and Commercial Boat Fleets Final Report* dated April 2012

Table 39
Distribution of Vessel Fleets
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Waterway | Percentage of Vessel Fleet | Below Project Alignment | Above Project Alignment |
|---|---|---|---|
| Houma Navigation Channel | 5% | 2% | 3% |
| Bayou Petit Caillou | 30% | 5% | 25% |
| Bayou Grand Caillou | 30% | 0% | 30% |
| Bayou Dularge | 15% | 12% | 3% |
| Bayou Terrebonne | 15% | 1% | 14% |
| Bayou Pointe aux Chene | 5% | 2% | 3% |
| Total | 100% | **22%** | **78%** |

Source: *Economic Benefits of Protecting the Large Recreational and Commercial Boat Fleets Final Report* dated April 2012

Table 40
Distance to Refuge Without- & With-Project
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| | Without-Project | | | | |
|---|---|---|---|---|---|
| | Percent Below | Nautical Miles | Percent Above | Distance | Weighted Average |
| Houma Navigation Channel | 2% | 15.0 | 3% | 0.0 | 0.30 |
| Bayou Petit Caillou | 5% | 20.0 | 25% | 15.0 | 4.75 |
| Bayou Grand Caillou | 0% | 0.0 | 30% | 10.0 | 3.00 |
| Bayou Dularge | 12% | 8.0 | 3% | 2.0 | 1.02 |
| Bayou Terrebonne | 1% | 15.0 | 14% | 12.0 | 1.83 |
| Bayou Pointe aux Chene | 2% | 1.0 | 3% | 0.5 | 0.04 |
| Total | **22%** | | **78%** | | **10.94** |
| | **With-Project** | | | | |
| | Percent Below | Nautical Miles | Percent Above | Distance | Weighted Average |
| Houma Navigation Channel | 2% | 10.0 | 3% | 0.0 | 0.20 |
| Bayou Petit Caillou | 5% | 8.0 | 25% | 0.0 | 0.40 |
| Bayou Grand Caillou | 0% | 0.0 | 30% | 0.0 | 0.00 |
| Bayou Dularge | 12% | 4.0 | 3% | 0.0 | 0.48 |
| Bayou Terrebonne | 1% | 5.0 | 14% | 0.0 | 0.05 |
| Bayou Pointe aux Chene | 2% | 0.5 | 3% | 0.0 | 0.01 |
| Total | **22%** | | **78%** | | **1.14** |

Source: *Economic Benefits of Protecting the Large Recreational and Commercial Boat Fleets Final Report* dated April 2012

Table 41
Travel Cost by Vessel Type and Size
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| **Recreation & Commercial Passenger** | | | | | | | |
|---|---|---|---|---|---|---|---|
| Vessel Size | Speed (knots) | Hourly Fuel Consumption | Cost of Diesel (gal) | Hourly Fuel Cost | Hourly Cost of Crew | Hourly Operating Cost | Cost per Nautical Mile |
| 26' to < 40' | 23 | 25 | $ 3.13 | $ 78.25 | $ 20.00 | $ 98.25 | $ 4.27 |
| 40' to < 65' | 18 | 25 | $ 3.13 | $ 79.29 | $ 35.00 | $ 114.29 | $ 6.35 |
| 65' and over | 11 | 16 | $ 3.13 | $ 50.08 | $ 50.00 | $ 100.08 | $ 9.10 |
| **Commercial Fishing** | | | | | | | |
| Vessel Size | Speed (knots) | Hourly Fuel Consumption | Cost of Diesel (gal) | Hourly Fuel Cost | Hourly Cost of Crew | Hourly Operating Cost | Cost per Nautical Mile |
| 26' to < 40' | 8 | 6 | $ 3.13 | $ 18.78 | $ 35.00 | $ 53.78 | $ 6.72 |
| 40' to < 65' | 10 | 8 | $ 3.13 | $ 25.04 | $ 50.00 | $ 75.04 | $ 7.50 |
| 65' and over | 10 | 16 | $ 3.13 | $ 50.08 | $ 65.00 | $ 115.08 | $ 11.51 |
| **Other Vessels** | | | | | | | |
| Vessel Size | Speed (knots) | Hourly Fuel Consumption | Cost of Diesel (gal) | Hourly Fuel Cost | Hourly Cost of Crew | Hourly Operating Cost | Cost per Nautical Mile |
| 26' to < 40' | 8 | 10 | $ 3.13 | $ 31.30 | $ 50.00 | $ 81.30 | $ 10.16 |
| 40' to < 65' | 10 | 16 | $ 3.13 | $ 50.08 | $ 65.00 | $ 115.08 | $ 11.51 |
| 65' and over | 12 | 20 | $ 3.13 | $ 62.60 | $ 80.00 | $ 142.60 | $ 11.88 |

Source: *Economic Benefits of Protecting the Large Recreational and Commercial Boat Fleets Final Report dated April 2012*

Table 42
Total Travel Cost by Vessel Size
(2024-2085)
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Without-Project | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Low Forecast | | | Median Forecast | | | High Forecast | | |
| Vessel Size | 2024 | 2035 | 2085 | 2024 | 2035 | 2085 | 2024 | 2035 | 2085 |
| 26' to < 40' | 30,804 | 29,426 | 28,609 | 41,715 | 41,524 | 46,032 | 52,942 | 54,718 | 65,151 |
| 40' to < 65' | 29,704 | 30,054 | 30,122 | 42,998 | 45,724 | 52,818 | 55,835 | 61,333 | 77,224 |
| 65' and over | 15,259 | 15,663 | 15,803 | 19,217 | 20,532 | 23,818 | 23,491 | 26,775 | 38,564 |
| Total | 75,767 | 75,143 | 74,534 | 103,930 | 107,780 | 122,668 | 132,268 | 142,826 | 180,940 |
| **With-Project** | | | | | | | | | |
| | Low Forecast | | | Median Forecast | | | High Forecast | | |
| Vessel Size | 2024 | 2035 | 2085 | 2024 | 2035 | 2085 | 2024 | 2035 | 2085 |
| 26' to < 40' | 3,211 | 3,068 | 2,983 | 4,349 | 4,329 | 4,799 | 5,519 | 5,705 | 6,792 |
| 40' to < 65' | 3,097 | 3,133 | 3,140 | 4,483 | 4,767 | 5,506 | 5,821 | 6,394 | 8,051 |
| 65' and over | 1,591 | 1,633 | 1,647 | 2,003 | 2,140 | 2,483 | 2,449 | 2,791 | 4,020 |
| Total | 7,899 | 7,834 | 7,770 | 10,835 | 11,236 | 12,788 | 13,789 | 14,890 | 18,863 |
| **Benefits** | | | | | | | | | |
| | Low Forecast | | | Median Forecast | | | High Forecast | | |
| Vessel Size | 2024 | 2035 | 2085 | 2024 | 2035 | 2085 | 2024 | 2035 | 2085 |
| 26' to < 40' | 27,593 | 26,359 | 25,626 | 37,366 | 37,195 | 41,233 | 47,423 | 49,014 | 58,359 |
| 40' to < 65' | 26,607 | 26,921 | 26,982 | 38,515 | 40,957 | 47,312 | 50,014 | 54,939 | 69,174 |
| 65' and over | 13,668 | 14,030 | 14,155 | 17,213 | 18,391 | 21,335 | 21,042 | 23,983 | 34,544 |
| Total | 67,868 | 67,309 | 66,763 | 93,095 | 96,544 | 109,880 | 118,478 | 127,936 | 162,076 |

Source: *Economic Benefits of Protecting the Large Recreational and Commercial Boat Fleets Final Report* dated April 2012

Table 43
Expected Annual Travel Cost and Benefits
(2024-2085)
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| | Low Forecast | | | Median Forecast | | | High Forecast | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2024 | 2035 | 2085 | 2024 | 2035 | 2085 | 2024 | 2035 | 2085 |
| Without-Project Costs | 11,214 | 11,121 | 11,031 | 15,382 | 15,951 | 18,155 | 19,576 | 21,138 | 26,779 |
| With-Project Costs | 1,169 | 1,159 | 1,150 | 1,604 | 1,663 | 1,893 | 2,041 | 2,204 | 2,792 |
| Benefits | 10,045 | 9,962 | 9,881 | 13,778 | 14,288 | 16,262 | 17,535 | 18,934 | 23,987 |

Source: *Economic Benefits of Protecting the Large Recreational and Commercial Boat Fleets Final Report* dated April 2012

Table 44
Additional Costs Associated with High Salinity Levels
Morganza to the Gulf
Post-Authorization Change Report

| | Without-Project | | | | | | | With-Project 1% and 3% AEP Alternatives | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Chemicals Costs | Treatment Costs | Operation Costs | Refurbish Costs | Replacement Costs | TOTAL | Year | Chemicals Costs | Treatment Costs | Operation Costs | Refurbish Costs | Replacement Costs | TOTAL |
| 2012 | $10,744 | $275,000 | $330 | | | $286,074 | 2012 | $10,744 | $275,000 | $330 | | | $286,074 |
| 2013 | $10,744 | | $330 | | | $11,074 | 2013 | $10,744 | | $330 | | | $11,074 |
| 2014 | $10,744 | | $330 | | | $11,074 | 2014 | $10,744 | | $330 | | | $11,074 |
| 2015 | $10,744 | $275,000 | $330 | | | $286,074 | 2015 | $10,744 | $275,000 | $330 | | | $286,074 |
| 2016 | $10,744 | | $330 | | | $11,074 | 2016 | $10,744 | | $330 | | | $11,074 |
| 2017 | $10,744 | | $330 | | | $11,074 | 2017 | $10,744 | | $330 | | | $11,074 |
| 2018 | $10,744 | $275,000 | $330 | | | $286,074 | 2018 | $10,744 | $275,000 | $330 | | | $286,074 |
| 2019 | $10,744 | | $330 | | | $11,074 | 2019 | $8,175 | | $251 | | | $8,426 |
| 2020 | $10,744 | | $330 | $1,000,000 | $500,000 | $1,511,074 | 2020 | $8,175 | | $251 | | | $8,426 |
| 2021 | $10,744 | $275,000 | $330 | | | $286,074 | 2021 | $8,175 | | $251 | | | $8,426 |
| 2022 | $10,744 | | $330 | | | $11,074 | 2022 | $8,175 | $275,000 | $251 | | | $283,426 |
| 2023 | $10,744 | | $330 | | | $11,074 | 2023 | $8,175 | | $251 | | | $8,426 |
| 2024 | $10,744 | $275,000 | $330 | | | $286,074 | 2024 | $8,175 | | $251 | | | $8,426 |
| 2025 | $10,744 | | $330 | | | $11,074 | 2025 | $8,175 | | $251 | | | $8,426 |
| 2026 | $10,744 | | $330 | | | $11,074 | 2026 | $8,175 | $275,000 | $251 | | | $283,426 |
| 2027 | $10,744 | $275,000 | $330 | | | $286,074 | 2027 | $8,175 | | $251 | | | $8,426 |
| 2028 | $10,744 | | $330 | | | $11,074 | 2028 | $8,175 | | $251 | | | $8,426 |
| 2029 | $10,744 | | $330 | | | $11,074 | 2029 | $8,175 | | $251 | | | $8,426 |
| 2030 | $10,744 | $275,000 | $330 | | | $286,074 | 2030 | $8,175 | $275,000 | $251 | | | $283,426 |
| 2031 | $10,744 | | $330 | | | $11,074 | 2031 | $8,175 | | $251 | | | $8,426 |
| 2032 | $10,744 | | $330 | | | $11,074 | 2032 | $8,175 | | $251 | | | $8,426 |
| 2033 | $10,744 | $275,000 | $330 | | | $286,074 | 2033 | $8,175 | | $251 | | | $8,426 |
| 2034 | $10,744 | | $330 | | | $11,074 | 2034 | $8,175 | $275,000 | $251 | | | $283,426 |
| 2035 | $10,744 | | $330 | | | $11,074 | 2035 | $8,175 | | $251 | | | $8,426 |
| 2036 | $10,744 | $275,000 | $330 | | | $286,074 | 2036 | $8,175 | | $251 | | | $8,426 |
| 2037 | $10,744 | | $330 | | | $11,074 | 2037 | $8,175 | | $251 | | | $8,426 |
| 2038 | $10,744 | | $330 | | | $11,074 | 2038 | $8,175 | $275,000 | $251 | | | $283,426 |
| 2039 | $10,744 | $275,000 | $330 | | | $286,074 | 2039 | $8,175 | | $251 | | | $8,426 |
| 2040 | $10,744 | | $330 | $135,000 | $135,000 | $281,074 | 2040 | $8,175 | | $251 | | | $8,426 |
| 2041 | $10,744 | | $330 | | | $11,074 | 2041 | $8,175 | | $251 | | | $8,426 |
| 2042 | $10,744 | $275,000 | $330 | | | $286,074 | 2042 | $8,175 | $275,000 | $251 | | | $283,426 |
| 2043 | $10,744 | | $330 | | | $11,074 | 2043 | $8,175 | | $251 | | | $8,426 |
| 2044 | $10,744 | | $330 | | | $11,074 | 2044 | $8,175 | | $251 | | | $8,426 |
| 2045 | $10,744 | $275,000 | $330 | | | $286,074 | 2045 | $8,175 | | $251 | | | $8,426 |
| 2046 | $10,744 | | $330 | | | $11,074 | 2046 | $8,175 | $275,000 | $251 | | | $283,426 |
| 2047 | $10,744 | | $330 | | | $11,074 | 2047 | $8,175 | | $251 | | | $8,426 |
| 2048 | $10,744 | $275,000 | $330 | | | $286,074 | 2048 | $8,175 | | $251 | | | $8,426 |
| 2049 | $10,744 | | $330 | | | $11,074 | 2049 | $8,175 | | $251 | | | $8,426 |
| 2050 | $10,744 | | $330 | | | $11,074 | 2050 | $8,175 | $275,000 | $251 | | | $283,426 |
| 2051 | $10,744 | $275,000 | $330 | | | $286,074 | 2051 | $8,175 | | $251 | | | $8,426 |
| 2052 | $10,744 | | $330 | | | $11,074 | 2052 | $8,175 | | $251 | | | $8,426 |
| 2053 | $10,744 | | $330 | | | $11,074 | 2053 | $8,175 | | $251 | | | $8,426 |
| 2054 | $10,744 | $275,000 | $330 | | | $286,074 | 2054 | $8,175 | $275,000 | $251 | | | $283,426 |
| 2055 | $10,744 | | $330 | | | $11,074 | 2055 | $8,175 | | $251 | | | $8,426 |
| 2056 | $10,744 | | $330 | | | $11,074 | 2056 | $8,175 | | $251 | | | $8,426 |
| 2057 | $10,744 | $275,000 | $330 | | | $286,074 | 2057 | $8,175 | | $251 | | | $8,426 |
| 2058 | $10,744 | | $330 | | | $11,074 | 2058 | $8,175 | $275,000 | $251 | | | $283,426 |
| 2059 | $10,744 | | $330 | | | $11,074 | 2059 | $8,175 | | $251 | | | $8,426 |
| 2060 | $10,744 | $275,000 | $330 | $1,000,000 | $500,000 | $1,786,074 | 2060 | $8,175 | | $251 | | | $8,426 |
| 2061 | $10,744 | | $330 | | | $11,074 | 2061 | $8,175 | | $251 | | | $8,426 |
| 2062 | $10,744 | | $330 | | | $11,074 | 2062 | $8,175 | $275,000 | $251 | | | $283,426 |
| 2063 | $10,744 | $275,000 | $330 | | | $286,074 | 2063 | $8,175 | | $251 | | | $8,426 |
| 2064 | $10,744 | | $330 | | | $11,074 | 2064 | $8,175 | | $251 | | | $8,426 |
| 2065 | $10,744 | | $330 | | | $11,074 | 2065 | $8,175 | | $251 | | | $8,426 |
| 2066 | $10,744 | $275,000 | $330 | | | $286,074 | 2066 | $8,175 | $275,000 | $251 | | | $283,426 |
| 2067 | $10,744 | | $330 | | | $11,074 | 2067 | $8,175 | | $251 | | | $8,426 |
| 2068 | $10,744 | | $330 | | | $11,074 | 2068 | $8,175 | | $251 | | | $8,426 |
| 2069 | $10,744 | $275,000 | $330 | | | $286,074 | 2069 | $8,175 | | $251 | | | $8,426 |
| 2070 | $10,744 | | $330 | | | $11,074 | 2070 | $8,175 | $275,000 | $251 | | | $283,426 |
| 2071 | $10,744 | | $330 | | | $11,074 | 2071 | $8,175 | | $251 | | | $8,426 |
| 2072 | $10,744 | $275,000 | $330 | | | $286,074 | 2072 | $8,175 | | $251 | | | $8,426 |
| 2073 | $10,744 | | $330 | | | $11,074 | 2073 | $8,175 | | $251 | | | $8,426 |
| 2074 | $10,744 | | $330 | | | $11,074 | 2074 | $8,175 | $275,000 | $251 | | | $283,426 |
| 2075 | $10,744 | $275,000 | $330 | | | $286,074 | 2075 | $8,175 | | $251 | | | $8,426 |
| 2076 | $10,744 | | $330 | | | $11,074 | 2076 | $8,175 | | $251 | | | $8,426 |
| 2077 | $10,744 | | $330 | | | $11,074 | 2077 | $8,175 | | $251 | | | $8,426 |
| 2078 | $10,744 | $275,000 | $330 | | | $286,074 | 2078 | $8,175 | $275,000 | $251 | | | $283,426 |
| 2079 | $10,744 | | $330 | | | $11,074 | 2079 | $8,175 | | $251 | | | $8,426 |
| 2080 | $10,744 | | $330 | $135,000 | $135,000 | $281,074 | 2080 | $8,175 | | $251 | | | $8,426 |
| 2081 | $10,744 | $275,000 | $330 | | | $286,074 | 2081 | $8,175 | | $251 | | | $8,426 |
| 2082 | $10,744 | | $330 | | | $11,074 | 2082 | $8,175 | $275,000 | $251 | | | $283,426 |
| 2083 | $10,744 | | $330 | | | $11,074 | 2083 | $8,175 | | $251 | | | $8,426 |
| 2084 | $10,744 | $275,000 | $330 | | | $286,074 | 2084 | $8,175 | | $251 | | | $8,426 |

Source: Based on schedule of water supply costs provided by Houma Water Treatment Plant
Note: The expected value for the annual number of days of high salinity during the period, 2012 to 2084, is 31.2 days.

Table 45
3% AEP Total Annual Costs
(2011 Price Level; 3.75% Discount Rate)
Morganza to the Gulf
Post-Authorization Change Report
($ Millions)

| Year | Years from Base Year | Expenditures | Present Value Factor | Present Value of Expenditures |
|---|---|---|---|---|
| 2010 | -24 | | 2.419 | 0 |
| 2011 | -23 | | 2.332 | 0 |
| 2012 | -22 | $0 | 2.248 | 0 |
| 2013 | -21 | $0 | 2.166 | 0 |
| 2014 | -20 | $14 | 2.088 | 30 |
| 2015 | -19 | $695 | 2.013 | 1,398 |
| 2016 | -18 | $625 | 1.940 | 1,213 |
| 2017 | -17 | $716 | 1.870 | 1,339 |
| 2018 | -16 | $708 | 1.802 | 1,276 |
| 2019 | -15 | $398 | 1.737 | 691 |
| 2020 | -14 | $355 | 1.674 | 595 |
| 2021 | -13 | $587 | 1.614 | 947 |
| 2022 | -12 | $557 | 1.555 | 866 |
| 2023 | -11 | $328 | 1.499 | 491 |
| 2024 | -10 | $102 | 1.445 | 147 |
| 2025 | -9 | $35 | 1.393 | 48 |
| 2026 | -8 | $20 | 1.342 | 27 |
| 2027 | -7 | $0 | 1.294 | 0 |
| 2028 | -6 | $0 | 1.247 | 0 |
| 2029 | -5 | $0 | 1.202 | 0 |
| 2030 | -4 | $10 | 1.159 | 12 |
| 2031 | -3 | $8 | 1.117 | 9 |
| 2032 | -2 | $8 | 1.076 | 8 |
| 2033 | -1 | $106 | 1.038 | 110 |
| 2034 | 0 | $106 | 1.000 | 106 |
| 2035 | 1 | $213 | 0.964 | 205 |
| 2036 | 2 | $34 | 0.929 | 32 |
| 2037 | 3 | $13 | 0.895 | 12 |
| 2038 | 4 | $13 | 0.863 | 11 |
| 2039 | 5 | $0 | 0.832 | 0 |
| 2040 | 6 | $32 | 0.802 | 25 |
| 2041 | 7 | $21 | 0.773 | 16 |
| 2042 | 8 | $14 | 0.745 | 10 |
| 2043 | 9 | $14 | 0.718 | 10 |
| 2044 | 10 | $0 | 0.692 | 0 |
| 2045 | 11 | $20 | 0.667 | 14 |
| 2046 | 12 | $10 | 0.643 | 7 |

Table 45 (Cont.)
3% AEP Total Annual Costs
(2011 Price Level; 3.75% Discount Rate)
Morganza to the Gulf
Post-Authorization Change Report
($ Millions)

| Year | Years from Base Year | Expenditures | Present Value Factor | Present Value of Expenditures |
|---|---|---|---|---|
| 2047 | 13 | $0 | 0.620 | 0 |
| 2048 | 14 | $0 | 0.597 | 0 |
| 2049 | 15 | $0 | 0.576 | 0 |
| 2050 | 16 | $25 | 0.555 | 14 |
| 2051 | 17 | $8 | 0.535 | 4 |
| 2052 | 18 | $0 | 0.515 | 0 |
| 2053 | 19 | $17 | 0.497 | 8 |
| 2054 | 20 | $17 | 0.479 | 8 |
| 2055 | 21 | $0 | 0.462 | 0 |
| 2056 | 22 | $0 | 0.445 | 0 |
| 2057 | 23 | $0 | 0.429 | 0 |
| 2058 | 24 | $0 | 0.413 | 0 |
| 2059 | 25 | $0 | 0.398 | 0 |
| 2060 | 26 | $0 | 0.384 | 0 |
| 2061 | 27 | $0 | 0.370 | 0 |
| 2062 | 28 | $0 | 0.357 | 0 |
| 2063 | 29 | $0 | 0.344 | 0 |
| 2064 | 30 | $0 | 0.331 | 0 |
| 2065 | 31 | $11 | 0.319 | 4 |
| 2066 | 32 | $0 | 0.308 | 0 |
| 2067 | 33 | $0 | 0.297 | 0 |
| 2068 | 34 | $0 | 0.286 | 0 |
| 2069 | 35 | $0 | 0.276 | 0 |
| 2070 | 36 | $35 | 0.266 | 9 |
| 2071 | 37 | $0 | 0.256 | 0 |
| 2072 | 38 | $0 | 0.247 | 0 |
| 2073 | 39 | $15 | 0.238 | 3 |
| 2074 | 40 | $15 | 0.229 | 3 |
| 2075 | 41 | | 0.221 | 0 |
| Discount Rate (%) | 3.75 | | | |
| Amortization Factor | 0.04457 | | | |
| Annual Implementation Costs | | | | $ 432.8 |
| Operations and Maintenance Cost | | | | $ 5.5 |
| Total Annual Costs ($Millions) | | | | $ 438.3 |

*Project costs include acquistion costs of structures in 12 study area reaches receiving induced damages south of the proposed alternatives.

Table 46
1% AEP Total Annual Costs
(2011 Price Level; 3.75% Discount Rate)
Morganza to the Gulf
Post-Authorization Change Report
($ Millions)

| Year | Period of Analysis | Construction Cost | PV Factor | PV Construction Cost |
|---|---|---|---|---|
| 2010 | -24 | | 2.419 | 0 |
| 2011 | -23 | | 2.332 | 0 |
| 2012 | -22 | $0 | 2.248 | 0 |
| 2013 | -21 | $0 | 2.166 | 0 |
| 2014 | -20 | $22 | 2.088 | 46 |
| 2015 | -19 | $822 | 2.013 | 1,653 |
| 2016 | -18 | $728 | 1.940 | 1,412 |
| 2017 | -17 | $893 | 1.870 | 1,670 |
| 2018 | -16 | $958 | 1.802 | 1,727 |
| 2019 | -15 | $663 | 1.737 | 1,151 |
| 2020 | -14 | $445 | 1.674 | 744 |
| 2021 | -13 | $773 | 1.614 | 1,248 |
| 2022 | -12 | $836 | 1.555 | 1,301 |
| 2023 | -11 | $723 | 1.499 | 1,084 |
| 2024 | -10 | $605 | 1.445 | 874 |
| 2025 | -9 | $405 | 1.393 | 565 |
| 2026 | -8 | $231 | 1.342 | 310 |
| 2027 | -7 | $185 | 1.294 | 240 |
| 2028 | -6 | $162 | 1.247 | 202 |
| 2029 | -5 | $188 | 1.202 | 226 |
| 2030 | -4 | $185 | 1.159 | 214 |
| 2031 | -3 | $115 | 1.117 | 129 |
| 2032 | -2 | $21 | 1.076 | 22 |
| 2033 | -1 | $142 | 1.038 | 147 |
| 2034 | 0 | $192 | 1.000 | 192 |
| 2035 | 1 | $261 | 0.964 | 252 |
| 2036 | 2 | $63 | 0.929 | 59 |
| 2037 | 3 | $22 | 0.895 | 20 |
| 2038 | 4 | $22 | 0.863 | 19 |
| 2039 | 5 | $22 | 0.832 | 18 |
| 2040 | 6 | $22 | 0.802 | 18 |
| 2041 | 7 | $0 | 0.773 | 0 |
| 2042 | 8 | $0 | 0.745 | 0 |
| 2043 | 9 | $0 | 0.718 | 0 |
| 2044 | 10 | $0 | 0.692 | 0 |
| 2045 | 11 | $99 | 0.667 | 66 |
| 2046 | 12 | $52 | 0.643 | 34 |

Table 46 (Cont.)
1% AEP Total Annual Costs
(2011 Price Level; 3.75% Discount Rate)
Morganza to the Gulf
Post-Authorization Change Report
($ Millions)

| Year | Period of Analysis | Construction Cost | PV Factor | PV Construction Cost |
|---|---|---|---|---|
| 2047 | 13 | $9 | 0.620 | 6 |
| 2048 | 14 | $9 | 0.597 | 6 |
| 2049 | 15 | $0 | 0.576 | 0 |
| 2050 | 16 | $13 | 0.555 | 7 |
| 2051 | 17 | $29 | 0.535 | 16 |
| 2052 | 18 | $16 | 0.515 | 8 |
| 2053 | 19 | $0 | 0.497 | 0 |
| 2054 | 20 | $0 | 0.479 | 0 |
| 2055 | 21 | $47 | 0.462 | 22 |
| 2056 | 22 | $47 | 0.445 | 21 |
| 2057 | 23 | $0 | 0.429 | 0 |
| 2058 | 24 | $0 | 0.413 | 0 |
| 2059 | 25 | $0 | 0.398 | 0 |
| 2060 | 26 | $21 | 0.384 | 8 |
| 2061 | 27 | $5 | 0.370 | 2 |
| 2062 | 28 | $19 | 0.357 | 7 |
| 2063 | 29 | $19 | 0.344 | 7 |
| 2064 | 30 | $0 | 0.331 | 0 |
| 2065 | 31 | $0 | 0.319 | 0 |
| 2066 | 32 | $0 | 0.308 | 0 |
| 2067 | 33 | $0 | 0.297 | 0 |
| 2068 | 34 | $0 | 0.286 | 0 |
| 2069 | 35 | $0 | 0.276 | 0 |
| 2070 | 36 | $27 | 0.266 | 7 |
| 2071 | 37 | $27 | 0.256 | 7 |
| 2072 | 38 | $0 | 0.247 | 0 |
| 2073 | 39 | $0 | 0.238 | 0 |
| 2074 | 40 | $14 | 0.229 | 3 |
| 2075 | 41 | $14 | 0.221 | 3 |
| | | $ 10,177.2 | | $ 15,772.4 |
| Discount Rate (%) | 3.75 | | | |
| Amortization Factor | 0.04457 | | | |
| Annual Implementation Costs | | | | $ 703.0 |
| Operations and Maintenance Cost | | | | $ 7.3 |
| Total Annual Costs ($Millions) | | | | $ 710.3 |

*Project costs include acquistion costs of structures in 12 study area reaches receiving induced damages south of the proposed alternatives.

Table 47
3% Annual Exceedance Probability Alternative
(2011 Price Level; 3.75% Discount Rate)
Total Equivalent Annual Net Benefits
Morganza to the Gulf
Post-Authorization Change Report
($ Millions)

| Item | Equiv Annual W/O Project Damages (2035-2084) | Equiv Annual With-Project Damages (2035-2084) | Equiv Annual Benefits (2035-2084) | Equiv Annual Benefits During Construction (2024-2034) | Total Equiv Annual Benefits | |
|---|---|---|---|---|---|---|
| Damage Category | | | | | | |
| Residential & Commercial - Structure/Content/Vehicles | $ 819.5 | $ 409.9 | $ 409.6 | $ 173.8 | $ 583.4 | |
| Industrial - Structure/Contents | $ 16.5 | $ 6.4 | $ 10.1 | $ 4.4 | $ 14.5 | |
| Highways | $ 6.6 | $ 4.2 | $ 2.3 | $ 1.1 | $ 3.4 | |
| Streets | $ 15.5 | $ 5.6 | $ 9.9 | $ 3.7 | $ 13.6 | |
| Debris Removal & Cleanup | $ 25.7 | $ 12.6 | $ 13.1 | $ 5.9 | $ 19.0 | |
| Water Supply | $ 0.1 | $ 0.1 | $ 0.1 | $ 0.1 | $ 0.2 | |
| Boat Fleets | $ 0.0 | $ 0.0 | $ 0.0 | $ 0.0 | $ 0.0 | |
| Avoided Structure-Raising Costs | $ 4.9 | $ - | $ 4.9 | $ 5.3 | $ 10.3 | |
| Total | $ 888.9 | $ 438.8 | $ 450.1 | $ 194.2 | $ 644.4 | |
| | | | | | | |
| | | | | | | |
| First Costs | | | | | | $ 5,902 |
| Interest During Construction | | | | | | $ 3,937 |
| Annual Operation & Maintenance Costs | | | | | | $ 6 |
| Total Annual Costs | | | | | | $ 438 |
| | | | | | | |
| B/C Ratio | | | | | | 1.47 |
| Equivalent Annual Net Benefits - 2035 Base Year | | | | | | $ 206 |

*Total equivalent annual benefits, net benefits and b/c ratio after changes to CSVRs following model certification.

Table 48
1% Annual Exceedance Probability Alternative
(2011 Price Level; 3.75% Discount Rate)
Total Equivalent Annual Net Benefits
Morganza to the Gulf
Post-Authorization Change Report
($ Millions)

| Item | Equiv Annual W/O Project Damages (2035-2084) | Equiv Annual With-Project Damages (2035-2084) | Equiv Annual Benefits (2035-2084) | Equiv Annual Benefits During Construction (2024-2034) | Total Equiv Annual Benefits | |
|---|---|---|---|---|---|---|
| Damage Category | | | | | | |
| Residential & Commercial - Structure/Content/Vehicles | $ 819.5 | $ 123.4 | $ 696.2 | $ 225.1 | $ 921.3 | |
| Industrial - Structure/Contents | $ 16.5 | $ 1.3 | $ 15.2 | $ 5.1 | $ 20.3 | |
| Highways | $ 6.6 | $ 2.3 | $ 4.3 | $ 1.5 | $ 5.7 | |
| Streets | $ 15.5 | $ 2.3 | $ 13.3 | $ 4.2 | $ 17.4 | |
| Debris Removal & Cleanup | $ 25.7 | $ 4.0 | $ 21.7 | $ 7.3 | $ 29.0 | |
| Water Supply | $ 0.1 | $ 0.1 | $ 0.1 | $ 0.1 | $ 0.2 | |
| Boat Fleets | $ 0.0 | $ 0.0 | $ 0.0 | $ 0.0 | $ 0.0 | |
| Avoided Structure-Raising Costs | $ 4.9 | $ - | $ 4.9 | $ 5.3 | $ 10.3 | |
| Total | $ 888.9 | $ 133.2 | $ 755.7 | $ 248.6 | $ 1,004.3 | |
| | | | | | | |
| | | | | | | |
| First Costs | | | | | | $ 10,177 |
| Interest During Construction | | | | | | $ 5,864 |
| Annual Operation & Maintenance Costs | | | | | | $ 7 |
| Total Annual Costs | | | | | | $ 710 |
| | | | | | | |
| B/C Ratio | | | | | | 1.41 |
| Equivalent Annual Net Benefits Base Year 2035 | | | | | | $ 294 |

*Total equivalent annual benefits, net benefits and b/c ratio after changes to CSVRs following model certification.

Table 49
3% Annual Exceedance Probability Alternative - Without Future Development
(2011 Price Level; 3.75% Discount Rate)
Total Equivalent Annual Net Benefits
Morganza to the Gulf
Post-Authorization Change Report
($ Millions)

| Item | Equiv Annual W/O Project Damages (2035-2084) | Equiv Annual With-Project Damages (2035-2084) | Equiv Annual Benefits (2035-2084) | Equiv Annual Benefits During Construction (2024-2034) | Total Equiv Annual Benefits | Adjusted Total Equiv Annual Benefits |
|---|---|---|---|---|---|---|
| Damage Category | | | | | | |
| Residential & Commercial - Structure/Content/Vehicles | $ 727.2 | $ 362.0 | $ 365.3 | $ 155.4 | $ 520.7 | |
| Industrial - Structure/Contents | $ 16.5 | $ 6.4 | $ 10.1 | $ 4.4 | $ 14.5 | |
| Highways | $ 6.6 | $ 4.2 | $ 2.3 | $ 1.1 | $ 3.4 | |
| Streets | $ 15.5 | $ 5.6 | $ 9.9 | $ 3.7 | $ 13.6 | |
| Debris Removal & Cleanup | $ 24.2 | $ 11.2 | $ 13.1 | $ 5.8 | $ 18.9 | |
| Water Supply | $ 0.1 | $ 0.1 | $ 0.1 | $ 0.1 | $ 0.2 | |
| Boat Fleets | $ 0.0 | $ 0.0 | $ 0.0 | $ 0.0 | $ 0.0 | |
| Avoided Structure-Raising Costs | $ 4.9 | $ - | $ 4.9 | $ 5.3 | $ 10.3 | |
| Total | $ 795.1 | $ 389.4 | $ 405.7 | $ 175.8 | $ 581.5 | $ 639.5 |
| | | | | | | |
| | | | | | | |
| First Costs | | | | | | $ 5,902 |
| Interest During Construction | | | | | | $ 3,937 |
| Annual Operation & Maintenance Costs | | | | | | $ 6 |
| Total Annual Costs | | | | | | $ 438 |
| | | | | | | |
| B/C Ratio | | | | | | 1.46 |
| Equivalent Annual Net Benefits - 2035 Base Year | | | | | | $ 201 |

*Total equivalent annual benefits, net benefits and b/c ratio were adjusted to reflect changes in CSVRs following model certification.

Table 50
1% Annual Exceedance Probability Alternative - Without Future Development
(2011 Price Level; 3.75% Discount Rate)
Total Equivalent Annual Net Benefits
Morganza to the Gulf
Post-Authorization Change Report
($ Millions)

| Item | Equiv Annual W/O Project Damages (2035-2084) | Equiv Annual With-Project Damages (2035-2084) | Equiv Annual Benefits (2035-2084) | Equiv Annual Benefits During Construction (2024-2034) | Total Equiv Annual Benefits | Adjusted Total Equiv Annual Benefits |
|---|---|---|---|---|---|---|
| | | | | | | |
| Damage Category | | | | | | |
| Residential & Commercial - Structure/Content/Vehicles | $ 747.9 | $ 113.9 | $ 634.0 | $ 207.2 | $ 841.2 | |
| Industrial - Structure/Contents | $ 16.5 | $ 1.3 | $ 15.2 | $ 5.1 | $ 20.3 | |
| Highways | $ 6.6 | $ 2.3 | $ 4.3 | $ 1.5 | $ 5.7 | |
| Streets | $ 15.5 | $ 2.3 | $ 13.3 | $ 4.2 | $ 17.4 | |
| Debris Removal & Cleanup | $ 25.7 | $ 4.0 | $ 21.7 | $ 7.3 | $ 29.0 | |
| Water Supply | $ 0.1 | $ 0.1 | $ 0.1 | $ 0.1 | $ 0.2 | |
| Boat Fleets | $ 0.0 | $ 0.0 | $ 0.0 | $ 0.0 | $ 0.0 | |
| Avoided Structure-Raising Costs | $ 4.9 | $ - | $ 4.9 | $ 5.3 | $ 10.3 | |
| Total | $ 795.1 | $ 112.0 | $ 683.1 | $ 230.8 | $ 913.9 | $ 993.0 |
| | | | | | | |
| | | | | | | |
| First Costs | | | | | | $ 10,177 |
| Interest During Construction | | | | | | $ 5,864 |
| Annual Operation & Maintenance Costs | | | | | | $ 7 |
| Total Annual Costs | | | | | | $ 710 |
| | | | | | | |
| B/C Ratio | | | | | | 1.40 |
| Equivalent Annual Net Benefits Base Year 2035 | | | | | | $ 283 |

*Total equivalent annual benefits, net benefits and b/c ratio were adjusted to reflect changes in CSVRs following model certification.

Table 51
Donaldsonville to the Gulf, LA Depth-Damage Relationships for Structures, Contents and Vehicles
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Occupancy Type | Category Name | Damage Type | Parameter | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1STY-PIER | Residential | | Stage | -1.1 | -1.0 | -0.5 | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 |
| | | Structure | Mean % | 0.0 | 1.7 | 2.7 | 27.6 | 47.1 | 54.1 | 56.4 | 58.7 | 63.8 | 72.2 | 77.4 | 79.9 | 80.3 | 84.4 | 87.9 | 88.6 | 88.9 | 89.0 | 89.3 | 89.4 |
| | | | Lower % | 0.0 | 0.0 | 0.9 | 3.5 | 16.0 | 45.1 | 47.8 | 48.4 | 53.3 | 61.8 | 64.3 | 66.7 | 69.2 | 72.2 | 76.2 | 76.2 | 76.2 | 76.2 | 76.2 | 76.2 |
| | | | Upper % | 0.0 | 3.6 | 4.0 | 41.9 | 50.4 | 64.5 | 65.2 | 69.3 | 73.2 | 78.0 | 92.5 | 98.2 | 98.2 | 102.3 | 107.9 | 107.9 | 108.2 | 108.2 | 109.2 | 109.2 |
| | | | Stage | -1.1 | -1.0 | -0.5 | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 |
| | | Contents | Mean % | 0.0 | 0.0 | 0.0 | 35.0 | 46.8 | 48.4 | 50.3 | 56.7 | 67.5 | 76.3 | 80.9 | 88.1 | 88.4 | 89.1 | 89.1 | 89.1 | 89.1 | 89.1 | 89.1 | 89.1 |
| | | | Lower % | 0.0 | 0.0 | 0.0 | 27.5 | 39.9 | 45.2 | 48.0 | 53.0 | 65.6 | 74.1 | 78.5 | 85.5 | 85.7 | 86.4 | 86.5 | 86.5 | 86.5 | 86.5 | 86.5 | 86.5 |
| | | | Upper % | 0.0 | 0.0 | 0.0 | 38.6 | 50.9 | 51.2 | 54.9 | 59.1 | 69.5 | 80.6 | 85.4 | 92.9 | 93.2 | 93.9 | 94.0 | 94.0 | 94.0 | 94.0 | 94.0 | 94.0 |
| 1STY-SLAB | Residential | | Stage | -1.0 | -0.5 | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 |
| | | Structure | Mean % | 0.0 | 1.0 | 9.8 | 31.1 | 37.7 | 41.4 | 44.6 | 50.0 | 62.3 | 67.0 | 69.4 | 69.8 | 74.9 | 80.7 | 81.4 | 81.5 | 81.5 | 82.0 | 82.0 | 82.0 |
| | | | Lower % | 0.0 | 0.0 | 2.8 | 11.1 | 28.5 | 30.9 | 32.3 | 41.7 | 54.5 | 55.1 | 56.0 | 59.0 | 66.3 | 70.6 | 70.6 | 70.6 | 70.6 | 70.6 | 70.6 | 70.6 |
| | | | Upper % | 0.0 | 6.0 | 41.4 | 46.6 | 50.9 | 50.9 | 55.8 | 58.1 | 77.1 | 77.1 | 81.5 | 81.5 | 90.3 | 93.9 | 97.4 | 97.4 | 97.4 | 97.4 | 97.4 | 97.4 |
| | | | Stage | -1.0 | -0.5 | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 |
| | | Contents | Mean % | 0.0 | 0.0 | 0.0 | 35.0 | 46.8 | 48.4 | 50.3 | 56.7 | 67.5 | 76.3 | 80.9 | 88.1 | 88.4 | 89.1 | 89.1 | 89.1 | 89.1 | 89.1 | 89.1 | 89.1 |
| | | | Lower % | 0.0 | 0.0 | 0.0 | 27.5 | 39.9 | 45.2 | 48.0 | 53.0 | 65.6 | 74.1 | 78.5 | 85.5 | 85.7 | 86.4 | 86.5 | 86.5 | 86.5 | 86.5 | 86.5 | 86.5 |
| | | | Upper % | 0.0 | 0.0 | 0.0 | 38.6 | 50.9 | 51.2 | 54.9 | 59.1 | 69.5 | 80.6 | 85.4 | 92.9 | 93.2 | 93.9 | 94.0 | 94.0 | 94.0 | 94.0 | 94.0 | 94.0 |
| 2STY-PIER | Residential | | Stage | -1.1 | -1.0 | -0.5 | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 |
| | | Structure | Mean % | 0.0 | 1.5 | 2.4 | 8.3 | 23.1 | 28.7 | 31.5 | 34.2 | 35.8 | 43.3 | 46.5 | 47.4 | 47.7 | 50.1 | 63.6 | 65.6 | 67.0 | 69.3 | 72.1 | 73.3 |
| | | | Lower % | 0.0 | 0.0 | 0.4 | 0.4 | 10.8 | 20.5 | 27.7 | 28.0 | 28.2 | 32.0 | 37.8 | 40.1 | 40.1 | 40.1 | 52.5 | 56.7 | 59.5 | 60.4 | 63.3 | 65.0 |
| | | | Upper % | 0.0 | 3.4 | 5.6 | 31.6 | 36.3 | 37.6 | 37.8 | 47.0 | 47.3 | 58.7 | 58.7 | 59.3 | 59.3 | 61.2 | 75.7 | 76.9 | 80.7 | 80.8 | 85.6 | 91.9 |
| | | | Stage | -1.0 | -0.5 | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 |
| | | Contents | Mean % | 0.0 | 0.7 | 21.3 | 24.8 | 30.7 | 34.6 | 37.7 | 45.6 | 50.5 | 56.7 | 60.6 | 61.6 | 62.3 | 68.1 | 68.1 | 72.0 | 74.0 | 75.8 | 77.0 | 77.2 |
| | | | Lower % | 0.0 | 0.0 | 19.6 | 22.9 | 29.7 | 33.5 | 36.5 | 44.2 | 49.0 | 54.0 | 58.7 | 59.7 | 60.4 | 66.0 | 66.0 | 69.7 | 71.7 | 73.4 | 74.6 | 74.8 |
| | | | Upper % | 0.0 | 1.5 | 22.1 | 25.8 | 31.6 | 35.6 | 38.8 | 46.9 | 53.9 | 59.3 | 64.7 | 65.7 | 66.4 | 72.7 | 72.7 | 76.7 | 78.9 | 80.8 | 82.1 | 82.3 |
| 2STY-SLAB | Residential | | Stage | -1.1 | -1.0 | -0.5 | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 |
| | | Structure | Mean % | 0.0 | 0.0 | 0.0 | 5.9 | 19.1 | 25.3 | 26.0 | 30.1 | 32.1 | 43.0 | 46.9 | 47.5 | 47.6 | 52.0 | 61.9 | 64.3 | 65.7 | 67.6 | 69.6 | 69.6 |
| | | | Lower % | 0.0 | 0.0 | 0.0 | 0.0 | 5.8 | 17.2 | 18.1 | 22.6 | 25.4 | 26.6 | 37.0 | 37.0 | 37.0 | 40.4 | 55.0 | 57.6 | 57.6 | 60.0 | 60.4 | 60.4 |
| | | | Upper % | 0.0 | 0.0 | 0.0 | 34.0 | 38.3 | 40.5 | 40.8 | 48.3 | 48.3 | 65.2 | 65.2 | 67.3 | 67.3 | 73.0 | 74.1 | 75.2 | 75.2 | 75.2 | 75.2 | 75.2 |
| | | | Stage | -1.0 | -1.0 | -0.5 | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 |
| | | Contents | Mean % | 0.0 | 0.0 | 0.7 | 21.3 | 24.8 | 30.7 | 34.6 | 37.7 | 45.6 | 50.5 | 56.7 | 60.6 | 61.6 | 62.3 | 68.1 | 68.1 | 72.0 | 74.0 | 75.8 | 77.0 |
| | | | Lower % | 0.0 | 0.0 | 0.0 | 19.6 | 22.9 | 29.7 | 33.5 | 36.5 | 44.2 | 49.0 | 54.0 | 58.7 | 59.7 | 60.4 | 66.0 | 66.0 | 69.7 | 71.7 | 73.4 | 74.6 |
| | | | Upper % | 0.0 | 0.0 | 1.5 | 22.1 | 25.8 | 31.6 | 35.6 | 38.8 | 46.9 | 53.9 | 59.3 | 64.7 | 65.7 | 66.4 | 72.7 | 72.7 | 76.7 | 78.9 | 80.8 | 82.1 |
| AUTO | AUTO | | Stage | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 | 16.0 | 17.0 |
| | | Structure | Mean % | 0.0 | 0.0 | 8.0 | 19.0 | 27.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| | | | Lower % | 0.0 | 0.0 | 4.0 | 13.0 | 18.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| | | | Upper % | 0.0 | 0.0 | 10.0 | 20.0 | 30.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

Table 51 (cont)
Donaldsonville to the Gulf, LA Depth-Damage Relationships for Structures, Contents and Vehicles
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Occupancy Type | Category Name | Damage Type | Parameter | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EAT | COM | | Stage | -1.0 | -0.5 | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 |
| | | Structure | Mean % | 0.0 | 0.6 | 0.6 | 14.3 | 18.6 | 21.4 | 23.5 | 26.2 | 30.9 | 31.3 | 33.0 | 34.6 | 43.6 | 51.0 | 54.1 | 56.8 | 60.1 | 60.4 | 61.6 | 61.8 |
| | | | Lower % | 0.0 | 0.0 | 0.0 | 4.0 | 13.3 | 15.7 | 16.1 | 20.2 | 23.6 | 24.0 | 24.0 | 24.0 | 32.6 | 39.1 | 46.3 | 46.9 | 49.8 | 50.1 | 51.4 | 51.4 |
| | | | Upper % | 0.0 | 1.5 | 1.6 | 21.8 | 23.0 | 31.7 | 33.4 | 35.2 | 39.5 | 39.5 | 49.3 | 54.8 | 61.5 | 68.0 | 68.0 | 68.7 | 69.9 | 69.9 | 70.9 | 70.9 |
| | | | Stage | -1.0 | -0.5 | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 |
| | | Contents | Mean % | 0.0 | 0.0 | 0.0 | 31.2 | 34.3 | 60.3 | 65.0 | 84.0 | 91.0 | 93.4 | 93.4 | 96.1 | 96.1 | 96.1 | 96.1 | 96.1 | 96.1 | 96.1 | 96.1 | 96.1 |
| | | | Lower % | 0.0 | 0.0 | 0.0 | 28.1 | 30.9 | 54.2 | 58.5 | 75.6 | 81.9 | 84.1 | 84.1 | 86.5 | 86.5 | 86.5 | 86.5 | 86.5 | 86.5 | 86.5 | 86.5 | 86.5 |
| | | | Upper % | 0.0 | 0.0 | 0.0 | 39.0 | 42.9 | 75.4 | 81.2 | 89.9 | 95.8 | 97.8 | 97.8 | 98.3 | 98.3 | 98.3 | 98.3 | 98.3 | 98.3 | 98.3 | 98.3 | 98.3 |
| GROC | COM | | Stage | -1.0 | -0.5 | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 |
| | | Structure | Mean % | 0.0 | 0.6 | 0.6 | 14.3 | 18.6 | 21.4 | 23.5 | 26.2 | 30.9 | 31.3 | 33.0 | 34.6 | 43.6 | 51.0 | 54.1 | 56.8 | 60.1 | 60.4 | 61.6 | 61.8 |
| | | | Lower % | 0.0 | 0.0 | 0.0 | 4.0 | 13.3 | 15.7 | 16.1 | 20.2 | 23.6 | 24.0 | 24.0 | 24.0 | 32.6 | 39.1 | 46.3 | 46.9 | 49.8 | 50.1 | 51.4 | 51.4 |
| | | | Upper % | 0.0 | 1.5 | 1.6 | 21.8 | 23.0 | 31.7 | 33.4 | 35.2 | 39.5 | 39.5 | 49.3 | 54.8 | 61.5 | 68.0 | 68.0 | 68.7 | 69.9 | 69.9 | 70.9 | 70.9 |
| | | | Stage | -1.0 | -0.5 | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 |
| | | Contents | Mean % | 0.0 | 0.0 | 85.7 | 87.3 | 87.5 | 88.1 | 89.6 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| | | | Lower % | 0.0 | 0.0 | 71.2 | 78.6 | 78.7 | 79.3 | 80.7 | 58.9 | 89.9 | 89.9 | 90.0 | 90.0 | 90.0 | 90.0 | 90.0 | 90.0 | 90.0 | 90.0 | 90.0 | 90.0 |
| | | | Upper % | 0.0 | 0.0 | 92.7 | 94.9 | 95.7 | 96.1 | 97.7 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| MOBHOM | MOBHOME | | Stage | -1.1 | -1.0 | -0.5 | 0.0 | 0.5 | 1.0 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 |
| | | Structure | Mean % | 0.0 | 10.3 | 12.3 | 34.5 | 62.3 | 64.1 | 68.9 | 71.6 | 74.7 | 79.8 | 80.4 | 81.7 | 94.0 | 94.3 | 95.4 | 95.4 | 95.4 | 95.4 | 95.4 | 95.4 |
| | | | Lower % | 0.0 | 0.0 | 0.0 | 9.6 | 41.1 | 47.0 | 53.3 | 56.9 | 58.5 | 71.0 | 71.0 | 71.0 | 80.9 | 84.6 | 84.6 | 84.6 | 84.6 | 84.6 | 84.6 | 84.6 |
| | | | Upper % | 0.0 | 15.4 | 19.1 | 55.2 | 68.2 | 69.9 | 74.7 | 77.8 | 83.9 | 84.6 | 84.6 | 88.4 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| | | | Stage | -1.0 | -0.5 | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 |
| | | Contents | Mean % | 0.0 | 0.0 | 0.0 | 0.1 | 15.0 | 30.1 | 45.6 | 58.8 | 69.2 | 78.3 | 82.4 | 84.3 | 84.4 | 84.4 | 84.4 | 84.4 | 84.4 | 84.4 | 84.4 | 84.4 |
| | | | Lower % | 0.0 | 0.0 | 0.0 | 0.0 | 14.5 | 29.1 | 44.2 | 57.0 | 67.1 | 75.9 | 79.8 | 81.7 | 81.7 | 81.7 | 81.7 | 81.7 | 81.7 | 81.7 | 81.7 | 81.7 |
| | | | Upper % | 0.0 | 0.0 | 0.0 | 0.1 | 15.4 | 30.9 | 46.9 | 62.8 | 73.9 | 83.6 | 87.9 | 89.9 | 90.0 | 90.0 | 90.0 | 90.0 | 90.0 | 90.0 | 90.0 | 90.0 |
| MULT | COM | | Stage | -1.0 | -0.5 | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 |
| | | Structure | Mean % | 0.0 | 0.0 | 0.0 | 28.1 | 32.8 | 35.2 | 37.9 | 39.7 | 47.2 | 49.7 | 52.0 | 54.6 | 61.7 | 64.9 | 67.8 | 68.0 | 70.3 | 70.4 | 70.6 | 70.9 |
| | | | Lower % | 0.0 | 0.0 | 0.0 | 9.2 | 22.6 | 28.2 | 29.1 | 30.4 | 43.4 | 43.7 | 47.2 | 47.9 | 53.3 | 53.3 | 60.2 | 60.3 | 64.5 | 64.5 | 64.5 | 64.5 |
| | | | Upper % | 0.0 | 0.0 | 0.0 | 38.5 | 45.7 | 49.9 | 51.9 | 52.6 | 54.0 | 58.9 | 59.1 | 71.6 | 78.1 | 78.3 | 78.6 | 78.8 | 79.0 | 79.2 | 79.5 | 79.7 |
| | | | Stage | -1.0 | -0.5 | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 |
| | | Contents | Mean % | 0.0 | 0.0 | 0.0 | 15.2 | 19.9 | 22.4 | 27.7 | 44.5 | 48.9 | 48.9 | 48.9 | 48.9 | 48.9 | 48.9 | 64.1 | 71.3 | 93.4 | 97.8 | 97.8 | 97.8 |
| | | | Lower % | 0.0 | 0.0 | 0.0 | 12.0 | 17.0 | 21.0 | 28.4 | 41.6 | 47.5 | 47.5 | 47.5 | 47.5 | 47.5 | 47.5 | 50.5 | 66.6 | 87.4 | 95.1 | 95.1 | 95.1 |
| | | | Upper % | 0.0 | 0.0 | 0.0 | 16.9 | 21.8 | 23.6 | 30.2 | 46.0 | 50.1 | 50.2 | 51.6 | 51.6 | 51.6 | 51.6 | 70.9 | 75.0 | 96.5 | 100.0 | 100.0 | 100.0 |
| PROF | COM | | Stage | -1.0 | -0.5 | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 |
| | | Structure | Mean % | 0.0 | 0.0 | 4.1 | 16.6 | 18.9 | 21.2 | 24.5 | 27.1 | 35.4 | 36.3 | 36.9 | 38.0 | 41.9 | 51.4 | 52.9 | 54.2 | 54.7 | 54.8 | 55.4 | 55.5 |
| | | | Lower % | 0.0 | 0.0 | 0.2 | 5.3 | 11.1 | 15.3 | 18.7 | 22.7 | 27.4 | 28.0 | 28.0 | 28.0 | 40.1 | 40.3 | 46.3 | 46.3 | 46.3 | 46.3 | 46.3 | 46.3 |
| | | | Upper % | 0.0 | 0.0 | 23.1 | 25.2 | 26.2 | 26.2 | 36.2 | 36.6 | 53.9 | 53.9 | 54.4 | 56.5 | 65.9 | 65.9 | 65.9 | 65.9 | 66.3 | 66.3 | 69.4 | 69.4 |
| | | | Stage | -1.0 | -0.5 | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 |
| | | Contents | Mean % | 0.0 | 0.0 | 0.0 | 26.0 | 31.2 | 34.8 | 38.2 | 67.6 | 86.9 | 86.9 | 99.0 | 99.0 | 99.0 | 99.0 | 99.0 | 99.0 | 99.0 | 99.0 | 99.0 | 99.0 |
| | | | Lower % | 0.0 | 0.0 | 0.0 | 23.4 | 28.0 | 31.3 | 34.4 | 60.9 | 78.3 | 78.3 | 89.2 | 89.2 | 89.2 | 89.2 | 89.2 | 89.2 | 89.2 | 89.2 | 89.2 | 89.2 |
| | | | Upper % | 0.0 | 0.0 | 0.0 | 32.5 | 38.9 | 43.4 | 47.7 | 84.5 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

Table 51 (cont)
Donaldsonville to the Gulf, LA Depth-Damage Relationships for Structures, Contents and Vehicles
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PUBL | COM | | Stage | -1.0 | -0.5 | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 |
| | | Structure | Mean % | 0.0 | 0.6 | 0.6 | 14.3 | 18.6 | 21.4 | 23.5 | 26.2 | 30.9 | 31.3 | 33.0 | 34.6 | 43.6 | 51.0 | 54.1 | 56.8 | 60.1 | 60.4 | 61.6 | 61.8 |
| | | | Lower % | 0.0 | 0.0 | 0.0 | 4.0 | 13.3 | 15.7 | 16.1 | 20.2 | 23.6 | 24.0 | 24.0 | 24.0 | 32.6 | 39.1 | 46.3 | 46.9 | 49.8 | 50.1 | 51.4 | 51.4 |
| | | | Upper % | 0.0 | 1.5 | 1.6 | 21.8 | 23.0 | 31.7 | 33.4 | 35.2 | 39.5 | 39.5 | 49.3 | 54.8 | 61.5 | 68.0 | 68.0 | 68.7 | 69.9 | 69.9 | 70.9 | 70.9 |
| | | | Stage | -1.0 | -0.5 | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 |
| | | Contents | Mean % | 0.0 | 0.0 | 0.0 | 8.6 | 11.7 | 13.6 | 16.6 | 90.2 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| | | | Lower % | 0.0 | 0.0 | 0.0 | 6.5 | 8.8 | 10.2 | 12.4 | 67.6 | 75.0 | 75.0 | 75.0 | 75.0 | 75.0 | 75.0 | 75.0 | 75.0 | 75.0 | 75.0 | 75.0 | 75.0 |
| | | | Upper % | 0.0 | 0.0 | 0.0 | 9.5 | 12.8 | 15.0 | 18.2 | 92.8 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| REPA | COM | | Stage | -1.0 | -0.5 | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 |
| | | Structure | Mean % | 0.0 | 0.0 | 0.0 | 28.1 | 32.8 | 35.2 | 37.9 | 39.7 | 47.2 | 49.7 | 52.0 | 54.6 | 61.7 | 64.9 | 67.8 | 68.0 | 70.3 | 70.4 | 70.6 | 70.9 |
| | | | Lower % | 0.0 | 0.0 | 0.0 | 9.2 | 22.6 | 28.2 | 29.1 | 30.4 | 43.4 | 43.7 | 47.2 | 47.9 | 53.3 | 53.3 | 60.2 | 60.3 | 64.5 | 64.5 | 64.5 | 64.5 |
| | | | Upper % | 0.0 | 0.0 | 0.0 | 38.5 | 45.7 | 49.9 | 51.9 | 52.6 | 54.0 | 58.9 | 59.1 | 71.6 | 78.1 | 78.3 | 78.6 | 78.8 | 79.0 | 79.2 | 79.5 | 79.7 |
| | | | Stage | -1.0 | -0.5 | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 |
| | | Contents | Mean % | 0.0 | 0.0 | 0.0 | 32.9 | 33.7 | 33.7 | 63.9 | 66.0 | 68.0 | 73.0 | 76.4 | 76.4 | 76.4 | 76.4 | 76.4 | 76.4 | 76.4 | 76.4 | 76.4 | 76.4 |
| | | | Lower % | 0.0 | 0.0 | 0.0 | 29.7 | 30.3 | 30.3 | 57.5 | 59.4 | 61.2 | 65.8 | 68.7 | 68.7 | 68.7 | 68.7 | 68.7 | 68.7 | 68.7 | 68.7 | 68.7 | 68.7 |
| | | | Upper % | 0.0 | 0.0 | 0.0 | 41.2 | 42.1 | 42.1 | 79.8 | 82.5 | 85.0 | 91.3 | 95.5 | 95.5 | 95.5 | 95.5 | 95.5 | 95.5 | 95.5 | 95.5 | 95.5 | 95.5 |
| RETA | COM | | Stage | -1.0 | -0.5 | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 |
| | | Structure | Mean % | 0.0 | 0.6 | 0.6 | 14.3 | 18.6 | 21.4 | 23.5 | 26.2 | 30.9 | 31.3 | 33.0 | 34.6 | 43.6 | 51.0 | 54.1 | 56.8 | 60.1 | 60.4 | 61.6 | 61.8 |
| | | | Lower % | 0.0 | 0.0 | 0.0 | 4.0 | 13.3 | 15.7 | 16.1 | 20.2 | 23.6 | 24.0 | 24.0 | 24.0 | 32.6 | 39.1 | 46.3 | 46.9 | 49.8 | 50.1 | 51.4 | 51.4 |
| | | | Upper % | 0.0 | 1.5 | 1.6 | 21.8 | 23.0 | 31.7 | 33.4 | 35.2 | 39.5 | 39.5 | 49.3 | 54.8 | 61.5 | 68.0 | 68.0 | 68.7 | 69.9 | 69.9 | 70.9 | 70.9 |
| | | | Stage | -1.0 | -0.5 | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 |
| | | Contents | Mean % | 0.0 | 0.0 | 0.0 | 55.0 | 66.0 | 77.0 | 88.0 | 89.9 | 91.9 | 93.8 | 99.6 | 99.6 | 99.6 | 99.6 | 99.6 | 99.6 | 99.6 | 99.6 | 99.6 | 99.6 |
| | | | Lower % | 0.0 | 0.0 | 0.0 | 49.4 | 59.4 | 69.1 | 79.2 | 81.0 | 82.6 | 84.4 | 89.7 | 89.7 | 89.7 | 89.7 | 89.8 | 89.8 | 89.8 | 89.8 | 89.8 | 89.8 |
| | | | Upper % | 0.0 | 0.0 | 0.0 | 63.1 | 75.8 | 88.6 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| WARE | COM | | Stage | -1.0 | -0.5 | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 |
| | | Structure | Mean % | 0.0 | 0.0 | 0.0 | 28.1 | 32.8 | 35.2 | 37.9 | 39.7 | 47.2 | 49.7 | 52.0 | 54.6 | 61.7 | 64.9 | 67.8 | 68.0 | 70.3 | 70.4 | 70.6 | 70.9 |
| | | | Lower % | 0.0 | 0.0 | 0.0 | 9.2 | 22.6 | 28.2 | 29.1 | 30.4 | 43.4 | 43.7 | 47.2 | 47.9 | 53.3 | 53.3 | 60.2 | 60.3 | 64.5 | 64.5 | 64.5 | 64.5 |
| | | | Upper % | 0.0 | 0.0 | 0.0 | 38.5 | 45.7 | 49.9 | 51.9 | 52.6 | 54.0 | 58.9 | 59.1 | 71.6 | 78.1 | 78.3 | 78.6 | 78.8 | 79.0 | 79.2 | 79.5 | 79.7 |
| | | | Stage | -1.0 | -0.5 | 0.0 | 0.5 | 1.0 | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 |
| | | Contents | Mean % | 0.0 | 0.0 | 0.0 | 15.6 | 19.4 | 19.4 | 26.8 | 34.1 | 41.6 | 49.0 | 56.5 | 63.9 | 71.4 | 75.2 | 75.2 | 75.2 | 75.2 | 75.2 | 75.2 | 75.2 |
| | | | Lower % | 0.0 | 0.0 | 0.0 | 14.1 | 17.5 | 17.5 | 24.1 | 30.6 | 37.4 | 44.1 | 50.9 | 57.6 | 64.2 | 67.6 | 67.6 | 67.6 | 67.6 | 67.6 | 67.6 | 67.6 |
| | | | Upper % | 0.0 | 0.0 | 0.0 | 19.6 | 24.4 | 24.4 | 33.5 | 42.7 | 51.9 | 61.2 | 70.6 | 79.9 | 89.1 | 93.9 | 93.9 | 93.9 | 93.9 | 93.9 | 93.9 | 93.9 |

Source: *Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-to-Structure Value Ratios (CSVRs) in Support of the Donaldsonville to the Gulf, Louisiana, Feasibility Study Final Report dated March 2006*
Note: Long duration, saltwater depth-damage relationships were used for the sensitivity analysis

Table 52
3% Annual Exceedance Probability Alternative Using Donaldsonville to the Gulf Depth-Damage Relationships
(2011 Price Level; 3.75% Discount Rate)
Total Equivalent Annual Net Benefits
Sensitivity Analysis
Morganza to the Gulf
Post-Authorization Change Report
($ Millions)

| Item | Equiv Annual W/O Project Damages (2035-2084) | Equiv Annual With-Project Damages (2035-2084) | Equiv Annual Benefits (2035-2084) | Equiv Annual Benefits During Construction (2024-2034) | Total Equiv Annual Benefits | Adjusted Total Equiv Annual Benefits |
|---|---|---|---|---|---|---|
| Damage Category | | | | | | |
| Residential & Commercial - Structure/Content/Vehicles | $ 615.2 | $ 319.0 | $ 296.3 | $ 126.4 | $ 422.6 | |
| Industrial - Structure/Contents | $ 16.5 | $ 6.4 | $ 10.1 | $ 4.4 | $ 14.5 | |
| Highways | $ 6.6 | $ 4.2 | $ 2.3 | $ 1.1 | $ 3.4 | |
| Streets | $ 15.5 | $ 5.6 | $ 9.9 | $ 3.7 | $ 13.6 | |
| Debris Removal & Cleanup | $ 25.7 | $ 12.6 | $ 13.1 | $ 5.9 | $ 19.0 | |
| Water Supply | $ 0.1 | $ 0.1 | $ 0.1 | $ 0.1 | $ 0.2 | |
| Boat Fleets | $ 0.0 | $ 0.0 | $ 0.0 | $ 0.0 | $ 0.0 | |
| Avoided Structure-Raising Costs | $ 4.9 | $ - | $ 4.9 | $ 5.3 | $ 10.3 | |
| Total | $ 684.6 | $ 347.9 | $ 336.7 | $ 146.8 | $ 483.6 | $ 532 |
| | | | | | | |
| | | | | | | |
| First Costs | | | | | | $ 5,902 |
| Interest During Construction | | | | | | $ 3,937 |
| Annual Operation & Maintenance Costs | | | | | | $ 6 |
| Total Annual Costs | | | | | | $ 438 |
| | | | | | | |
| B/C Ratio | | | | | | 1.21 |
| Equivalent Annual Net Benefits - 2035 Base Year | | | | | | $ 94 |

*Total equivalent annual benefits, net benefits and b/c ratio were adjusted to reflect changes in M2G CSVRs following model certification.

Table 53
1% Annual Exceedance Probability Alternative Using Donaldsonville to the Gulf Depth-Damage Relationships
(2011 Price Level; 3.75% Discount Rate)
Total Equivalent Annual Net Benefits
Sensitivity Analysis
Morganza to the Gulf
Post-Authorization Change Report
($ Millions)

| Item | Equiv Annual W/O Project Damages (2035-2084) | Equiv Annual With-Project Damages (2035-2084) | Equiv Annual Benefits (2035-2084) | Equiv Annual Benefits During Construction (2024-2034) | Total Equiv Annual Benefits | |
|---|---|---|---|---|---|---|
| | | | | | | |
| Damage Category | | | | | | |
| Residential & Commercial - Structure/Content/Vehicles | $ 615.2 | $ 98.5 | $ 516.7 | $ 166.1 | $ 682.8 | |
| Industrial - Structure/Contents | $ 16.5 | $ 1.3 | $ 15.2 | $ 5.1 | $ 20.3 | |
| Highways | $ 6.6 | $ 2.3 | $ 4.3 | $ 1.5 | $ 5.7 | |
| Streets | $ 15.5 | $ 2.3 | $ 13.3 | $ 4.2 | $ 17.4 | |
| Debris Removal & Cleanup | $ 25.7 | $ 4.0 | $ 21.7 | $ 7.3 | $ 29.0 | |
| Water Supply | $ 0.1 | $ 0.1 | $ 0.1 | $ 0.1 | $ 0.2 | |
| Boat Fleets | $ 0.0 | $ 0.0 | $ 0.0 | $ 0.0 | $ 0.0 | |
| Avoided Structure-Raising Costs | $ 4.9 | $ - | $ 4.9 | $ 5.3 | $ 10.3 | |
| Total | $ 684.6 | $ 108.4 | $ 576.2 | $ 189.6 | $ 765.8 | $ 832 |
| | | | | | | |
| | | | | | | |
| First Costs | | | | | | $ 10,177 |
| Interest During Construction | | | | | | $ 5,864 |
| Annual Operation & Maintenance Costs | | | | | | $ 7 |
| Total Annual Costs | | | | | | $ 710 |
| | | | | | | |
| B/C Ratio | | | | | | 1.17 |
| Equivalent Annual Net Benefits Base Year 2035 | | | | | | |
| *Total equivalent annual benefits, net benefits and b/c ratio were adjusted to reflect changes in M2G CSVRs following model certification. | | | | | | $ 122 |

Table 54
3% Annual Exceedance Probability Alternative
(2012 Price Level; 3.75% Discount Rate)
Total Equivalent Annual Net Benefits
Morganza to the Gulf
Post-Authorization Change Report
($ Millions)

| Item | Equiv Annual W/O Project Damages (2035-2084) | Equiv Annual With-Project Damages (2035-2084) | Equiv Annual Benefits (2035-2084) | Equiv Annual Benefits During Construction (2024-2034) | Total Equiv Annual Benefits | |
|---|---|---|---|---|---|---|
| Damage Category | | | | | | |
| Residential & Commercial - Structure/Content/Vehicles | $ 834.3 | $ 417.3 | $ 417.0 | $ 176.9 | $ 593.9 | |
| Industrial - Structure/Contents | $ 16.8 | $ 6.5 | $ 10.3 | $ 4.5 | $ 14.8 | |
| Highways | $ 6.9 | $ 4.5 | $ 2.5 | $ 1.1 | $ 3.6 | |
| Streets | $ 16.5 | $ 6.0 | $ 10.5 | $ 3.9 | $ 14.4 | |
| Debris Removal & Cleanup | $ 26.2 | $ 12.8 | $ 13.3 | $ 6.0 | $ 19.3 | |
| Water Supply | $ 0.1 | $ 0.1 | $ 0.1 | $ 0.1 | $ 0.2 | |
| Boat Fleets | $ 0.0 | $ 0.0 | $ 0.0 | $ 0.0 | $ 0.0 | |
| Avoided Structure-Raising Costs | $ 5.0 | $ - | $ 5.0 | $ 5.4 | $ 10.4 | |
| Total | $ 905.8 | $ 447.1 | $ 458.7 | $ 197.9 | $ 656.6 | |
| | | | | | | |
| | | | | | | |
| First Costs | | | | | | $ 5,950 |
| Interest During Construction | | | | | | $ 3,981 |
| Annual Operation & Maintenance Costs | | | | | | $ 6 |
| Total Annual Costs | | | | | | $ 442 |
| | | | | | | |
| B/C Ratio | | | | | | 1.48 |
| Equivalent Annual Net Benefits - 2035 Base Year | | | | | | 214 |

Note: The following indexes were used to update the benefit categories and cost values from 2011 to 2012: the Construction Index developed by the Bureau of Labor Statistics was used for residential and non-residential benefit categories, including the industrial benefit category, and the avoided structure-raising costs category; the National Highway Construction Cost Index was used for the highway and streets benefit categories; the Remediation Services Index developed by the Bureau of Labor Statistics was used for the debris removal and cleanup benefit category and the Diesel Fuel Price Index developed by the Energy Information Administration was used for boat fleets benefit category.
Costs were calculated to reflect 2012 prices.

Table 55
1% Annual Exceedance Probability Alternative
(2012 Price Level; 3.75% Discount Rate)
Total Equivalent Annual Net Benefits
Morganza to the Gulf
Post-Authorization Change Report
($ Millions)

| Item | Equiv Annual W/O Project Damages (2035-2084) | Equiv Annual With-Project Damages (2035-2084) | Equiv Annual Benefits (2035-2084) | Equiv Annual Benefits During Construction (2024-2034) | Total Equiv Annual Benefits | |
|---|---|---|---|---|---|---|
| Damage Category | | | | | | |
| Residential & Commercial - Structure/Content/Vehicles | $ 834.3 | $ 125.6 | $ 708.7 | $ 229.1 | $ 937.8 | |
| Industrial - Structure/Contents | $ 16.8 | $ 1.3 | $ 15.5 | $ 5.2 | $ 20.7 | |
| Highways | $ 6.9 | $ 2.4 | $ 4.5 | $ 1.6 | $ 6.1 | |
| Streets | $ 16.5 | $ 2.4 | $ 14.1 | $ 4.4 | $ 18.5 | |
| Debris Removal & Cleanup | $ 26.2 | $ 4.1 | $ 22.1 | $ 7.4 | $ 29.5 | |
| Water Supply | $ 0.1 | $ 0.1 | $ 0.1 | $ 0.1 | $ 0.2 | |
| Boat Fleets | $ 0.0 | $ 0.0 | $ 0.0 | $ 0.0 | $ 0.0 | |
| Avoided Structure-Raising Costs | $ 5.0 | $ - | $ 5.0 | $ 5.4 | $ 10.4 | |
| Total | $ 905.8 | $ 135.8 | $ 770.0 | $ 253.3 | $ 1,023.3 | |
| | | | | | | |
| | | | | | | |
| First Costs | | | | | | $ 10,265 |
| Interest During Construction | | | | | | $ 5,914 |
| Annual Operation & Maintenance Costs | | | | | | $ 7 |
| Total Annual Costs | | | | | | $ 716 |
| | | | | | | |
| B/C Ratio | | | | | | 1.43 |
| | | | | | | |
| Equivalent Annual Net Benefits Base Year 2035 | | | | | | $ 307 |

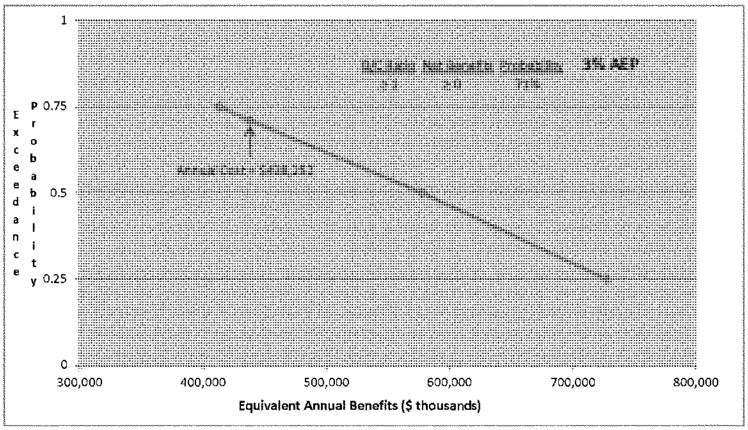
Note: The following indexes were used to update the benefit categories and cost values from 2011 to 2012: the Construction Index developed by the Bureau of Labor Statistics was used for residential and non-residential benefit categories, including the industrial benefit category, and the avoided structure-raising costs category; the National Highway Construction Cost Index was used for the highway and streets benefit categories; the Remediation Services Index developed by the Bureau of Labor Statistics was used for the debris removal and cleanup benefit category and the Diesel Fuel Price Index developed by the Energy Information Administration was used for boat fleets benefit category.
Costs were calculated to reflect 2012 prices.

Table 56
Equivalent Annual Damages and Benefits (1000's)
(2024-2085)
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Plan Name | Equivalent Annual Damage | | | Probability Damage Reduced Exceeds Indicated Values (Forecasted) | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total Without Project | Total With Project | Damages Reduced | 1.00 | 0.75 | [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | $ [illegible] | [illegible] | [illegible] | $ [illegible] | $ [illegible] | $ [illegible] | $ [illegible] | $ [illegible] | $ [illegible] |
| [illegible] | $ [illegible] | $ [illegible] | $ [illegible] | $ [illegible] | $ [illegible] | $ [illegible] | $ [illegible] | $ [illegible] | $ [illegible] |

Note: Based on CSVR values after model certification and 2011 prices.

Notes 1: A trend function was applied to estimate the forecasted damaged reduced values above 0.75.
2: Highlighted values represent the equivalent annual cost (1,000s) of each alternative.
3: The 3% AEP has a 71 percent chance of having postivite net benefits.
4: The 1% AEP has a 69 percent chance of having postivite net benefits.



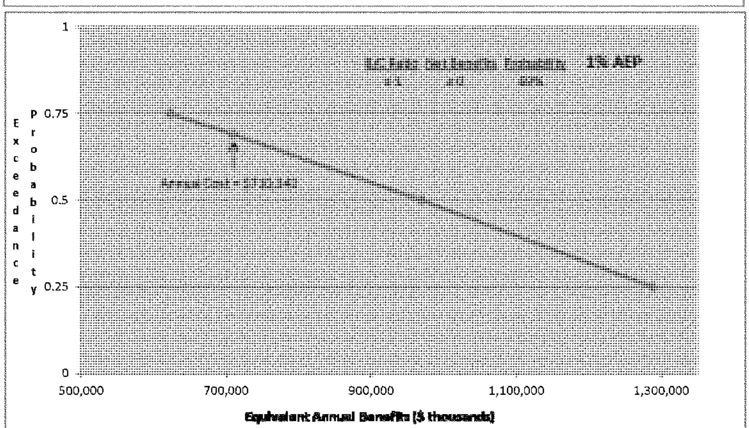



Table 57
Residual Risk for Total Study Area in 2035
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| | Without Project | | 3% Alt | 1% Alt |
|---|---|---|---|---|
| ACE | Number of Structures Damaged assuming Non-Federal Levees Fail (No Autos) | Damages assuming Non-Federal Levees Fail ($1,000s) | Residual Damages assuming Federal Levees do not Fail ($1,000s) | |
| 0.99 | 260 | $ 17,341 | $ - | $ - |
| 0.20 | 1,120 | $ 34,788 | $ - | $ - |
| 0.10 | 5,585 | $ 270,082 | $ - | $ - |
| 0.04 | 34,943 | $ 4,308,716 | $ - | $ - |
| 0.02 | 48,362 | $ 9,893,168 | $ 12,011,222 | $ - |
| 0.01 | 58,836 | $ 12,266,509 | $ 14,835,662 | $ - |
| 0.005 | 61,166 | $ 14,947,946 | $ 15,900,216 | $ 15,900,216 |
| 0.002 | 61,387 | $ 16,095,073 | $ 16,708,703 | $ 16,708,703 |

Note: It should be noted that the residual risk will be higher with the project alternatives in place relative to the without-project conditions since structures below the 10% ACE (10-year) event are elevated above the 1% ACE (100-year) event to account for the response of residents to repetitive flood loss. Also, the residual damages under with-project conditions are higher since the structure detail output file produced by the HEC-FDA model uses the exterior water surface profiles to the Federal levee to show damages under with-project conditions and interior water surface profiles to the non-Federal levee to show damages under without project conditions.

Source: HEC-FDA model Structure Detail output file for the year 2035.

Table 58
Total Study Area Depth of Flooding for the 1% ACE (100-year) Event in 2035
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| *Depth of Flooding in Feet* | *Number of Structures** | *Percentage by Bin* |
|---|---|---|
| 0 | 11,679 | 19.00% |
| 3 | 7,384 | 12.02% |
| 6 | 21,980 | 35.77% |
| 9 | 18,396 | 29.94% |
| 12 | 1,827 | 2.97% |
| >12 | 187 | 0.30% |
| Total Number of Structures | | 61,453 |
| Total Number of Structures that have a depth of flooding >0 | | 49,773 |

* No Automobiles

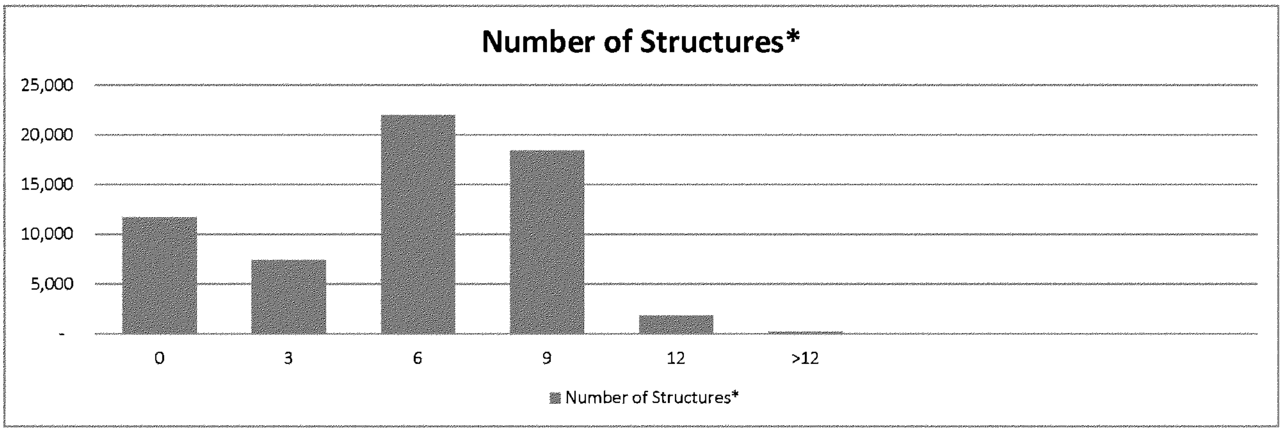


Table 59
Levee Performance Annual Exceedance Probability
(2010-2085)
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Study Area Reach 11BW79 Station 64 | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2010 | | | | | | | | | | | | |
| Plan Name | Target Stage | Target Stage Annual Exceedance Probability | | Long-Term Risk (years) | | | Conditional Non-Exceedance Probability by Events | | | | | |
| | | Median | Expected | 10 | 30 | 50 | 0.1000 | 0.0400 | 0.0200 | 0.0100 | 0.0040 | 0.0020 |
| Without | Levee | 0.1068 | 0.1054 | 0.6719 | 0.9647 | 0.9962 | 0.8864 | 0.2528 | 0.0864 | 0.0441 | 0.0233 | 0.0153 |
| 2024 | | | | | | | | | | | | |
| Plan Name | Target Stage | Target Stage Annual Exceedance Probability | | Long-Term Risk (years) | | | Conditional Non-Exceedance Probability by Events | | | | | |
| | | Median | Expected | 10 | 30 | 50 | 0.1000 | 0.0400 | 0.0200 | 0.0100 | 0.0040 | 0.0020 |
| Without | Levee | 0.1147 | 0.1136 | 0.7005 | 0.9731 | 0.9976 | 0.8423 | 0.2053 | 0.0637 | 0.0292 | 0.0150 | 0.0098 |
| 3% | 9.4 | 0.0254 | 0.0271 | 0.2399 | 0.5609 | 0.7463 | 0.9998 | 0.7857 | 0.3715 | 0.1786 | 0.0953 | 0.0509 |
| 1% | 13.6 | 0.0072 | 0.0104 | 0.0997 | 0.2702 | 0.4084 | 0.9998 | 0.9915 | 0.8250 | 0.5631 | 0.3645 | 0.2204 |
| 2035 | | | | | | | | | | | | |
| Plan Name | Target Stage | Target Stage Annual Exceedance Probability | | Long-Term Risk (years) | | | Conditional Non-Exceedance Probability by Events | | | | | |
| | | Median | Expected | 10 | 30 | 50 | 0.1000 | 0.0400 | 0.0200 | 0.0100 | 0.0040 | 0.0020 |
| Without | Levee | 0.1196 | 0.1190 | 0.7184 | 0.9579 | 0.9982 | 0.7955 | 0.1743 | 0.0492 | 0.0206 | 0.0106 | 0.0066 |
| 3% | 10.5 | 0.0237 | 0.0256 | 0.2287 | 0.4776 | 0.7269 | 0.9997 | 0.7959 | 0.4132 | 0.2097 | 0.1107 | 0.0628 |
| 1% | 15.9 | 0.0040 | 0.0072 | 0.0697 | 0.1654 | 0.3034 | 0.9997 | 0.9976 | 0.9156 | 0.7153 | 0.4977 | 0.3305 |
| 2085 | | | | | | | | | | | | |
| Plan Name | Target Stage | Target Stage Annual Exceedance Probability | | Long-Term Risk (years) | | | Conditional Non-Exceedance Probability by Events | | | | | |
| | | Median | Expected | 10 | 30 | 50 | 0.1000 | 0.0400 | 0.0200 | 0.0100 | 0.0040 | 0.0020 |
| Without | Levee | 0.2231 | 0.2193 | 0.9159 | 0.9994 | 1.0000 | 0.3740 | 0.0564 | 0.0195 | 0.0104 | 0.0054 | 0.0042 |
| 3% | 11.2 | 0.0307 | 0.0330 | 0.2849 | 0.6343 | 0.8130 | 0.9994 | 0.6656 | 0.2913 | 0.1279 | 0.0546 | 0.0310 |
| 1% | 18.3 | 0.0033 | 0.0052 | 0.0505 | 0.1441 | 0.2284 | 0.9998 | 0.9998 | 0.9764 | 0.8291 | 0.5569 | 0.3822 |

Note: Non-Federal Levee has 7 foot top of levee elevation under without-project conditions.

Table 59 (Cont.)
Levee Performance Annual Exceedance Probability
(2010-2085)
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Study Area Reach 11BW5 Station 58 | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2010 | | | | | | | | | | | | |
| Plan Name | Target Stage | Target Stage Annual Exceedance Probability | | Long-Term Risk (years) | | | Conditional Non-Exceedance Probability by Events | | | | | |
| | | Median | Expected | 10 | 30 | 50 | 0.1000 | 0.0400 | 0.0200 | 0.0100 | 0.0040 | 0.0020 |
| Without | Levee | 0.0663 | 0.0683 | 0.5072 | 0.8803 | 0.9709 | 0.8226 | 0.2587 | 0.0509 | 0.0245 | 0.0129 | 0.0084 |
| 2024 | | | | | | | | | | | | |
| Plan Name | Target Stage | Target Stage Annual Exceedance Probability | | Long-Term Risk (years) | | | Conditional Non-Exceedance Probability by Events | | | | | |
| | | Median | Expected | 10 | 30 | 50 | 0.1000 | 0.0400 | 0.0200 | 0.0100 | 0.0040 | 0.0020 |
| Without | Levee | 0.0842 | 0.0827 | 0.5782 | 0.9249 | 0.9866 | 0.7681 | 0.1777 | 0.0423 | 0.0191 | 0.0096 | 0.0060 |
| 3% | 9.4 | 0.0253 | 0.0269 | 0.2389 | 0.5591 | 0.7446 | 0.9997 | 0.7993 | 0.3681 | 0.1727 | 0.0890 | 0.0455 |
| 1% | 13.6 | 0.0072 | 0.0103 | 0.0987 | 0.2679 | 0.4053 | 0.9997 | 0.9930 | 0.8309 | 0.5654 | 0.3608 | 0.2132 |
| 2035 | | | | | | | | | | | | |
| Plan Name | Target Stage | Target Stage Annual Exceedance Probability | | Long-Term Risk (years) | | | Conditional Non-Exceedance Probability by Events | | | | | |
| | | Median | Expected | 10 | 30 | 50 | 0.1000 | 0.0400 | 0.0200 | 0.0100 | 0.0040 | 0.0020 |
| Without | Levee | 0.1191 | 0.1200 | 0.7214 | 0.9590 | 0.9983 | 0.7131 | 0.1369 | 0.0351 | 0.0137 | 0.0067 | 0.0039 |
| 3% | 10.5 | 0.0237 | 0.0256 | 0.2296 | 0.4774 | 0.7269 | 0.9997 | 0.7959 | 0.4132 | 0.2097 | 0.1107 | 0.0628 |
| 1% | 15.9 | 0.0040 | 0.0072 | 0.0696 | 0.1650 | 0.3029 | 0.9997 | 0.9976 | 0.9156 | 0.7153 | 0.4977 | 0.3305 |
| 2085 | | | | | | | | | | | | |
| Plan Name | Target Stage | Target Stage Annual Exceedance Probability | | Long-Term Risk (years) | | | Conditional Non-Exceedance Probability by Events | | | | | |
| | | Median | Expected | 10 | 30 | 50 | 0.1000 | 0.0400 | 0.0200 | 0.0100 | 0.0040 | 0.0020 |
| Without | Levee | 0.3564 | 0.3460 | 0.9857 | 1.0000 | 1.0000 | 0.2489 | 0.0384 | 0.0128 | 0.0062 | 0.0029 | 0.0031 |
| 3% | 11.2 | 0.0307 | 0.0327 | 0.2832 | 0.6317 | 0.8108 | 0.9993 | 0.6693 | 0.2954 | 0.1304 | 0.0566 | 0.0327 |
| 1% | 18.3 | 0.0033 | 0.0052 | 0.0505 | 0.1441 | 0.2284 | 0.9998 | 0.9998 | 0.9764 | 0.8291 | 0.5569 | 0.3822 |

Note: Non-Federal Levee has 5.5 foot top of levee elevation under without-project conditions.

Table 59 (Cont.)
Levee Performance Annual Exceedance Probability
(2010-2085)
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Study Area Reach 1-5 Station 82 | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2010 | | | | | | | | | | | | |
| Plan | Target | Target Stage Annual Exceedance Probability | | Long-Term Risk (years) | | | Conditional Non-Exceedance Probability by Events | | | | | |
| Name | Stage | Median | Expected | 10 | 30 | 50 | 0.1000 | 0.0400 | 0.0200 | 0.0100 | 0.0040 | 0.0020 |
| Without | Levee | 0.1863 | 0.1786 | 0.8602 | 0.9973 | 0.9999 | 0.3185 | 0.0524 | 0.0145 | 0.0089 | 0.0051 | 0.0036 |
| 2024 | | | | | | | | | | | | |
| Plan | Target | Target Stage Annual Exceedance Probability | | Long-Term Risk (years) | | | Conditional Non-Exceedance Probability by Events | | | | | |
| Name | Stage | Median | Expected | 10 | 30 | 50 | 0.1000 | 0.0400 | 0.0200 | 0.0100 | 0.0040 | 0.0020 |
| Without | Levee | 0.4063 | 0.3854 | 0.9923 | 1.0000 | 1.0000 | 0.1626 | 0.0259 | 0.0106 | 0.0054 | 0.0028 | 0.0020 |
| 3% | 14.8 | 0.0159 | 0.0184 | 0.1693 | 0.2890 | 0.4336 | 0.9997 | 0.9851 | 0.8042 | 0.5544 | 0.3133 | 0.1978 |
| 1% | 17.2 | 0.0026 | 0.0048 | 0.0467 | 0.1336 | 0.2126 | 0.9998 | 0.9997 | 0.9712 | 0.8476 | 0.6097 | 0.4355 |
| 2035 | | | | | | | | | | | | |
| Plan | Target | Target Stage Annual Exceedance Probability | | Long-Term Risk (years) | | | Conditional Non-Exceedance Probability by Events | | | | | |
| Name | Stage | Median | Expected | 10 | 30 | 50 | 0.1000 | 0.0400 | 0.0200 | 0.0100 | 0.0040 | 0.0020 |
| Without | Levee | 0.7554 | 0.7538 | 1.0000 | 1.0000 | 1.0000 | 0.0025 | 0.0052 | 0.0007 | 0.0027 | 0.0014 | 0.0001 |
| 3% | 16.2 | 0.0074 | 0.0101 | 0.9690 | 0.2250 | 0.3993 | 0.9997 | 0.9919 | 0.8486 | 0.5902 | 0.3356 | 0.2126 |
| 1% | 20.5 | 0.0015 | 0.0031 | 0.0302 | 0.0737 | 0.1419 | 0.9998 | 0.9998 | 0.9941 | 0.9310 | 0.7404 | 0.5635 |
| 2085 | | | | | | | | | | | | |
| Plan | Target | Target Stage Annual Exceedance Probability | | Long-Term Risk (years) | | | Conditional Non-Exceedance Probability by Events | | | | | |
| Name | Stage | Median | Expected | 10 | 30 | 50 | 0.1000 | 0.0400 | 0.0200 | 0.0100 | 0.0040 | 0.0020 |
| Without | Levee | 0.0904 | 0.0939 | 0.6270 | 0.9481 | 0.9928 | 0.6308 | 0.1048 | 0.0340 | 0.0166 | 0.0092 | 0.0059 |
| 3% | 15.8 | 0.0159 | 0.0184 | 0.1693 | 0.4267 | 0.6044 | 0.9996 | 0.9277 | 0.6095 | 0.3093 | 0.1442 | 0.0843 |
| 1% | 21.8 | 0.0023 | 0.0040 | 0.0394 | 0.1136 | 0.1820 | 0.9998 | 0.9997 | 0.9909 | 0.8875 | 0.6450 | 0.4635 |

Note: Non-Federal Levee has 3.0 foot top of levee elevation under without-project conditions.

Table 59 (Cont.)
Levee Performance Annual Exceedance Probability
(2010-2085)
Morganza to the Gulf of Mexico, LA
Post-Authorization Change Report

| Study Area Reach BL89 Station 298 | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2010 | | | | | | | | | | | | |
| Plan | Target | Target Stage Annual Exceedance Probability | | Long-Term Risk (years) | | | Conditional Non-Exceedance Probability by Events | | | | | |
| Name | Stage | Median | Expected | 10 | 30 | 50 | 0.1000 | 0.0400 | 0.0200 | 0.0100 | 0.0040 | 0.0020 |
| Without | Levee | 0.0529 | 0.0545 | 0.4289 | 0.8137 | 0.9392 | 0.9978 | 0.1924 | 0.0384 | 0.0107 | 0.0000 | 0.0000 |
| 2024 | | | | | | | | | | | | |
| Plan | Target | Target Stage Annual Exceedance Probability | | Long-Term Risk (years) | | | Conditional Non-Exceedance Probability by Events | | | | | |
| Name | Stage | Median | Expected | 10 | 30 | 50 | 0.1000 | 0.0400 | 0.0200 | 0.0100 | 0.0040 | 0.0020 |
| Without | Levee | 0.0691 | 0.0717 | 0.5247 | 0.8926 | 0.9757 | 0.8180 | 0.1383 | 0.0415 | 0.0177 | 0.0060 | 0.0027 |
| 3% | 14.7 | 0.0111 | 0.0135 | 0.1270 | 0.3347 | 0.4929 | 0.9997 | 0.9778 | 0.7508 | 0.4534 | 0.2328 | 0.1417 |
| 1% | 17.3 | 0.0050 | 0.0074 | 0.0714 | 0.1992 | 0.3095 | 0.9997 | 0.9989 | 0.9330 | 0.7091 | 0.4313 | 0.2776 |
| 2035 | | | | | | | | | | | | |
| Plan | Target | Target Stage Annual Exceedance Probability | | Long-Term Risk (years) | | | Conditional Non-Exceedance Probability by Events | | | | | |
| Name | Stage | Median | Expected | 10 | 30 | 50 | 0.1000 | 0.0400 | 0.0200 | 0.0100 | 0.0040 | 0.0020 |
| Without | Levee | 0.0899 | 0.0866 | 0.5956 | 0.8960 | 0.9892 | 0.5336 | 0.2005 | 0.0509 | 0.0111 | 0.0017 | 0.0000 |
| 3% | 15.1 | 0.0130 | 0.0154 | 0.1436 | 0.3213 | 0.5394 | 0.9996 | 0.9623 | 0.6913 | 0.3948 | 0.2002 | 0.1234 |
| 1% | 20.3 | 0.0027 | 0.0046 | 0.0453 | 0.1094 | 0.2068 | 0.9997 | 0.9997 | 0.9821 | 0.8542 | 0.6016 | 0.4254 |
| 2085 | | | | | | | | | | | | |
| Plan | Target | Target Stage Annual Exceedance Probability | | Long-Term Risk (years) | | | Conditional Non-Exceedance Probability by Events | | | | | |
| Name | Stage | Median | Expected | 10 | 30 | 50 | 0.1000 | 0.0400 | 0.0200 | 0.0100 | 0.0040 | 0.0020 |
| Without | Levee | 0.2475 | 0.2358 | 0.9324 | 0.9997 | 1.0000 | 0.1590 | 0.0275 | 0.0027 | 0.0000 | 0.0000 | 0.0000 |
| 3% | 14.4 | 0.0250 | 0.0272 | 0.2411 | 0.5630 | 0.7483 | 0.9996 | 0.7727 | 0.3886 | 0.1808 | 0.0857 | 0.0529 |
| 1% | 21.8 | 0.0031 | 0.0052 | 0.0509 | 0.1450 | 0.2298 | 0.9998 | 0.9997 | 0.9738 | 0.8181 | 0.5638 | 0.4026 |

Note: Non-Federal Levee has 5.0 foot top of levee elevation under without-project conditions.

# Regional Economic Development Appendix
# Morganza to the Gulf of Mexico, La

## Table of Contents

# Definitions

**Gross Regional Product**: total economic activity in the study area during the model year as measured by either production value of final goods and services (final demand) or income generation to factors of production (value added).

**Employment**: average annual jobs, both full and part time, not full time equivalents.

**Labor Income**: all forms of employment income, including employee compensation (wages and benefits) and proprietor income.

**Output**: represents the value of industry production, includes both value added and intermediate goods purchased in the economy.

**Direct Effects**: the response (change in employment, income, output, or gross regional product) for a given industry to a change in its final demand.

**Indirect Effects**: the impacts caused by industries purchasing from other industries in response to final demand changes, a multiplier effect.

**Induced Effects**: the impacts on all local industries caused by the expenditures of new household income generated by the direct and indirect effects of final demand changes, a multiplier effect.

## Background:

The Morganza to the Gulf of Mexico hurricane risk reduction system is located in the parishes of Terrebonne and Lafourche. The project is being constructed in response to reoccurring hurricane storm damage and is designed to prevent the loss of life, to reduce flood damages, to reduce negative impacts on navigation, and to prevent the destruction of wetlands. This flood risk reduction system would encompass an estimated 120,000 people.

### Construction Alternatives:

For this analysis two construction alternatives are being examined: One alternative has a levee height that reduces flood risk up to the 1% annual exceedance probability (AEP) flood event; the other alternative has a levee height that reduces flood risk up to the 3% AEP flood event. This 3% AEP alternative was originally the 1% AEP alternative according to the pre-Katrina requirements for levee construction.

### Study Area

The study area of Morganza to the Gulf consists of 20 parishes that were selected by the RECONS project team based on the labor market, commuter-shed, and population centers serving the project location (see table 1). According to RECONS' 2009 data, the population of the study area is 2,199,734. The number of households is 816,005. Total personal income is $90,517,000,000. The employment rate in the study area is 91%. The other region identified is the rest of Louisiana and consists of every other parish except for the ones in the study area.[1]

## Methodology:

This Regional Economic Development (RED) analysis employs input-output economic analysis, which measures the interdependence among industries and workers in an economy. This analysis uses a matrix representation of a region's economy to predict the effect of changes in one industry on others. The greater the interdependence among industry sectors, the larger the multiplier effect on the economy. Changes to government spending drive the input-output model to project new levels of sales (output), value added (GRP), employment, and income for each industry.

The specific input-output model used in this analysis is RECONS (Regional Economic System). This model was developed by the Institute for Water Resources (IWR), Michigan State University, and the Louis Berger Group. RECONS uses industry multipliers derived from the commercial input-output model IMPLAN to estimate the effects that spending on USACE projects has on a regional economy. The model is linear and static, showing relationships and impacts at a certain fixed point in time. Spending impacts are composed of three different effects: direct, indirect, and induced.

Direct effects represent the impacts the new federal expenditures have on industries which directly support the new project. Labor and construction materials can be considered direct components

[1] These metrics are current as of 2009, the year of the data used in the model.

to the project. Indirect effects represent changes to secondary industries that support the direct industries. Induced effects are changes in consumer spending patterns caused by the change in employment and income within the industries affected by the direct and induced effects. The additional income workers receive via a project may be spent on clothing, groceries, dining out, and other items in the regional area.

The inputs for the RECONS model are expenditures that are entered by work activity or industry sector, each with its own unique production function. For construction, the following work activities were identified: construction and major repairs of floodwalls, construction and major repair of earthen levees, construction activities for ecosystem and habitat restoration, lock or dam gate fabrication and installation, and lock construction of on-site features. For preconstruction, engineering, and design (PE&D), sector 369 engineering services was selected. For Supervision and administration (S&A), sector 386, business support services was selected. For pipeline relocation, sector 39 repair and maintenance construction activities was selected. And for environmental mitigation, the work activity remediation activities and services was selected.[2] The baseline data used by RECONS to represent the regional economy of Louisiana are annual averages from the Bureau of the Census, the Bureau of Labor Statistics, and the Bureau of Economic Analysis for the year 2009. The model results are expressed in 2011 dollars.

Assumptions

Input-output analysis rests on the following assumptions. The production functions of industries have constant returns to scale, so if output is to increase, inputs will increase in the same proportion. Industries face no supply constraints; they have access to all the materials they can use. Industries have a fixed commodity input structure; they will not substitute any commodities or services used in the production of output in response to price changes. Industries produce their commodities in fixed proportions, so an industry will not increase production of a commodity without increasing production in every other commodity it produces. Furthermore, it is assumed that industries use the same technology to produce all of its commodities. Finally, since the model is static, it is assumed that the economic conditions of 2009, the year of the socio-economic data in the RECONS model database, will prevail during the years of the construction process.

Column Descriptions for Tables 1 and 2

"Total Construction Stimulus" is the sum of all inputs including construction, preconstruction, engineering, and design (PED), supervision and administration (S&A), utility relocation, and environmental mitigation. "Output" is the sum total of transactions that take place as a result of the construction project, including both value added and intermediate goods purchased in the economy. "Labor Income" includes all forms of employment income, including employee compensation (wages and benefits) and proprietor income. "Gross Regional Product (GRP)" is the value-added output of the study regions. This metric captures all final goods and services produced in the study areas because of

[2] Real Estate transactions are considered a transfer of an asset resulting in no multiplier effects, and, therefore, are not included in this RED analysis.

the project's existence. It is different from output in the sense that one dollar of a final good or service may have multiple transactions associated with it. "Employment" is the estimated worker-years of labor required to build the project.

## Results

For the 3% AEP alternative, the construction stimulus of $5,897,000,000 would generate 85,000 worker-years of labor, $4,239,000,000 in labor income, $8,839,000,000 in output, and $5,802,000,000 in Gross Regional Product (see table 2). For the 1% AEP alternative, the construction stimulus of $9,819,915,000 would generate 155,000 worker-years of labor, $7,654,000,000 in labor income, $15,254,000,000 in output, and $10,243,000,000 in Gross Regional Product (see table 2).

In the remaining parishes for the 3% AEP alternative, the construction stimulus of $5,897,000,000 would generate 1,600 worker-years of labor, $40,000,000 in labor income, $151,000,000 in output, and $61,000,000 in Gross Regional Product. For the 1% AEP alternative, the construction stimulus of $9,819,915,000 would generate 3,300 worker-years of labor, $83,000,000 in labor income, $303,000,000 in output, and $124,000,000 in Gross Regional Product (see table 2). The annual regional impacts of constructing the hurricane risk reduction system will accrue to the impact areas in amounts proportional to the level of spending for each year of construction.

For both alternatives, the secondary effects, the combined indirect and induced multiplier effects, account for 45% of the total output, about 35% of employment, about 33% of labor income, and 41% of gross regional product in the project area. The study area captures about 85% of the direct spending on the project. The remaining 15% of spending leaks out of the study area (see table 3).

## Summary

The construction of the Morganza to the Gulf of Mexico levee system would yield significant increases in employment and gross regional product not only to the parishes of Terrebonne and Lafourche, but to Metro New Orleans and beyond. The 3% annual exceedance probability alternative would generate an estimated $5.8 billion in gross regional product and 85,000 worker-years of labor during the construction of the levee system. The 1% annual exceedance probability alternative would generate an estimated $10.2 billion in gross regional product and 155,000 worker-years of labor.

It should be noted that the costs used to generate the regional economic impacts of construction are in 2011 prices, and, so, the monetary impacts presented are also in 2011 prices. The model was not rerun with the costs in 2012 prices. However, the change in the regional benefits resulting from the price-level change from 2011 prices to 2012 prices would be proportional to the change in the benefits of the NED analysis.

## Table 1
## Study Area Summary
## Morganza to the Gulf of Mexico, La

| Parish | Area (sq. mi) | Population | Households | Total Personal Income (in millions) |
|---|---|---|---|---|
| Ascension | 303 | 104,702 | 37,280 | $3,916 |
| Assumption | 365 | 23,632 | 8,552 | $799 |
| East Baton Rouge | 469 | 429,211 | 166,068 | $18,149 |
| East Feliciana | 456 | 21,057 | 6,827 | $695 |
| Iberville | 653 | 32,987 | 10,770 | $1,035 |
| Jefferson | 496 | 439,261 | 169,681 | $19,446 |
| Lafourche | 1,177 | 93,768 | 33,790 | $3,954 |
| Livingston | 703 | 122,404 | 43,929 | $3,848 |
| Orleans | 349 | 326,968 | 124,294 | $15,261 |
| Plaquemines | 1,041 | 27,039 | 9,364 | $895 |
| Pointe Coupee | 591 | 23,137 | 8,750 | $784 |
| St Bernard | 488 | 29,365 | 11,218 | $1,224 |
| St Charles | 410 | 53,810 | 18,475 | $1,969 |
| St Helena | 410 | 10,582 | 4,004 | $336 |
| St James | 258 | 22,227 | 7,460 | $689 |
| St John The Baptist | 348 | 48,996 | 16,546 | $1,618 |
| St Tammany | 1,110 | 240,775 | 87,796 | $10,406 |
| Terrebonne | 1,480 | 111,202 | 38,980 | $4,268 |
| West Baton Rouge | 205 | 23,108 | 8,375 | $805 |
| West Feliciana | 426 | 15,503 | 3,846 | $421 |
| **Total** | **11,737** | **2,199,734** | **816,005** | **$90,517** |

Source: RECONS Database (2009)

## Table 2
## Summary of Regional Economic Impacts
## Morganza to the Gulf of Mexico, La
**(Dollars are in Thousands)**

### Project Area

| Alternative | Construction Stimulus | Employment | Labor Income | Output | Gross Regional Product |
|---|---|---|---|---|---|
| 3% AEP | $5,897,800 | 85,000 | $4,239,000 | $8,839,000 | $5,802,000 |
| 1% AEP | $9,819,915 | 155,000 | 7,654,000 | 15,254,000 | 10,243,000 |

### The Remaining Parishes in LA

| Alternative | Construction Stimulus | Employment | Labor Income | Output | Gross Regional Product |
|---|---|---|---|---|---|
| 3% AEP | $5,897,800 | 1,600 | $40,000 | $151,000 | $61,000 |
| 1% AEP | $9,819,915 | 3,300 | 83,000 | 303,000 | 124,000 |

Notes:
1. October 2011 Price level
2. Construction Stimulus reflects costs estimates as of October 25, 2012.

**Table 3**
**Direct and Secondary Effects of Expenditures**
**Morganza to the Gulf PAC**
**(Dollars are in 000s)**

**Project Area**
**3% AEP Alternative**

| Effects | Gross Regional Product | Output | Labor Income | Employment |
|---|---|---|---|---|
| **Direct** | 3,411,000 | 4,892,000 | 2,828,000 | 55,000 |
| **Secondary** | 2,391,000 | 3,947,000 | 1,411,000 | 30,000 |
| **Total** | 5,802,000 | 8,839,000 | 4,239,000 | 85,000 |

**1% AEP Alternative**

| Effects | Gross Regional Product | Output | Labor Income | Employment |
|---|---|---|---|---|
| **Direct** | 6,090,000 | 8,394,000 | 5,212,000 | 103,000 |
| **Secondary** | 4,153,000 | 6,859,000 | 2,442,000 | 52,000 |
| **Total** | 10,243,000 | 15,253,000 | 7,654,000 | 155,000 |

**The Remaining Parishes**
**3% AEP Alternative**

| Effects | Gross Regional Product | Output | Labor Income | Employment |
|---|---|---|---|---|
| **Direct** | 3,429,000 | 6,913,000 | 2,599,000 | 50 |
| **Secondary** | 58,000 | 146,000 | 38,000 | 1,600 |
| **Total** | 3,487,000 | 7,059,000 | 2,637,000 | 1,650 |

**1% AEP Alternative**

| Effects | Gross Regional Product | Output | Labor Income | Employment |
|---|---|---|---|---|
| **Direct** | 5,000 | 10,000 | 4,000 | 70 |
| **Secondary** | 119,000 | 293,000 | 79,000 | 3,000 |
| **Total** | 124,000 | 303,000 | 83,000 | 3,070 |

Note: The secondary effects include the indirect and induced multiplier effects.

# MORGANZA, LOUISIANA, TO THE GULF OF MEXICO POST AUTHORIZATION CHANGE REPORT (PAC)

## OTHER SOCIAL EFFECTS APPENDIX

# I. INTRODUCTION

This appendix presents a socioeconomic evaluation of the alternatives being considered for storm surge risk reduction for the Morganza to the Gulf evaluation area, which includes portions of two parishes in the state of Louisiana. It was prepared in accordance with Engineering Regulation (ER) 1105-2-100, Planning Guidance Notebook, ER 1105-2-101, Planning Guidance, Risk Analysis for Flood Damage Reduction Studies, and Engineering Circular (EC) 1105-2-409.

**Purpose**

The purpose of this appendix is to describe the Other Social Effects (OSE) account of the Morganza to the Gulf of Mexico Post-Authorization Change (PAC) Hurricane Protection Project. The OSE account considers the potential social ramifications of Corps actions so that decision makers and stakeholders are able to evaluate the social implications of each alternative and choose an alternative that will be judged as complete, effective, and fair.

**Study Area**

The Morganza to the Gulf PAC study area is located in coastal Louisiana approximately 60 miles southwest of the city of New Orleans and includes all of Terrebonne Parish and the portion of Lafourche Parish to the south and west of Bayou Lafourche. Communities located within the study area include the city of Houma, the towns of Chauvin, Dulac, and Montegut in southern Terrebonne Parish, the towns of Donner and Gibson in western Terrebonne Parish, and the towns of Gray and Schriever in northern Terrebonne Parish. Also included are the towns of Raceland, Lockport, and Pointe aux Chenes in Lafourche Parish and the portion of the city of Thibodaux south of Bayou Lafourche. Both parishes have historically suffered extensive hurricane and tropical storm damage due to insufficient flood control features. The impact of preparing for, mitigating, and recovering from these damages has placed a significant physical and emotional burden on individuals and has been devastating for communities. The goals of the proposed project are to provide protection to residents within the study area from the damaging effects of storm surges while also protecting and preserving the fragile and rapidly deteriorating coastal wetlands.

**Overview of Other Social Effects**

While federal water resources planning guidance has long called for an examination of the social effects associated with USACE water resources planning projects, the tendency has historically been to discount the social impacts of Corps projects during the planning process and focus instead on the economic analysis (USACE, 2008). EC 1105-2-409, however, states that "all Corps planning studies will evaluate, display and compare the full range of alternative plans' effects across all four Principles and Guidelines' accounts (National Economic Development

(NED), Regional Economic Development (RED), Environmental Quality (EQ), and Other Social Effects (OSE)" (USACE, 2008 pg. 4).

The OSE account ensures that adequate attention is paid to the beneficial and adverse social effects of Corps' projects during the planning process. This appendix follows the guidance set forth by the USACE Institute for Water Resources (IWR) in the *Handbook on Applying "Other Social Effects" Factors in Corps of Engineers Water Resources Planning* (USACE, 2008). The handbook describes the procedures for analyzing and using OSE criteria in the planning process and identifies social factors that affect individual and group definitions of satisfaction and well-being.

**Organization of Appendix**

The OSE appendix is organized as follows:

- Section 1 provides an introduction to OSE.
- Section 2 provides a description of the existing and future without-project socioeconomic characteristics and other social factors of the study area.
- Section 3 provides an OSE analysis of the project alternatives.

## II. OTHER SOCIAL EFFECTS STUDY AREA CHARACTERISTICS

This section provides a description of the existing and future without-project socioeconomic characteristics and other social factors of the study area.

**Socioeconomic Characteristics of the Study Area**

In this section, socioeconomic data for Lafourche and Terrebonne Parishes are presented in order to provide a context from which to evaluate the potential social impacts of the proposed project.

<u>Population and Households.</u>

Population characteristics such as size and change constitute important areas of consideration in that they determine consumption patterns, land use activities, and future development patterns. Table 1 displays the population in each of the parishes for the years 1970, 1980, 1990, 2000, and 2010 (study year), as well as projections for the year 2035 and the year 2085, the two years that were modeled by Hydraulics and Hydrology Branch (H&H) and used to calculate damages and benefits. Population projections are based on Moody's County Forecast Database which has population projections to the year 2038. Moody's projections were extended by the New Orleans District from the year 2038 to the year 2085 based on the growth rate forecasted by Moody's for the years 2018 through 2038. The slow, steady growth rate projected by Moody's during this 20-year period was consistent with the growth predicted by parish planning officials.

As shown in Table 1, both Lafourche and Terrebonne Parishes have experienced a steady increase in population between 1970 and 2010. According to U.S. Census data, the population of Lafourche Parish was 89,974 in 2000 and 96,318 in 2010, an increase of 6,344 residents over the ten-year period. During the same period, the population of Terrebonne Parish increased from 104,503 to 111,860, an increase of 7,357 residents. The population in both parishes is projected to maintain this steady increase in population growth, with Lafourche Parish expected to have roughly 97,900 residents in 2035 and approximately 104,200 residents in the year 2085. Terrebonne Parish is expected to experience even more growth with an estimated population of roughly 120,900 in 2035 and 142,800 in 2085. Approximately 218,800 residents are projected to reside in the two-parish area in 2035, while approximately 247,000 residents are projected for the year 2085.

Table 2 shows the number of households in each parish in 1970, 1980, 1990, 2000, and 2010 and projections for the years 2035 and 2085. The projected number of households was based on Moody's County Forecast Database and extended from the year 2038 to 2085 by the New Orleans District based on the growth rate forecasted by Moody's for the years 2018 through 2038.

The total number of households in Lafourche and Terrebonne Parishes experienced a steady increase between 1970 and 2010, which paralleled the growth in population. This increase, which was commensurate with the population growth experienced by the entire Gulf Coast region during the same period, can be attributed to increases in oil and gas exploration in the Gulf of Mexico and technological advancements in the industry. Similar to the projected population growth in the two-parish area, the number of households is expected to continue increasing through the year 2085. Lafourche Parish is projected to have approximately 36,300 households in the year 2035, while Terrebonne Parish is projected to have about 43,400 households. By the year 2085, the number of households in Lafourche Parish is expected to reach approximately 38,100, while the number in Terrebonne Parish is expected to reach to approximately 50,400. In total, the two parishes are projected to have approximately 88,600 households in the year 2085.

Employment.

Table 3 shows the total nonfarm employment by parish for the years 1970, 1980, 1990, 2000, 2010, and projections for the years 2035 and 2085. The employment projections were based on the Moody's County Forecast Database and extended from the year 2038 to the year 2085 by New Orleans District based on the growth rate forecasted by Moody's for the years 2018 through 2038.

Employment trends in the area have historically moved with the demand for oil and gas resources. The unemployment rate in Terrebonne and Lafourche parishes averaged approximately three percent prior to the end of 2008. The Houma-Thibodaux Metropolitan

Statistical Area (MSA) continues to lead the state in jobs created and has one of the lowest unemployment rates in the state.

While the oil and gas industry pays the highest wages of all of the sectors of the economy, the services industry employs the largest number of residents. The retail sector is the second largest employer followed by government and other public agencies. The oil and gas sector in Terrebonne Parish employs slightly over 5,000 residents.

In addition to the oil and gas industry, there are three other sectors of the economy that are important to the region: energy, fisheries, and agriculture. The GIWW, the Houma Navigation Canal, and Bayou Lafourche provide key navigational channels for the energy sector. The coastal region provides a fertile spawning ground for fisheries including shrimp, crabs, oysters, and finfish. Finally, the area grows and processes sugarcane that is used both domestically and abroad.

**Social Profile of the Study Area**

This section provides a baseline profile of the social characteristics of the study area. Data for the social profile were obtained from a variety of sources including 2010 U.S. Census records, the 2006-2010 U.S. Census Bureau's American Community Survey (ACS) estimates[1], ESRI data, and aerial photography. The baseline characteristics are considered the existing and future-without project conditions.

Health and Safety

Severe flood events threaten the health and safety of residents living within the study area. Loss of life, injury, and post flood health hazards may occur in the event of catastrophic flooding. For example, while the study area was not directly impacted by Hurricane Katrina, the Louisiana Recovery Authority estimated (as of November 2006) that 1,464 fatalities occurred associated with Hurricane Katrina with 135 more residents declared missing. Hurricanes Gustov and Ike were less costly in terms of lives lost, but still claimed 98 deaths. When facilities that provide critical care or emergency services are impacted by flood events, residents are at an even greater risk for experiencing negative health outcomes. Both Hurricanes Katrina and Rita reduced the previous availability of health facilities and services and required additional fire and police protection. During Gustov and Ike, some police stations were required to relocate because of flooding. In addition to the damages of Katrina and Rita to hospitals, police stations, and fire stations, many employees providing related services lost their homes reducing the staff needed to operate health and safety services. As many as 30 hospitals were initially closed following the hurricanes with as many as 141 damaged at various levels of impact.

[1] The U.S. Census Bureau is now only providing population and housing characteristics in the decennial censuses. Other social characteristics (e.g., low-income) will now be provided in the U.S. Census Bureau's American Community Survey (ACS). The ACS provides estimates of social characteristics based on data collected over five years. The 2006-2010 estimates represent the average characteristics over the 5-year period of time.

The number of medical facilities, police stations, and fire stations located within the study area were obtained using 2010 ESRI data (latest year available).

Medical Care Facilities

There are two hospitals, two nursing homes, and three health care service facilities within the portion of Lafourche Parish included in the study area, and 15 medical care facilities (e.g., hospitals, medical centers, home health care services, and nursing homes) in Terrebonne Parish.

Police Stations

Lafourche Parish has seven police stations/sheriff's offices and a juvenile justice facility located within the study area and Terrebonne Parish has four police stations/sheriff's offices, according to ESRI data.

Fire Stations

There are 23 fire stations located within the study area—five in Lafourche Parish and 18 in Terrebonne Parish.

Social Connectedness

The degree to which communities are able to instill a shared sense of belonging and purpose among residents is in large part determined by the communities' civic infrastructure. The presence of social institutions such as libraries, places of worship, and schools provide residents an opportunity for civic participation and engagement which allows residents to come together and work toward a common goal. The number of libraries, places of worship, and schools located within the study area were obtained using 2010 ESRI data (latest year available).

Civic Infrastructure

According to ESRI data, the portion of Lafourche Parish included in the study area has one library, 7 places of worship, and 16 schools. ESRI data also show that there are 6 libraries, 34 places of worship, and 45 schools located within the study area in Terrebonne Parish.

Leisure and Recreation

Having personal leisure time available and having access to recreational areas contributes to residents' quality of life and is therefore an important aspect of well-being. The number of recreational areas within the study area was obtained using 2010 ESRI data (latest year available).

Recreational Areas

Lafourche Parish has four recreational areas located within the study area—the Sugarland Country Club, Acadia Park, Bayou Country Club, and Peltier Municipal Park. Terrebonne Parish has four also: Southern Oaks Golf Club, Ellendale Country Club, Gray Park, and Colonial Acres Golf Course.

Additionally, recreational fishing and hunting are very important to the area. The high quality of the recreational fishery, especially an abundance of red fish and trout, has made this an important leisure time activity for residents. Inland saltwater fish species, crabs, and shrimp are also available in the more brackish water. Game species hunted in the area include waterfowl, deer, rabbit, squirrels, rail, gallinule, and snipe.

Social Vulnerability/Resiliency

The devastation left behind after Hurricane Katrina brought attention to the salience of the related concepts of social vulnerability and resiliency when evaluating water resources projects (USACE, 2008). Social vulnerability is a characteristic of groups or communities that limits or prevents their ability to withstand adverse impacts from hazards to which they are exposed. Resiliency, in turn, refers to the ability of groups or communities to cope with and recover from adverse events. The factors that contribute to vulnerability often reduce the ability of groups or communities to recover from a disaster; therefore, more socially vulnerable groups or communities are typically less resilient.

Several factors have been shown to contribute to an area's vulnerability/resiliency, including poverty, racial/ethnic composition, educational attainment, and proportion of the population over the age of 65.

Poverty Rate

High poverty rates negatively impact the social welfare of residents and undermine the community's ability to assist residents in times of need. The 2006-2010[2] U.S. Census data indicate that 15.6 percent of the population of Lafourche and 17.4 percent of the population in Terrebonne Parish fell below the poverty line. In contrast, 18.1 percent of the population in the state of Louisiana and 13.8 percent in the nation overall fell below the poverty line during the same period.

Racial / Ethnic Composition

Race/ethnicity continues to play an important role in the everyday lives of Americans. Unequal access to social resources and language barriers may affect preparing for and recovering from flood events for certain groups. Table 4 shows the racial and ethnic characteristics of Lafourche and Terrebonne Parishes, according to the 2010 U.S. Census. In both parishes, the majority of the population is non-Hispanic white (78.0% in Lafourche Parish and 68.6% in Terrebonne Parish), followed by non-Hispanic black (13.2% in Lafourche Parish and 18.8% in Terrebonne Parish). The Hispanic population in both parishes is roughly 4.0 percent.

[2] As stated previously, the 2006-2010 estimates represent the average characteristics over the 5-year period of time.

Additionally, approximately 230 members of the Biloxi-Chitimacha tribe are located in Isle de Jean Charles which is in the southern portion of Terrebonne Parish.

Educational Attainment

Educational attainment also has important implications for the social vulnerability/resiliency of communities. More educated individuals have less difficulty accessing information and navigating the sometimes complex process of recovery after flood events (e.g., obtaining government assistance, insurance claims, etc.) According to 2006-2010 ACS data, the percentage of the population age 25 and older in Lafourche Parish with a high school diploma is 72.1 percent and 14.3 percent has a bachelor's degree or higher. Similarly, 73.0 percent of the population 25 and older in Terrebonne Parish has a high school diploma and 13.0 percent has a bachelor's degree or higher. These figures are lower than the state of Louisiana (81.0% has a high school diploma and 20.9% has a bachelor's degree or higher) and the nation overall (85.0% and 27.9%, respectively).

Age

Age is another important factor to consider when examining the social vulnerability/resiliency of a community. For example, elderly residents may have special needs or mobility issues and require more social resources before, during, and after flood events. According to 2010 U.S. Census data, the proportion aged 65 and older in Lafourche Parish is 12.5 percent and 11.2 percent in Terrebonne Parish. The state of Louisiana and the nation overall have roughly the same proportion of the population over the age of 65 (12.3% and 13.0%, respectively).

Social Vulnerability Index

The Hazards and Vulnerability Research Institute at the University of South Carolina created an index that compares the social vulnerability of U.S. counties/parishes to environmental hazards. The variables included in the index are based on previous research which has found that certain characteristics (e.g., poverty, racial/ethnic composition, educational attainment, and proportion over the age of 65) contribute to a community's vulnerability when exposed to hazards. According to the IWR OSE handbook (USACE, 2008), the Social Vulnerability Index (SoVI®)[3] is a valuable tool that can be used in the planning process to identify areas that are socially vulnerable and whose residents may be less able to withstand adverse impacts from hazards.

The SoVI® was computed as a comparative measure of social vulnerability for all counties/parishes in the U.S., with higher scores indicating more social vulnerability than lower scores. Lafourche Parish has a SoVI® 2005-09 score of -1.20 (0.29 national percentile) and Terrebonne Parish has a SoVI® 2005-09 score of -1.08 (0.31 national percentile). Stated another way, Lafourche and Terrebonne Parishes are less socially vulnerable than roughly 70 percent of counties/parishes in the U.S. In comparison, Orleans Parish—notorious for its enduring levels of

[3] More information on the methodology and data used to calculate the SoVI® can be found here: http://webra.cas.sc.edu/hvri/products/sovi.aspx

high poverty—has a SoVI® 2005-09 score of 2.06 with only 18 percent of counties/parishes in the nation ranked more socially vulnerable.

The study area's social vulnerability, however, is expected to increase over time if subsidence and sea level rise continue to occur, and the population in the study area increases as it is projected to do. The absolute number of socially vulnerable people (e.g., low-income, minority, less-educated, and over the age of 65) at risk for flood events will increase. This, in turn, may lead to an increased burden placed on local, state, and federal agencies to ensure that these socially vulnerable populations have access to resources before, during, and after flood events.

## III. OTHER SOCIAL EFFECTS EVALUATION OF ALTERNATIVES

**Social Implications of the Alternatives**

This section provides an OSE analysis of the project alternatives. The evaluation is based on the differential impact that each alternative is expected to have on the socioeconomic characteristics and other social factors of the study area presented in the previous section.

The analysis was conducted based on without-project overflow and depth-of-flooding data provided by Engineering Division. The data were provided for the years 2035 and 2085 for 2% annual chance exceedance (ACE) events (50-year), 1% ACE events (100-year), and for 0.2% ACE events (500-year). Figures 1-3 show the estimated depth of inundation during 2%, 1%, and 0.2% ACE events for the year 2085.

The data do not take into account the performance of local levees. As a result, impacts to population, housing, medical facilities, etc. are overstated. Local levee systems provide flood risk reduction under existing conditions (2010) for over 25,000 residential and non-residential structures. Local levees are expected to provide flood risk reduction between a 10% ACE event (10-year) and 7% ACE event (15-year), on average.

Performance of the federal levee for the 1% AEP Alternative would reduce risk for elevations up to approximately the stages associated with the 1% ACE event (100-year) or slightly above. This is again assuming that the levee doesn't fail at an elevation below the design elevation of the Federal levee.

Performance of the federal levee for the 3% Annual Exceedance Probability (AEP) Alternative would reduce risk for elevations up to approximately the stages associated with the 3% ACE event (35-year)—assuming that the levee doesn't fail at an elevation below the design elevation of the Federal levee. Therefore, for the purposes of this analysis, it is assumed that the 3% AEP Alternative would fail when exposed to 2% ACE events (50-year) and for less frequent events.

Tables 5 and 6 present the results of the impacts to population and housing, medical/emergency facilities, civic infrastructure, and recreational areas under the No Action Alternative, the 1% AEP Alternative, and the 3% AEP Alternative based on these without-project overflow and depth-of-flooding data. The impacted population and housing figures are based only on without-project overflow data and not depth-of-flooding data. Therefore, impacts due to flooding could range from minimal to extensive. Medical/emergency facilities, civic infrastructure, and recreational areas are considered impacted if depth-of-flooding data show two feet or more of flooding in the facility location.

Again, it is important to note that the reduced risk associated with the 1% AEP Alternative and the 3% AEP Alternative are based on without-project depth-of-flooding data and the assumption that the 1% AEP Alternative will provide flood risk reduction for 1% (and more frequent) ACE events and the 3% AEP Alternative will provide flood risk reduction for 3% (and more frequent) ACE events.

Population and Housing

No Action Alternative

As shown in Table 5, if the population and housing units increase at the rate projected by Moody's, a 0.2% ACE event in 2035 would impact 206,700 residents/71,300 housing units; a 1% ACE event would impact 181,500 individuals/62,600 housing units; and a 2% ACE event would impact 180,200 residents/62,100 housing units.

Table 6 shows that in 2085, a 0.2% ACE event would impact 242,400 residents/83,600 housing units; a 1% ACE event would impact 217,200 individuals/74,900 housing units; and a 2% ACE event would impact 215,900 residents/74,500 housing units.

The No Action Alternative would not provide risk reduction to the residents living within the study area which would increase over time due to sea level rise. A catastrophic flood would result in severe negative impacts to residents and cause significant damage to residential structures. Additionally, residents in these communities would not be able to benefit from discounted flood insurance premiums offered by the National Flood Insurance Program (NFIP) should the flood rate insurance maps be updated to reflect increases in flood risk over time due to sea level rise.

1% AEP Storm Surge Risk Reduction System Alternative

As shown in Tables 5 and 6, if no action is taken by USACE, approximately 181,500 individuals/62,600 housing units would be impacted by a 1% ACE event in 2035 and 217,200 residents/74,900 housing units in 2085.

Under the 1% AEP Alternative, these residents and housing units would be at a reduced risk for adverse impacts as a result of 1% (and more frequent) ACE events. Additionally, many residents in these communities would be able to benefit from discounted flood insurance premiums offered by the NFIP (should the flood rate insurance maps be updated to reflect increases in flood risk over time due to sea level rise).

It's also important to note that approximately 840 residential structures (roughly 2,500 people) are located outside of the project alignment and would not benefit from this alternative. This includes approximately 230 members of the Biloxi-Chitimacha tribe who are located in Isle de Jean Charles which is outside of the southern boundary of the project alignment in Terrebonne Parish.

3% AEP Storm Surge Risk Reduction System Alternative

Under the 3% AEP alternative, residents and housing units would be at a reduced risk for adverse impacts as a result of 3% (and more frequent) ACE events. However, if a 2% or less frequent ACE event occurs, these residents and housing units would not experience any reduction in risk. Additionally, residents in these communities would not be able to benefit from discounted flood insurance premiums offered by the NFIP (again, if the flood rate insurance maps are updated to reflect increases in flood risk over time due to sea level rise).

As with the 1% AEP Alternative, approximately 840 residential structures (roughly 2,500 people) are located outside of the project alignment and would not benefit from this alternative. This includes approximately 230 members of the Biloxi-Chitimacha tribe who are located in Isle de Jean Charles which is outside of the southern boundary of the project alignment in Terrebonne Parish.

Health and Safety

No Action Alternative

As stated previously, the study area includes 22 medical care facilities (e.g., hospitals, medical centers, home health care services, and nursing homes). As shown in Table 5, under the No Action Alternative, a 0.2% ACE event in 2035 would impact 20 medical facilities, 12 police stations/sheriff's offices/juvenile justice facility, and 22 fire stations; a 1% ACE event would impact 16 medical facilities, 6 police stations/sheriff's offices/juvenile justice facility, and 18 fire stations; and a 2% ACE event would impact 13 medical facilities, 4 police stations/sheriff's offices/juvenile justice facility, and 17 fire stations.

Table 6 shows that in 2085, a 0.2% ACE event would impact 20 medical facilities, 12 police stations/sheriff's offices/juvenile justice facility, and 22 fire stations; a 1% ACE event would impact 18 medical facilities, 8 police stations/sheriff's offices/juvenile justice facility, and 19 fire stations; and a 2% ACE event would impact 16 medical facilities, 5 police stations/sheriff's offices/juvenile justice facility, and 17 fire stations.

While evacuation for severe weather events in the Morganza study area is typically high due to mandatory evacuation orders by state authorities, flood events threaten the health and safety of those residents who remain in the area. The potential for loss of life and injuries during flood events for those remain, and the risks of post flood health hazards attributable to such widespread flooding, are greater under the No Action Alternative as compared to the project alternatives. Residents are at an even greater risk for experiencing negative health outcomes when facilities that provide critical care or emergency services are impacted by flood events. The No Action Alternative has a higher potential for reducing the availability of health facilities and services and requiring additional fire and police protection than the project alternatives.

1% AEP Storm Surge Risk Reduction System Alternative

As shown in Table 5, the 1% AEP Alternative would provide reduced risk during 1% ACE events (100-year) to 16 medical care facilities, 6 police stations/sheriff's offices, and 18 fire stations that without-project depth-of-flooding data show would experience two feet or more of flooding in 2035. Table 6 shows that by the year 2085, the number of medical facilities experiencing reduced risk under this alternative would increase to 18, police stations/sheriff's offices would increase to 8, and fire stations would increase to 19.

The 1% AEP would result in the greatest potential for reduced risk to the health and safety of residents living within the Morganza study area.

3% AEP Storm Surge Risk Reduction System Alternative

The 3% AEP Alternative would provide reduced risk during 3% (and more frequent) ACE events to medical care facilities, police stations/sheriff's offices, and fire stations located in the study area. However, if a 2% (or less frequent) ACE event occurs, these facilities would not experience any reduction in risk.

The 3% AEP would result in reduced risk to the health and safety of residents living within the study area during 3% (and more frequent) ACE events. However, residents would remain at risk for experiencing negative health outcomes during less frequent events.

Social Connectedness

No Action Alternative

As stated previously, the study area includes 7 libraries, 41 places of worship, and 61 schools. Table 5 shows that under the No Action Alternative, a 0.2% ACE event (500-year) would impact all 7 libraries, 40 places of worship, and 56 schools in 2035. Table 5 also shows that under the No Action Alternative, a 1% ACE event (100-year) would impact 6 libraries, 36 places of worship, and 43 schools, and a 2% ACE event (50-year) would impact 5 libraries, 34 places of worship, and 38 schools.

Table 6 shows that in 2085, 0.2% ACE event would remain similar to that of 2035, while a 1% ACE event would impact 7 libraries, 39 places of worship, and 56 schools, and a 2% ACE event would impact 6 libraries, 35 places of worship, and 43 schools.

1 % AEP Storm Surge Risk Reduction System Alternative

As shown in Table 5, the 1% AEP Alternative would provide reduced risk during 1% ACE events (100-year) to 6 libraries, 36 places of worship, and 43 schools that without-project depth-of-flooding data show would experience two feet or more of flooding in 2035. Table 6 shows that by the year 2085, the number of libraries experiencing reduced risk under this alternative would increase to 7, places of worship would increase to 39, and schools would increase to 56.

3 % AEP Storm Surge Risk Reduction System Alternative

The 3% AEP Alternative would provide reduced risk during 3% (and more frequent) ACE events to libraries, places of worship, and schools located in the study area. However, if a 2% (or less frequent) ACE event occurs, these facilities would not experience any reduction in risk.

Leisure and Recreation

No Action Alternative

Tables 5 and 6 show that under the No Action Alternative, a 0.2% ACE event (500-year) would impact all 8 recreational areas located within the study area under without-project conditions in the years 2035 and 2085, a 1% ACE event would impact 5 in the years 2035 and 2085, and a 3% ACE event would impact 4 in the years 2035 and 2085.

1 % AEP Storm Surge Risk Reduction System Alternative

As shown in Tables 5 and 6, the 1% AEP Alternative would provide reduced risk during 1% ACE events to 5 recreational areas in the years 2035 and 2085.

3 % AEP Storm Surge Risk Reduction System Alternative

The 3% AEP Alternative would provide reduced risk during 3% (and more frequent) ACE events to recreational areas located in the study area. However, if a 2% (or less frequent) ACE event occurs, these areas would not experience any reduction in risk.

Social Vulnerability and Resiliency

No Action Alternative

As stated previously, social vulnerability in the area is expected to increase over time as the absolute number of socially vulnerable people (e.g., low-income, minority, less-educated, and over the age of 65) at risk for flood events increases should subsidence, sea level rise, and population growth occur to levels expected. Under the No Action Alternative, the area would remain vulnerable to flooding, and long term resiliency would be hampered by the continued local efforts necessary to prepare for, and react to, flood events.

1% AEP Storm Surge Risk Reduction System Alternative

Under the 1% AEP Alternative, the study area would experience flood risk reduction for 1% (and more frequent) ACE events. The level of social vulnerability expected in the study area in the year 2085 would be reduced under this alternative as compared to the No Action Alternative, and thus, the study area's potential for long-term growth and sustainability would be enhanced.

3% AEP Storm Surge Risk Reduction System Alternative

Under the 3% AEP Alternative, the study area would experience flood risk reduction for 3% (and more frequent) ACE events. The social vulnerability of the study area would be reduced under this alternative as compared to the No Action Alternative, and thus, the study area's potential for long-term growth and sustainability would be enhanced. However, the study area would remain vulnerable to less frequent/more damaging events.

**Summary of Alternative Analysis**

The Morganza to the Gulf PAC study examined three alternatives—the No Action Alternative, the 1% AEP Alternative, and the 3% AEP Alternative. The OSE analysis evaluated the differential impact that each alternative is expected to have on the socioeconomic characteristics and other social factors of the study area. After first providing a description of the existing and future without-project socioeconomic characteristics and other social factors of the study area, an analysis of the impacts to population and housing, medical/emergency facilities, civic infrastructure, and recreational areas under the three alternatives was conducted. The analysis was conducted based on without-project overflow and depth-of-flooding data for the years 2035 and 2085. Results show significant differences between the alternatives with important implications for the overall social well-being of the study area.

The No Action Alternative would not reduce the risk associated with hurricane and tropical storm damage to residents of the Morganza study area. Therefore, there is a high potential for extensive hurricane and tropical storm damage to continue occurring in the area. The apparent subsidence, or relative sea level rise, that has been taking place in the Morganza to the Gulf area, coupled with the anticipated population growth, is expected to magnify the flooding problems in the future. As a result, subsequent flooding events could cause even more damage to housing units, public facilities, and commercial structures than has previously been experienced. Under this alternative, residents would remain at a higher risk for adverse health impacts such as loss of life and injury, as well as post flood health hazards. The area would remain vulnerable to flooding, and long term resiliency would be hampered by the continued local efforts necessary to prepare for, and react to, flood events.

The 1% AEP would result in the greatest potential for reduced flooding in the Morganza study area. This alternative would reduce the risks associated with damages to housing units, public facilities, and commercial structures for 1% (and more frequent) ACE events as well as provide increased protection to the health and safety of residents living within the study area. The area's social vulnerability would be reduced under this alternative, and thus, the potential for long-term growth and sustainability would be enhanced. Also, under this alternative, the area would be at a reduced risk of incurring the costs associated with clean-up, debris removal, and building and infrastructure repair as a result of flood events.

The 3% AEP would also reduce the risk of flooding in the Morganza study area. However, this alternative would only provide risk reduction for 3% (and more frequent) ACE events. The area would still face risks associated with less frequent (more damaging) events.

**References**

U.S. Army Corps of Engineers. 2008. Handbook on Applying "other Social Effects" Factors in Corps of Engineers Water Resources Planning.

U.S. Bureau of the Census, 2010. U.S. Census of Population and Housing, SF1 and SF3 datatables. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml. Accessed January 10th, 2012.

U.S. Bureau of the Census, 2006-2010 American Community Survey. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml. Accessed February 10th, 2012.

**Figures**

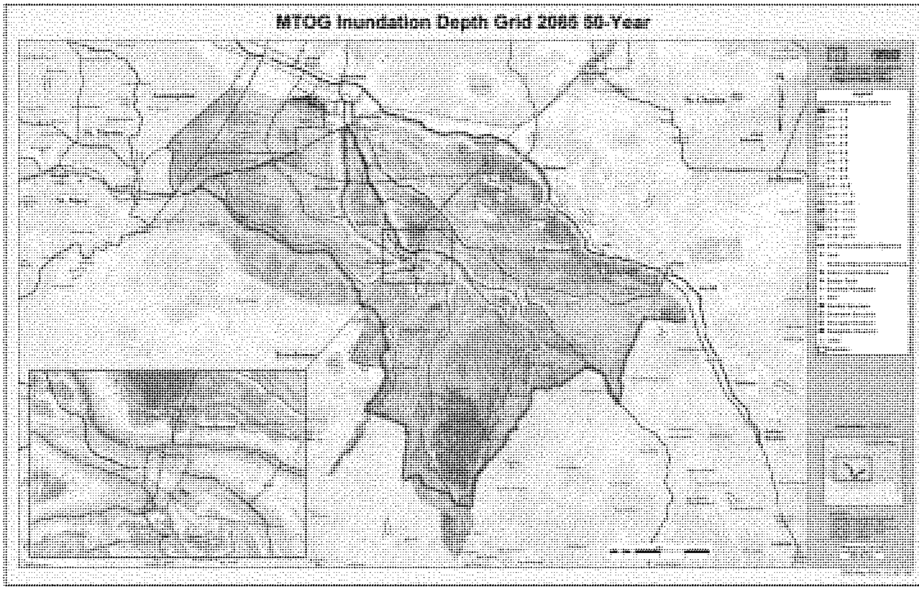



Figure 1. Morganza Study Area Estimated Inundation for 2% ACE Event (50-Year) in 2085

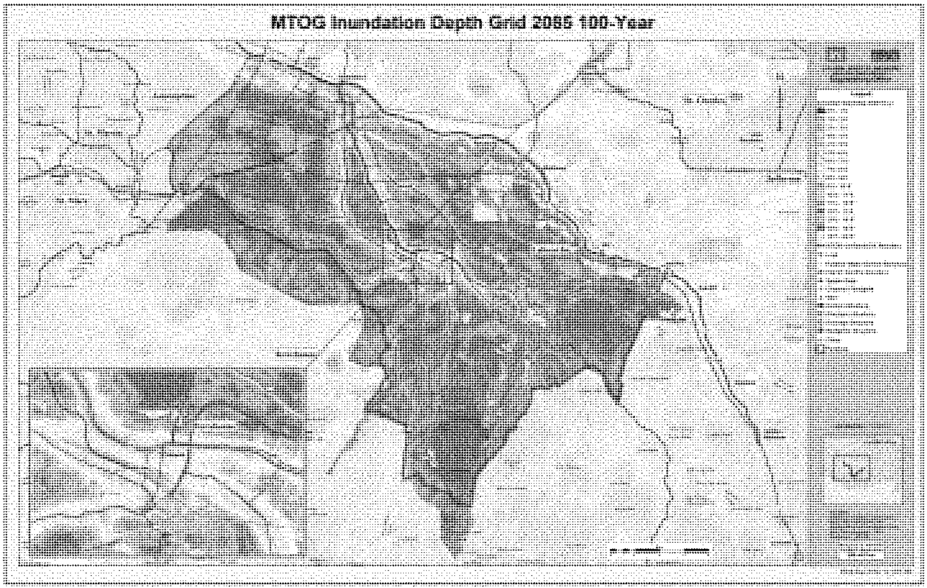



Figure 2. Morganza Study Area Estimated Inundation for 1% ACE Event (100-Year) in 2085

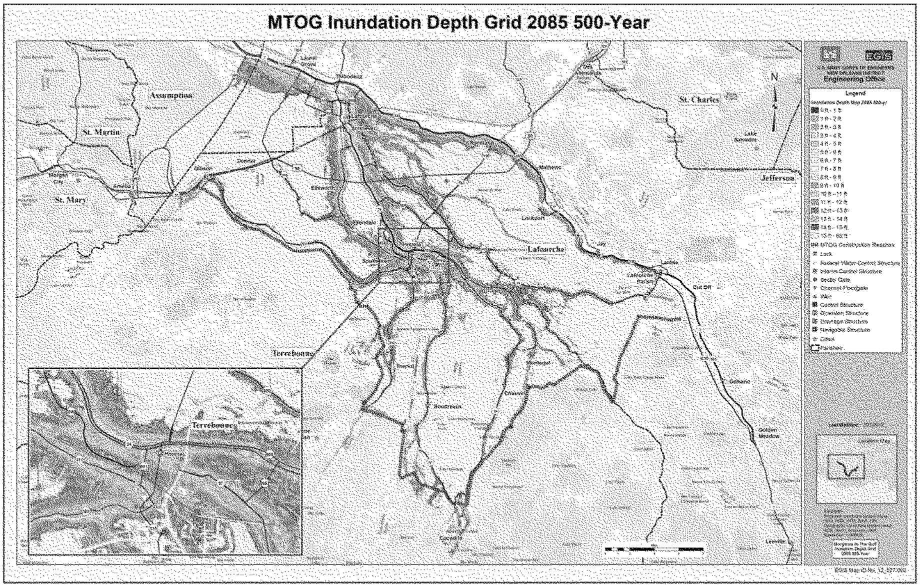



Figure 3. Morganza Study Area Estimated Inundation for 0.2% ACE Event (500-Year) in 2085

Table 1
Historical and Projected Parish Population (1,000s)
2010
Morganza to the Gulf of Mexico, La.
Post-Authorization Change Report

| Parish | 1970 | 1980 | 1990 | 2000 | 2010 | 2035 | 2085 |
|---|---|---|---|---|---|---|---|
| Lafourche | 69.1 | 83.5 | 85.8 | 90 | 96.3 | 97.9 | 104.2 |
| Terrebonne | 76.2 | 95.1 | 97 | 104.5 | 112.0 | 120.9 | 142.8 |
| Total | 145.2 | 178.6 | 182.9 | 194.4 | 208.3 | 218.8 | 247.0 |

Source: U.S. Census data, Moody's Country Forecast Database, and discussions with local officials.

Table 2
Number of Households by Parish (1,000s)
2010
Morganza to the Gulf of Mexico, La.
Post-Authorization Change Report

| Parish | 1970 | 1980 | 1990 | 2000 | 2010 | 2035 | 2085 |
|---|---|---|---|---|---|---|---|
| Lafourche | 18.0 | 25.7 | 28.8 | 32.1 | 33.7 | 36.3 | 38.1 |
| Terrebonne | 19.6 | 29.5 | 31.9 | 36.0 | 38.2 | 43.4 | 50.4 |
| Total | 37.6 | 55.2 | 60.7 | 68.1 | 71.9 | 79.7 | 88.5 |

Source: U.S. Census data, Moody's Country Forecast Database, and discussions with local officials.

Table 3
Total Nonfarm Employment (1,000s)
2010
Morganza to the Gulf of Mexico, La.
Post-Authorization Change Report

| Parish | 1970 | 1980 | 1990 | 2000 | 2010 | 2035 | 2085 |
|---|---|---|---|---|---|---|---|
| Lafourche | 15.1 | 24.4 | 22.1 | 30.4 | 37.5 | 40.7 | 44.2 |
| Terrebonne | 24.6 | 42.4 | 35.8 | 47.3 | 58.9 | 67.3 | 81.3 |
| Total | 39.7 | 66.8 | 57.9 | 77.7 | 96.4 | 108.0 | 125.5 |

Source: Based on Moody's Forecast and discussions with local officials

Table 4
Race and Ethnic Composition Morganza to the Gulf PAC
2010
Morganza to the Gulf of Mexico, La.
Post-Authorization Change Report

| | Lafourche Parish | | Terrebonne Parish | |
|---|---|---|---|---|
| | Number | % | Number | % |
| Total | 96,318 | | 111,860 | |
| Hispanic | 3,647 | 3.8 | 4,421 | 4 |
| Non-Hispanic | 92,671 | 96.2 | 107,439 | 96 |
| White alone | 75,080 | 78 | 76,789 | 68.6 |
| Black or African American alone | 12,679 | 13.2 | 21,046 | 18.8 |
| American Indian and Alaska Native alone | 2,623 | 2.7 | 6,226 | 5.6 |
| Asian alone | 707 | 0.7 | 1,127 | 1 |
| Native Hawaiian and Other Pacific Islander alone | 26 | 0 | 40 | 0 |
| Some Other Race alone | 62 | 0.1 | 93 | 0.1 |
| Two or More Races | 1,494 | 1.6 | 2,118 | 1.9 |

Source: 2010 U.S. Census

Table 5
Evaluation of Alternatives
2035
Morganza to the Gulf of Mexico, La.
Post-Authorization Change Report

| | No Action Alternative | | | 1% AEP Alternative | | | 3% AEP Alternative | | |
|---|---|---|---|---|---|---|---|---|---|
| | 50 | 100 | 500 | 50 | 100 | 500 | 50 | 100 | 500 |
| **Population and Housing** | | | | | | | | | |
| Population | 180.2 | 181.5 | 206.7 | 0 | 0 | 206.7 | 180.2 | 181.5 | 206.7 |
| Housing Units | 62.1 | 62.6 | 71.3 | 0 | 0 | 71.3 | 62.1 | 62.6 | 71.3 |
| **Social Factor** | | | | | | | | | |
| **Health and Safety** | | | | | | | | | |
| Medical Facilities | 13 | 16 | 20 | 0 | 0 | 20 | 13 | 16 | 20 |
| Police Stations | 4 | 6 | 12 | 0 | 0 | 12 | 4 | 6 | 12 |
| Fire Stations | 17 | 18 | 22 | 0 | 0 | 22 | 17 | 18 | 22 |
| **Social Connectedness** | | | | | | | | | |
| Libraries | 5 | 6 | 7 | 0 | 0 | 7 | 5 | 6 | 7 |
| Places of Worship | 34 | 36 | 40 | 0 | 0 | 40 | 34 | 36 | 40 |
| Schools | 38 | 43 | 56 | 0 | 0 | 56 | 38 | 43 | 56 |
| **Leisure and Recreation** | | | | | | | | | |
| Recreational Areas | | | | | | | | | |
| | 4 | 5 | 8 | 0 | 0 | 8 | 4 | 5 | 8 |

Source: U.S. Census data, Moody's Country Forecast Database, ESRI data.
Based on without-project overflow and depth-of-flooding data provided by Engineering Division
Population/housing figures are based on without-project overflow data and not depth-of-flooding data.
Facilities are considered impacted if depth-of-flooding data show two feet or more of flooding.

Table 6
Evaluation of Alternatives
2085
Morganza to the Gulf of Mexico, La.
Post-Authorization Change Report

| | No Action Alternative | | | 1% AEP Alternative | | | 3% AEP Alternative | | |
|---|---|---|---|---|---|---|---|---|---|
| | 50 | 100 | 500 | 50 | 100 | 500 | 50 | 100 | 500 |
| **Population and Housing** | | | | | | | | | |
| Population | 215.9 | 217.2 | 242.4 | 0 | 0 | 242.4 | 215.9 | 217.2 | 242.4 |
| Housing Units | 74.5 | 74.9 | 83.6 | 0 | 0 | 83.6 | 74.5 | 74.9 | 83.6 |
| **Social Factor** | | | | | | | | | |
| **Health and Safety** | | | | | | | | | |
| Medical Facilities | 16 | 18 | 20 | 0 | 0 | 20 | 16 | 18 | 20 |
| Police Stations | 5 | 8 | 12 | 0 | 0 | 12 | 5 | 8 | 12 |
| Fire Stations | 17 | 19 | 22 | 0 | 0 | 22 | 17 | 19 | 22 |
| **Social Connectedness** | | | | | | | | | |
| Libraries | 6 | 7 | 7 | 0 | 0 | 7 | 6 | 7 | 7 |
| Places of Worship | 35 | 39 | 40 | 0 | 0 | 40 | 35 | 40 | 40 |
| Schools | 43 | 56 | 56 | 0 | 0 | 56 | 43 | 56 | 56 |
| **Leisure and Recreation** | | | | | | | | | |
| Recreational Areas | 4 | 5 | 8 | 0 | 0 | 8 | 4 | 5 | 8 |

Source: U.S. Census data, Moody's Country Forecast Database, ESRI data.
Based on without-project overflow and depth-of-flooding data provided by Engineering Division
Population/housing figures are based on without-project overflow data and not depth-of-flooding data.
Facilities are considered impacted if depth-of-flooding data show two feet or more of flooding.

# Real Estate Plan

## Morganza to the Gulf of Mexico, Louisiana

Morganza to the Gulf Project Vicinity

# TABLE OF CONTENTS

# PURPOSE OF THE REAL ESTATE PLAN AND PROJECT DESCRIPTION

This Real Estate Appendix presents the real estate requirements and costs for the Post Authorization Change (PAC) Report for the Morganza to the Gulf of Mexico, Louisiana hurricane and storm damage reduction project. The information contained herein is tentative in nature for planning purposes only.

A previous Real Estate Plan was prepared in August, 2000 in support of the Final Feasibility Report, which was approved in March, 2002.

The Water Resources and Development Act of 2007 (WRDA 2007), Section 1001 (24) authorized construction of the Morganza to the Gulf of Mexico, Louisiana hurricane and storm damage reduction project (commonly referred to as "Morganza to the Gulf"). The authorization was based on reports of the Chief of Engineers dated August 23, 2002 and July 22, 2003. The project was intended to provide for the 100-year level of risk reduction (based on a storm surge elevation that has a 1% chance of being equaled or exceeded in a given year); however, the authorized project cost estimates do not reflect post-Katrina 100-year design elevations, criteria, borrow standards, or construction costs that must now be incorporated into the Morganza to the Gulf project. Changes to the authorized project have exceeded the 20% cost increase limit specified in WRDA 1986, Section 902, and must be documented in a Post Authorization Change Report (PAC REPORT).

This project analyzes the same levee alignment at two levels of risk reduction (1% and 3% probability). The 1% Annual Exceedance Probability (AEP) Storm Surge Risk Reduction System is a hurricane levee system that provides risk reduction for water levels that have a one percent probability of occurring each year. This alternative has the same intended level of risk reduction as the pre-Katrina authorized project but is modified to be consistent with post-Katrina design standards.

The 98-mile Morganza to the Gulf levee system primarily follows existing hydrologic barriers such as natural ridges, roadbeds, and existing local levees. The western extent ties into high ground along US 90 near the town of Gibson, and the eastern extent ties into Hwy 1 near Lockport, LA. Levee elevations range from 15.5 to 24.0 feet for base year (2035) conditions and from 19.5 to 26.5 feet NAVD88 for future year conditions. Structure elevations range from elevation 17.5 to 33.0 NAVD88.

The project includes 1 lock, 22 navigable floodgates, 23 environmental water control structures, 9 road gates, and fronting protection for 6 existing pumping stations. Structures on Federally maintained navigation channels include the Houma Navigation Canal Lock Complex (and 250-ft sector gate) and two 125-ft sector gates on the GIWW east and west of Houma. In addition, fourteen (14) 56-ft sector gates and five (5) 20- to 30-ft stop log gates are located on various waterways that cross the levee system.

A summary map showing the location of the project reaches is included as Exhibit A to this Real Estate Appendix.

The levees will be constructed in lifts. There will be a maximum of four lifts in various thicknesses. (Larose C-North 1% AEP plan includes a 5th lift.) It is assumed that the lifts will be constructed between 2015 and 2071, with final settlement being reached in the year 2085.

Figure 1-1 below is a summary map of the project reaches.

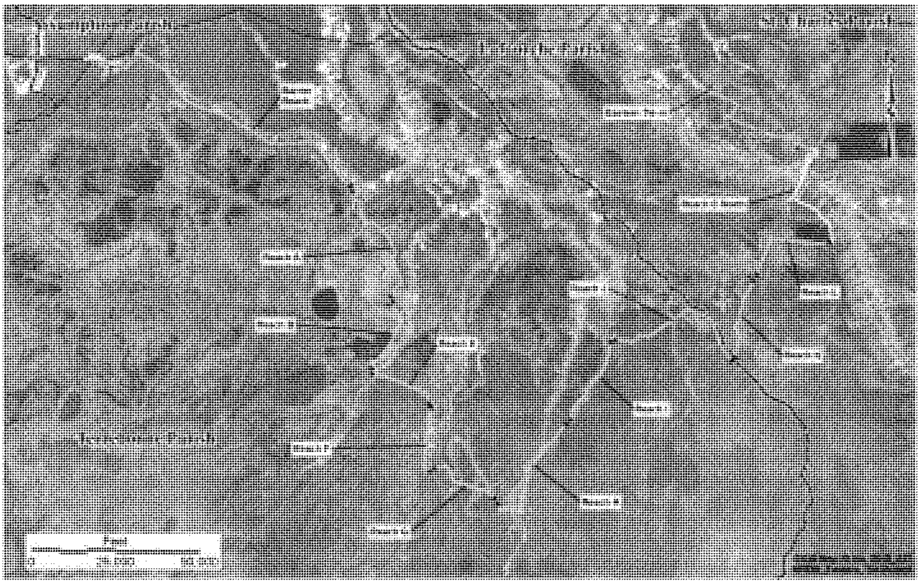


**Figure 1-1 Morganza PAC Alignment**

# PROJECT LOCATION

The project/study area is generally located in coastal Louisiana about 60 miles southwest of New Orleans. The area includes all of Terrebonne Parish and portionsof Lafourche Parish. The study area extends south to the saline marshes bordering the Gulf of Mexico and encompasses approximately 1,891 square miles. Bayou Lafourche forms the eastern study boundary and Bayou Black and Louisiana Highway 311 forms the western boundary. The Gulf Intracoastal Waterway (GIWW) passes through the northern part of the study area in an east-west direction, and the Houma Navigation Channel (HNC) extends due south from Houma to the Gulf of Mexico.

A map of the project area is located within Exhibit A. Preliminary design plates showing the location of each Reach are located in the Engineering Appendix of the Post Authorization Change Report.

## PROJECT AUTHORIZATION

The Morganza to the Gulf of Mexico project was conditionally authorized in WRDA 2000 at a cost of $550 million subject to having a favorable Chief of Engineer's Report completed by December 2000; however, the terms of this conditional authorization were not met. The PED phase on the HNC lock complex was initiated in advance of the PED phase for the Morganza to the Gulf of Mexico hurricane and storm damage reduction project. The PED Agreement for the HNC lock was signed in January 2000.
The Morganza to the Gulf feasibility study and PEIS were completed in March, 2002, and a PED agreement was signed in May, 2002. In August 2002, USACE issued a Chief of Engineers report. In July 2003, USACE issued a supplemental Chief of Engineers report, which made changes to the Non-Federal Sponsor's in-kind services. In accordance with the 2002 and 2003 reports of the Chief of Engineers, the Morganza project is authorized as a feature of the Mississippi River and Tributaries (MR&T). Section 158 of the Energy and Water Development Appropriations Act, 2004 (P.L. 108-137) authorized construction on Reach J-1, which had been previously identified as work-in-kind.

The PED Amendment 1 executed in March 2005 combined the two PED efforts into one and allowed the non-Federal sponsor to advance funds on the combined PED effort. WRDA 2007 authorized the Morganza to the Gulf of Mexico, Louisiana project for hurricane and storm damage reduction at a total cost of $886.7 million. The PED Amendment 2 executed in January 2011 increased the funding ceiling and changed the name of the Non-Federal Sponsor from Louisiana Department of Transportation and Development (DOTD) to the Louisiana Coastal Protection and Restoration Authority Board (CPRAB).

The Morganza to the Gulf Project was authorized by WRDA 2007 (P.L. 110-114, Section 1001(24)) on November 9, 2007. In accordance with the project authorization contained in Section 1001(24) of WRDA 2007, construction of the project requires a 65 percent cost share by the Federal government and a 35 percent cost share by the non-Federal sponsor. The operation, maintenance, repair, rehabilitation, and replacement of the HNC lock complex and the GIWW floodgate features of the project that provide for inland waterway transportation are a Federal responsibility in accordance with section 102 of WRDA 1986 (33 U.S.C. 2212). The Operation and Maintenance, Repair, Replacement and Rehabilitation (OMRR&R) of all other project features is the Non-Federal Sponsor's responsibility.

## NON-FEDERAL SPONSOR

The Louisiana Coastal Protection and Restoration Authority (CPRAB) and the Terrebonne Levee and Conservation District (TLCD) intend to be the non-Federal co-sponsors for the Morganza to the Gulf project (hereafter referred to as the Non-Federal Sponsor). Section 1001(24) of WRDA 2007 specifies Federal responsibility for OMRR&R of the HNC lock complex and the GIWW floodgate features that provide for inland waterway transportation in accordance with Section 102 of WRDA 1986, as amended. The Non-Federal Sponsor is responsible for OMRR&R of all other project features.

CPRAB and TLCD, as the Non-Federal Sponsors, are charged with responsibility for the provision of all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; performing or ensuring the performance of all relocations; and constructing all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material all as determined by the Government to be required or to be necessary for the construction, operation, and maintenance of the project (LERRDs).

While CPRAB has condemnation authority, it does not, at this time, possess quick-take condemnation authority. If that condition continues when the Real Estate acquisition process commences, TLCD will have responsibility for the acquisition of real estate interests necessary for construction of the project.

There may be areas which the TLCD does not have the authority to acquire (lands located in Lafourche Parish). If that is the case, CPRAB will enter into third party agreements with the South Lafourche Levee District (SLLD) and the North Lafourche Conservation, Levee and Drainage District (NLCLDD) to acquire real estate rights in Lafourche Parish on behalf of CPRAB. Although neither NLCLDD nor SLLD will be a party to the Project Partnership Agreement, they will utilize their statutory authority on behalf of CPRAB. For that reason, an Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability has been obtained for NLCLDD and SLLD, as well as CPRAB and TLCD.

Due to the need for a Post Authorization Change Report and Congressional reauthorization of the project, no PPA has been developed at this time. At such time as the project is reauthorized and funds appropriated for the construction of the project, MVN District will commence the PPA development and negotiation process.

Assessments of the Non-Federal Sponsor's Real Estate Acquisition Capability for CPRAB, TLCD, SLLD, and NLCLDD are attached as Exhibit B. The Non-Federal Sponsors have been found to be fully capable of performing acquisition of the LER required for the project.

The TLCD has started work on reaches that were initially proposed to be a part of the Morganza to the Gulf project, at their own expense, acknowledging that there is no signed PPA in place. The TLCD has substantially completed approximately 9 miles of first lift levees and a few floodgates, which are located along the proposed Morganza to the Gulf project. Discussion of those features is included in section 2 of the PAC Report.

In the absence of an executed PPA, the locally constructed levees do not form an integral part of the Morganza to the Gulf Project, and the work performed by the TLCD is not eligible for consideration and approval of work-in-kind credit. If the Morganza to the Gulf project is reauthorized, the Non-Federal Sponsor will be entitled to LERRD credit for the real estate acquired for those local levees, only to the extent that the Non-Federal

Sponsor is required to provide authorization for entry to the LERRDs necessary for any future Morganza to the Gulf project work that is conducted on the locally constructed levees.

## LANDS, EASEMENTS & RIGHTS-OF-WAY

The majority of the acreage affected by the project consists of marsh or wooded wetlands. Other lands impacted include woodland, agricultural (cane land), industrial waterfront on the GIWW, residential waterfront lots at the community of Waterproof, and mixed-use waterfront lots on Bayou Petite Caillou and Bayou du Large. (Mixed-use refers to recreational "camps" or residential waterfront lots.) The Right-of-Way in Lafourche Parish consists mostly of marsh and open water, with the exception of 3 acres of industrial property along the GIWW at the location of a proposed floodgate in the town of Larose. These 3 acres consist of industrial property that appears to be vacant. It is not anticipated that a business relocation will be necessary in this area.

This report references LERRDs for three different types of acquisitions: 1) The LERRDs required for construction and OMRR&R of the project, 2) the LERRDs required for future lift borrow, and 3) the LERRDs required for induced flooding (refer to the Section entitled Induced Flooding below). Because the location of future lift borrow sites has not yet been determined, and this project feature will be addressed in the future, this acquisition was not included in the LERRDs required for project construction (first lift). The LERRDs required for potential induced flooding are an assumed mitigation feature, and not a part of project construction. The PDT determined that these LERRDs should be included for cost purposes, should it be determined in the PED phase that it is necessary to acquire these properties for mitigation purposes. The chart below shows the estimated number of ownerships affected by each acquisition:

| | # Ownerships |
|---|---|
| Project/Levee Alignment | 580 |
| Future Lift Borrow | 325 |
| Induced Flooding | 1,010 |

PROJECT LEVEE ALIGNMENT

The project will affect approximately 580 ownerships*. Project features and proposed estates by Reach are shown on Table 1.1 below:

**Table 1.1 Project Features, Proposed Estates and Estimated Acres**

| Reach | Land Class | Est. Owners | Miles | Fee Exc. Minerals Acres | Perpetual Levee Easmt. Acres | Temp. Work Area (Borrow) Acres | Temp. Work Area (Access) Acres | Temp. Work Area (Staging) Acres | Temp. Work Area (Staging) HNC Acres |
|---|---|---|---|---|---|---|---|---|---|
| Barrier Alignment | W/F/C/WFR/R/I | 75 | 15.7 | | 732 | 434 | 5 | 20 | |
| A | M/W/F/C/WMA | 26 | 8.2 | | 373 | 226 | 7 | | |
| B | M | 33 | 5.1 | 259 | 398 | 118 | | 2 | |
| E-2 | M/R | 10 | 2.3 | 120 | 207 | 68 | 0.25 | | |
| E-1 | M | 10 | 2.1 | 151 | 253 | 93 | 0.25 | 2 | |
| F-2 | M | 3 | 1.9 | | 139 | 77 | | | |
| F-1 | M/C | 18 | 2.2 | 1287 | 75 | 51 | 1 | 16 | 298 |
| G-1 | M | 5 | 2.2 | 0 | 158 | 57 | 0.25 | | |
| G-2 | M | 5 | 1.7 | 150 | 88 | 25 | | 2 | |
| G-3 | M | 5 | 1.9 | 0 | 87 | 23 | 0.25 | | |
| H-1 | M/W/C/WFR | 15 | 1.9 | 99 | 120 | 68 | | 2 | |
| H-2 | M | 20 | 2.6 | 142 | 205 | 100 | | | |
| H-3 | M | 35 | 3.4 | 212 | 253 | 142 | | | |
| I-1 | M | 10 | 1.7 | | 156 | 61 | | | |
| I-2 | M/C/WFR | 33 | 2.1 | 161 | 164 | 105 | 0.25 | | |
| I-3 | M | 43 | 1.9 | 175 | 170 | 117 | | | |
| J-2 | C/WMA | 15 | 4.9 | 632 | 488 | 194 | | | |
| J-1 | WMA | 13 | 3.1 | 389 | 292 | 126 | | | |
| J-3 | W/WFR | 10 | 1.3 | 183 | 132 | 49 | | 2 | |
| K | M/C/WMA/WFR | 12 | 5.1 | 782 | 418 | 308 | | | |
| L | M/C/WMA | 2 | 5.9 | 0 | 499 | 184 | | 2 | |
| Larose Floodgate | I | 2 | | 3.5 | | | | 2 | |
| Lockport to Larose | M/W/F | 75 | 14 | | 412 | | | | |
| Larose C North | M/F/R/I | 105 | 7 | | 166 | | | | |
| **TOTALS:** | | **580** | **98.2** | **4,746** | **5,985** | **2,626** | **14.25** | **50** | **298** |

**M**=Marshland, **W**=Woodland, **F**=Farmland, **C**=Canals, **WMA**=Wildlife Management Areas, **WFR**=Water Front Residential, **R**=Residential, **I**=Industrial

ACCESS

Access to the construction area will be over existing public roads and navigable waters throughout the project area. In some areas, access will be via existing levee Right-of-Way. However, Temporary Access Easements are proposed in small areas where access is needed on privately owned lands. Table 1.1 shows the acreages over which a Temporary Access Easement is proposed. Access areas for Larose to Lockport and Larose C North will be determined during PED.

STAGING

The majority of staging areas for construction of this project will be located within the Right-of-Way for the levee footprint or existing Right-of-Way. Additional Right-of-Way will be required within a few reaches. Table 1.1 shows the acreages over which a Temporary Work Area Easement is proposed for staging.

BORROW

Borrow material for the first lift will be obtained adjacent to the levees in several of the Reaches. Table 1.1 demonstrates the anticipated acreage for the adjacent borrow areas. A Temporary Work Area Easement (Borrow) will be acquired in these reaches.

Borrow areas for the levee extensions (Lockport to Larose and Larose C North) have not yet been identified. As noted in the Project Description Section, additional refinement of designs and costs will need to continue through PED if the project is re-authorized.

Future Lift Borrow

Material for the remaining lifts will be hauled in from remote locations which have not yet been identified. A separate Chart of Accounts was prepared for the acquisition of LERRDs for borrow for future lifts.

Although sites have not yet been identified, the Chart of Accounts (Exhibit D) shows acquisition costs for estimated future lift borrow, assuming 325 landowners affected over 3,250 acres. A Temporary Work Area Easement (Borrow) will be acquired over these areas. While these costs are accounted for, they are estimates and the actual number of ownerships/acres will not be known until future lift borrow sites are identified.

**The 580 ownerships referred to in Table 1.1 is an estimate for the proposed features within the chart, and does not include the 325 landowners assumed for future lift borrow. The actual number of landowners affected by the future lift borrow feature is not known, and this rough estimate was not added to the number of landowners referenced in the chart. Total number of affected landowners including future lift borrow (a rough estimate) is 905.*

MITIGATION

There will be additional real estate required for mitigation. As noted in Table 1.1, approximately 4,700 acres** of Fee, Excluding Minerals will be acquired for mitigation areas. Please refer to this table for acres required in Fee by Reach. Costs for lands required for mitigation acres are included in costs for land payments in Exhibit D, Chart of Accounts. Real estate costs for mitigation lands are eligible for LERRD credit.

***The estimate of 4,700 acres was based on a preliminary mitigation analysis. Actual acreage may be less for this feature. A detailed mitigation plan and acreage for each of the programmatic features will be developed in the future.*

## INDUCED FLOODING

Existing pump stations are used to drain the project area. These pump stations, along with water control structures and navigation structures, will be operated so that the construction of the project features will not induce flooding on the protected side of the project.

Induced Flooding – Larose to Golden Meadow Project Area

Figure 2-2 below demonstrates the Larose to Golden Meadow project reaches:

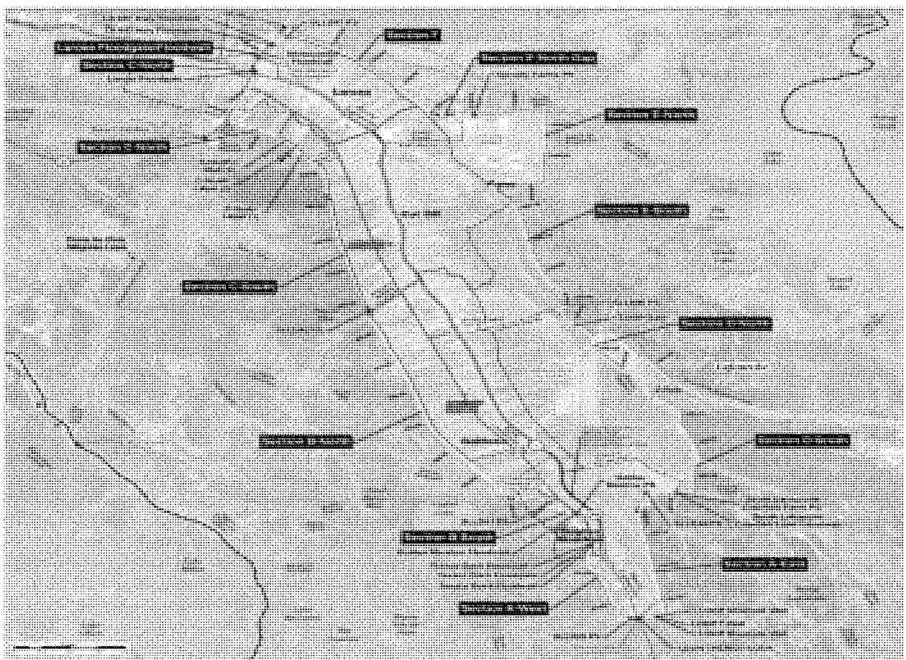


**Figure 2-1 Larose to Golden Meadow Project Reaches**

It was determined that there would be inducements in Larose levee Sections C-South, B-North, B-South and A-West (Refer to Figure 1.1). The existing levee would be raised in increments varying from 1-3 ft elevation. The impacts on the Larose to Golden Meadow project are discussed in greater detail in Section 6.5.2 of the PAC Report. It is assumed that the lifts in these sections could be constructed within existing Right-of-Way, and no additional LERRDs will be required for those sections.

Induced Flooding - Areas Outside of Levees

Construction of the levee system has the potential to raise water levels in areas immediately outside the levees by several feet during storm events. These areas include portions of the communities of Gibson, Bayou Dularge, Dulac, and Cocodrie. is the impacts outside the risk reduction system are discussed in greater detail in **Section 6.5.1** of the PAC report. At the current time, information is not available regarding the differences in frequency, depth, and duration of the flooding between the Future Without Project (FWOP) and Future With Project (FWP) conditions. This detailed information typically would be assessed in light of the uses to which the particular land is zoned, and the appropriate mitigation methods, if any, would be implemented to address the effects of the Federal project. Hydrologic modeling estimates that the Future With Project conditions could potentially increase the level of flooding to approximately 1,010 structures. Because of the vast scope of this project and the limited amount of available information at this time, the PDT was not able to look at each affected parcel individually to determine what the level of impact will be, and whether that impact would be categorized as a taking of property rights. To ensure that the public is informed of all potential impacts of the project and to prevent future delays to project schedule, the PDT, for purposes of this report, has assumed the worst case scenario (most expensive option), a 100% buy-out of all of the structures in the impacted areas.

This cost has been incorporated into the total project cost. These costs were not included as a part of the Gross Appraisal for this project, as they are based on an estimated average cost and not an actual appraisal of the properties involved.

The potential induced damages and mitigation for economic damages would be further addressed during detailed design and supplemental NEPA documents. Individual investigation and devising mitigation for each structure, if appropriate, will be done during Pre Construction Engineering & Design (PED).

Additional factors (height of structures vs. induced stages, type of residential structure, social concerns, etc.) would have to be investigated under PED. Each structure would have to be evaluated under PED to determine if mitigation is appropriate. Further modeling will be performed during PED to determine whether there is a potential taking. A Takings Analysis will be prepared during PED to address this issue, and at that time, it will be determined what real estate interest, if any, will be acquired.

For the purposes of this PAC report, it is assumed that there would be a taking, and that the properties will be acquired in fee excluding minerals. This acquisition will impact 876 residential structures and 134 non-residential structures. The estimate of acquisition costs for residential structures includes the value of the improvement, the value of the land, moving costs, differential housing payment, payment of last resort, and administrative costs. The estimate of acquisition for the non-residential structures includes the depreciated value of the improvements, land value, moving costs, re-establishment costs, necessary and reasonable incidental costs, and administrative costs. Administrative costs associated with acquisition include the costs of preparing/conducting the following for each ownership: maps and legal descriptions, title, appraisals, negotiations, relocations, closings and condemnation. The total real estate cost associated with this acquisition is estimated to be $305,115,300. These costs/assumptions are broken out in the chart below:

| | # Owners | Cost Per Owner (Rounded) | Subtotal | 25% Contingency | TOTAL |
|---|---|---|---|---|---|
| Acquisition by LS | 1,010 | 9,500 | 9,595,000 | 2,398,750 | 11,993,750 |
| Review of LS Acq | 1,010 | 5,000 | 5,050,000 | 1,262,500 | 6,312,500 |
| Condemnations | 500 | 10,000 | 5,000,000 | 1,250,000 | 6,250,000 |
| Appraisal by LS | 1,010 | 3,000 | 3,030,000 | 757,500 | 3,787,500 |
| Review of Appraisal | 1,010 | 1,000 | 1,010,000 | 252,500 | 1,262,500 |
| P.L. 91-646 Assistance | | | | | |
| Commercial | 134 | 80,300 | 10,760,200 | 2,690,050 | 13,450,250 |
| Residential | 876 | 48,011 | 42,057,800 | 10,514,450 | 52,572,250 |
| Improvement/ Land Value (Average)* | 1010 | 165,430 | 167,084,240 | 41,771,060 | 208,855,300 |
| LERRD Crediting Admin Cost | 1010 | 500 | 505,000 | 126,250 | 631,250 |
| **TOTAL** | | **$322,741** | **$244,092,240** | **$61,023,060** | **$305,115,300** |

*For purposes of the Chart of Accounts, total improvement and land value was divided by the number of structures to yield an average cost per owner.

The decision to buyout the 1,010 structures was made within two weeks of the deadline for the final report. That time frame is not sufficient for the preparation of a feasibility level cost estimate. Given the urgency to have the report completed by the deadline, the District real estate office decided to use existing data for real estate costs associated with this acquisition.

The value of the improvements was prepared by URS Group, Inc. under contract with the Corps of Engineers for the economic analysis. URS is mainly an engineering firm. For this assignment, they hired cost estimators to estimate the value of the improvements. URS used similar methodology to estimate the value of improvements as what Corps appraisers would utilize at the feasibility level. The company physically inspected the exterior of each structure, took photographs and cataloged the structure's physical characteristics including the effective age, quality of construction, and condition of structure. URS estimated the size of each structure utilizing an aerial photograph on which the structure's width and length were measured. The value was then estimated by the use of Marshall & Swift Valuation Service and Residential Handbook.

The estimate of land value for each structure is based on an average lot value for residential land and for commercial/industrial land. The estimate of land value is consistent with the values estimated in the gross appraisal for similar properties that will be acquired for the construction of the levee.

The value of the improvements and land value associated with this acquisition is not included in the gross appraisal for this project given that the information utilized to estimate the improvement values was not prepared by an appraiser. The District recognizes that this is not the conventional way to estimate value and that the inclusion of these costs in the REP is contrary to Corps regulations. However, in order to meet the required deadline this was the only alternative. The costs are included in this real estate plan in order to ensure that Congressional authorization of this project includes the necessary funds to construct the project. Once the project is authorized, a relocation plan will be prepared. In accordance with Public Law 91-646, each ownership to be acquired due to potential induced flooding will be appraised individually prior to acquisition of the property.

Estimated costs for this acquisition are included in the Chart of Accounts in Exhibit D to this Real Estate Plan.

Certain areas impacted by induced flooding may be disproportionately impacted by the project. During PED, further investigations will be performed regarding those communities. If those investigations reveal that the communities need to be relocated in a different manner than as addressed herein, the Real Estate Plan will be supplemented.

## NON-FEDERAL SPONSOR OWNED LER

Portions of Reach J-2, J-3, K and L are located within the Point Aux Chenes State Wildlife Management Area, which is owned by the Louisiana Department of Wildlife and Fisheries. Pointe Aux Chenes Wildlife Management Area encompasses 35,000 acres in Terrebonne and Lafourche Parishes, approximately 15 miles southeast of Houma. The state will issue a Grant of Particular Use to CPRAB for the lands required for the Morganza to the Gulf Project.

Several of the structures proposed for the project are located within state claimed water bodies. The State of Louisiana will provide authorization for entry for construction of these features. Below is a list of these structures:

| Reach | Structure/Location |
|---|---|
| BA | 56-ft sector gate on Bayou Black |
| B | 56-ft sector gate on Bayou Du Large |
| F-1 | 56-ft sector gate on Bayou Grand Caillou |
| G | 30-ft sector gate on Bayou Four Points |
| H-1 | 56-ft sector gate on Bayou Petit Caillou |
| I-1/I-2 | 56-ft sector gate on Bayou Terrebonne |
| J-3/K | 56-ft sector gate on Bayou Pointe Aux Chenes |
| L | 56-ft sector gate on Grand Bayou |

As discussed in Section 1.8 of the PAC Report, the Non-Federal Sponsors have constructed or plan to construct several portions of a levee which follows the alignment of this project.
If the Morganza to the Gulf project is reauthorized, the Non-Federal Sponsor will be entitled to LERRD credit for the real estate acquired for those local levees, only to the extent that the Non-Federal Sponsor is required to provide authorization for entry to the LERRDs necessary for any future Morganza to the Gulf project work that is conducted on the locally constructed levees.

The advanced property acquisition and relocation details have been provided to USACE for review and consideration. The Non-Federal Sponsor plans to request credit for the acquisition. However, for the purpose of providing the estimated total real estate costs for the project, the current LER acquisition being performed by TLCD is not included or accounted for in this Real Estate Plan. In other words, real estate costs are based on acquisition of the entire project alignment. The PPA states that after it has been signed, the Non-Federal Sponsor will be eligible for credit for lands that were acquired and necessary for the project, plus any incidental costs that were spent in acquiring these lands, within 5 years of the date the PPA is signed. Once the PPA is signed and the Non-Federal Sponsor submits a credit package for review, USACE will determine what credit they are entitled to receive.

The Non-Federal Sponsor has been notified in writing of the risks of acquiring LERRDs before execution of the PPA.

## ESTATES

The following standard estates will be required for the project:

*FEE EXCLUDING MINERALS (With Restriction on Use of the Surface).*

*The fee simple title to the land, subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; excepting and excluding all (coal) (oil and gas), in and under said land and all appurtenant rights for the exploration, development, production and removal of said (coal) (oil and gas), but without the right to enter upon or over the surface of said land for the for the purpose of exploration, development, production and removal therefrom of said (coal) (oil and gas).*

*FLOOD PROTECTION LEVEE EASEMENT*

*A perpetual and assignable right and easement in (the land described in Schedule A) (Tracts Nos, ____, ____ and ____) to construct, maintain, repair, operate, patrol and replace a flood protection (levee) (floodwall)(gate closure) (sandbag closure), including all appurtenances thereto; reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.*

*TEMPORARY WORK AREA EASEMENT*

*A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed ___________________, beginning with date possession of the land is granted to the United States, for use by the United States, its representatives, agents, and contractors as a (borrow area) (work area), including the right to (borrow and/or deposit fill, spoil and waste material thereon) (move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the _____________________ Project, together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.*

*TEMPORARY ACCESS EASEMENT (Non-Material Deviation from Standard Estate)*

*A non-exclusive and assignable temporary easement for a period not to exceed _____years beginning with date possession of the land is granted to the United States, for use by the United States, its representatives, agents, and contractors as an access route and/or right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____); together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions and other vegetation, structures, or obstacles within the limits of the right-of-way, reserving, however, to the owners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired, including the right to cross over the right-of-way as access to their adjoining land; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.*

Approval of the Temporary Access Easement (Non-Material Deviation from Standard Estate) is attached as Exhibit C.

## EXISTING FEDERAL PROJECTS WITHIN THE LER REQUIRED FOR THE PROJECT

<u>Gulf Intracoastal Waterway</u>

The Gulf Intracoastal Waterway (GIWW) crosses the northern portion of the project area. The proposed flood protection system will require two floodgates across the GIWW. The eastern floodgate will be in the town of Larose and will cross the Harvey Canal No. 2 segment of the GIWW, approximately 35.2 miles west of Harvey Lock (WHL). The Government has Fee ownership of the channel at this location. The western floodgate will be located about two miles west of the city of Houma, and will cross the Bourg Canal to Bayou Chene segment of the GIWW at mile 62 WHL. The Government owns a perpetual channel and disposal easement at this location. These Federal interests are sufficient for the construction of the floodgates. A small amount of additional fee land will be required on each side of the channel at the eastern floodgate.

<u>Coastal Wetlands Planning Protection Restoration Act (CWPPRA)</u>

CWPRRA Project TE-41, Mandalay Bank Protection Demonstration Project, lies within the footprint of Reach A of the Morganza to the Gulf Project. The sponsors for TE-41 are U.S. Fish and Wildlife Service and Louisiana Department of Natural Resources. The shoreline protection project is located within the boundaries of the Mandalay National Wildlife Refuge, which is owned by the U.S. Fish and Wildlife Service. The project was complete in 2003. Refer to the Federally Owned Lands Section below for more information.

Other Federal Projects in Planning Phase

As mentioned in the PAC Report, there are numerous other Federal projects which are being proposed within the Morganza to the Gulf Project area, including Coastal Wetlands Planning, Protection, Restoration Act (CWPPRA), Coastal Impact Assistance Program (CIAP) projects, the Houma Navigation Canal Lock, and the Larose to Golden Meadow project. These projects are currently in the planning phase, and LER has not yet been acquired for the projects. For most of these projects, except the Larose to Golden Meadow project, LER required is not expected to lie within or overlap the Morganza to the Gulf project footprint.

## FEDERALLY OWNED LANDS WITHIN THE LER FOR THE PROJECT

The United States owns fee title to lands within the Mandalay National Wildlife Refuge, located within Reach A. Approximately 80 acres within the Wildlife Refuge will be required for the project. The U.S. Fish and Wildlife Service (USFWS) is the managing agency for these lands. The Non-Federal Sponsor will acquire from the USFWS the necessary real estate interests required for the project.

## NAVIGATION SERVITUDE

Portions of the project water control structures lie within the navigable waters of the United States, and therefore the Federal Navigational Servitude will be invoked for those portions of the project.

The navigation servitude is the dominant right of the Government under the Commerce Clause of the U.S. Constitution to use, control and regulate the navigable waters of the United States and submerged lands thereunder. The applicability of the navigation servitude depends on both legal and factual determinations. First, it must be determined whether the project feature serves a purpose which is in the aid of commerce. Because this is a hurricane and storm damage risk reduction project, it would serve such a purpose. Secondly, it must be determined whether the land required for the project is located below the mean high water mark (in tidal areas), or below the ordinary high water mark of a navigable watercourse (in non-tidal areas).

The project requires crossing several navigable watercourses. Water control structures will be built within these streams to provide the hurricane and storm damage risk reduction measures for those openings. These portions of the project right-of-way lie below the ordinary high water mark in an inland watercourse that interstate or foreign commerce has either used, is presently using, or is susceptible to use. Therefore, it is within the Navigable Waters of the United States (33 CFR, Part 329). The Federal Navigational Servitude is available for those portions of the project.

## BASELINE COST ESTIMATES/CHART OF ACCOUNTS (COAs)

A Chart of Accounts for each Reach is included in Exhibit D of this Real Estate Plan. The total cost for Real Estate Acquisition by Reach is listed below:

| Reach Name | Total Real Estate Costs |
|---|---|
| Barrier Alignment | $ 3,702,000 |
| A | $ 896,000 |
| B | $ 1,045,000 |
| E-1 | $ 435,000 |
| E-2 | $ 565,000 |
| F-1 (includes HNC Lock Complex) | $ 1,139,000 |
| F-2 | $ 150,000 |
| G-1 | $ 198,000 |
| G-2 | $ 233,000 |
| G-3 | $ 154,000 |
| H-1 | $ 2,929,000 |
| H-2 | $ 611,000 |
| H-3 | $ 1,088,000 |
| I-1 | $ 322,000 |
| I-2 | $ 1,901,000 |
| I-3 | $ 1,203,000 |
| J-1 | $ 0 |
| J-2 | $ 0 |
| J-3 | $ 1,120,000 |
| K | $ 1,136,000 |
| L | $ 282,000 |
| Larose Floodgate | $ 159,000 |
| Future Lift Borrow | $ 17,424,000 |
| Induced Damages Flood Side | $305,115,000 |
| Lockport to Larose | $ 2,931,000 |
| Larose C North | $ 10,088,000 |
| **TOTAL ALL REACHES** | **$354,826,000** |

As noted above, costs for the HNC Lock Complex are included in Reach F-1.

The costs include land payments as well as administrative costs and incremental costs associated with acquiring the real estate interests. These estimates include costs of acquiring mitigation lands. The gross appraisal for LER was reviewed and approved at the Division level. However, a revised gross appraisal is currently under review.

Refer to Exhibit D for the Baseline Cost Estimate/Chart of Accounts estimate for each Reach.

*Note: The cost estimates do not reflect the costs for facilities/utilities relocations. Refer to the section entitled "Facility/Utility Relocations" for more information.*

## UNIFORM RELOCATION ASSISTANCE (PL 91-646, Title II as amended)

The benefits of Title II of the Uniform Relocation Assistance and Real Property Acquisition Policy Act of 1970 (P.L. 91-646), as amended, are applicable for this project. Title II requires that persons and businesses displaced by a Federal project be given advisory services and assistance in the location of replacement dwellings and businesses.

Under Title II, displaced persons are entitled to reimbursement for actual and reasonable moving of personal property, differential housing payment, and incidental costs associated with the relocation. Differential housing payment is a payment made by the Government when the compensation paid for the property being acquired is not sufficient to cover the costs of a replacement dwelling for the displaced persons. Differential payments are capped at $22,500 for homeowners and $5,280 for tenants. However, in cases where the difference between the compensation and the cost of a replacement dwelling is greater than that specified in the regulation, the agency may request approval for payment of last resort. Payment of last resort is calculated on a case by case basis and has no predetermined amount. For this study, the estimate of Title II payment assumes that all displaced persons are homeowners and that the agency will need to request approval for payment of last resort. This assumption is made because there is not sufficient time to survey residents in order to determine their residency status, and it allows for a higher estimate of Title II payments. Title II costs were estimated to be approximately $60,000 per displaced family (including contingencies).

The benefits of Title II for displaced businesses are not as lucrative as they are for displaced persons. Businesses are entitled to receive advisory services, reimbursement for actual reasonable moving costs, re-establishment costs which are capped at $10,000 and certain reasonable and necessary incidental costs associated with the relocation. For purposes of this study, the estimate of relocation for business includes all of these costs and was estimated to be approximately $100,000 per business (including contingencies).

The chart below demonstrates the estimated number of displaced landowners within the levee alignment and the type of property to be displaced. The estimate of relocation assistance benefits are included within the Chart of Accounts provided for each Reach within Exhibit D of this document.

| Reach | # Displaced | Type of Property to be Displaced |
|---|---|---|
| H | 7 | Residential |
| I-2 | 1 | Residential |
| J-3 | 1 | Residential |
| K | 1 | Residential |
| Flood-side Potential Induced Flooding | 1010 | 134 Non-Residential, 876 Residential |
| Larose C North | 51 | 51 Residential |

It is likely that comparable dwellings will be available to relocate persons displaced as a result of the levee alignments. However, the team recognizes the difficulty associated with relocating 1,010 displaced families and business impacted by the potential induced flooding. It is likely that there will not be sufficient replacement dwellings and business establishments on the market to meet the demand. It may be necessary for homeowners to construct new dwellings and for businesses to construct new buildings or to move to areas that are 25 miles from their current location. The project area is rural, and there is ample vacant land to accommodate new construction. Relocations will be accomplished in phases along with project construction and every effort will be made to relocate displaced persons and business as close to the current communities as possible.
The Non-Federal Sponsor will perform these relocations as a part of its responsibility under the project authority. These relocation costs are eligible for LERRD credit. These conclusions are preliminary only.

If the Morganza to the Gulf project is reauthorized, the Non-Federal Sponsor will be entitled to LERRD credit for the real estate acquired for those local levees, only to the extent that the Non-Federal Sponsor is required to provide authorization for entry to the LERRDs necessary for any future Morganza to the Gulf project work that is conducted on the locally constructed levees.

## TIMBER/MINERAL/ROW CROP ACTIVITY

The Louisiana Department of Natural Resources provides a Strategic Online Natural Resources Information System (SONRIS), which contains up-to-date information on oil & gas activity in the state of Louisiana. Review of this information indicated that there are several active oil and gas wells within the vicinity of the project. The PDT determined that oil and gas wells will not be relocation items, and the levee alignment would be changed, or T-walls used, during the project Plans and Specifications (P&S) phase to avoid them.

With the exception of the acquisition of the standard Fee Excluding Minerals (With Restrictions on the Use of the Surface) estate over certain lands, the Government will not acquire mineral rights to any of the LER required for the project. Over lands where the fee estate is being acquired, mineral rights will be subordinated. Mineral right owners can still explore for minerals through directional drilling. The timber on most of the wooded right-of-way has little or no value. Any timber present is included in the overall appraised value of the land. For properties impacted by the project which are in agricultural use, the owner will be allowed to harvest crops prior to acquisition.

## OYSTER LEASES

Southern Terrebonne and Lafourche Parishes are abundant with oysters. Several oyster leases exist within the project study area. For the Tentatively Selected Plan, seven (7) oyster leases will be impacted by the project. The table below provides information regarding the oyster leases within the project footprint:

| REACH | STATIONS | LOCATION | LEASE # | STATUS |
|---|---|---|---|---|
| H-3 | 4040-4050 | MIT/BORROW/LEVEE | 2980904 | EXPIRES 2019, TERRY NETTLETON |
| H-3 | 4055-4070 | BORROW AREA | 3041904 | EXPIRES 2019, NETTLETON OYSTERS |
| I-1 | 4250-4275 | MITIGATION AREA | 3127005 | EXPIRES 2020, BAY NEGRESSE, INC. |
| I-2 | 4345-4350 | MITIGATION AREA | 3303408 | EXPIRES 2023, BAY NEGRESSE, INC. |
| I-2/I-3 | 4385-4400 | MITIGATION/BORROW | 2757100 | EXPIRES 2015, SANDRA & TERRY, INC. |
| I-3 | 4400-4405 | MITIGATION AREA | 3234007 | EXPIRES 2022, TERRY'S SEAFOOD, INC. |
| I-3 | 4435-4465 | MIT/BORROW/LEVEE | 3366109 | EXPIRES 2024, COON OYSTERS, LLC |

In accordance with State statute (LA R.S. 56:432.1 and Act 523 (2009)), all oyster lease acreage determined to be directly impacted by a project feature shall be acquired. The area of impact to oyster leases is generally considered to be the footprint of the project feature plus an approximately 150 foot buffer. Considering State statute, it is anticipated that at least a portion of seven (7) oyster leases will need to be acquired. The total estimated cost of acquisition of these oyster leases is $316,300 (these costs are included in the Chart of Accounts Section above).

At this time, no estimate is included for possible business relocation costs associated with oyster lease acquisition. It is, however, anticipated that minimal moving costs may be associated with the moving of markers (personal property) that delineate the leased areas.

## ZONING ORDINANCES

There will be no application or enactment of zoning ordinances in lieu of, or to facilitate, acquisition in connection with this project.

## ACQUISITION SCHEDULE

The following acquisition schedule is based on the premise that the project will impact approximately 580 landowners for the levee alignment. It is assumed that the project will be constructed in sections. A detailed acquisition schedule will be prepared during PED once the 95% plans and specifications are prepared for each section of the project. The schedule below provides the total amount of time to complete the acquisition of real estate rights for mitigation and for the construction of the levee alignment based on the preliminary information available at this time. This schedule is only for purposes of the feasibility study.

| | | |
|---|---|---|
| 1) | TOD, Mapping | 3 years |
| 2) | Obtain Title & Appraisals (begin 1 year after mapping begins then run concurrently with mapping) | 6 years |
| 3) | Negotiations (begins 1 year after title and Appraisals begin and then run concurrently with those tasks) | 10 years |
| 4) | Closing/Condemnation (begins 1 year after negotiations begin and runs concurrently with negotiations) | 10 years |
| 5) | Eminent Domain Proceedings (begins 1 year after negotiations begin and ends 1 year after the end of negotiations) | 12 years |

The following acquisition schedule is for the acquisition of the areas potentially impacted by induced flooding. This schedule assumes acquisition of 1,010 properties. The time frame indicated below is in addition that calculated for acquisition of properties impacted by construction of the levee.

| | | |
|---|---|---|
| 1) | TOD, Mapping | 5 years |
| 2) | Obtain Title & Appraisals (begin 1 year after mapping begins then run concurrently with mapping) | 10 years |
| 3) | Negotiations (begins 1 year after title and Appraisals begin and then run concurrently with those tasks) | 15 years |
| 4) | Closing/Condemnation (begins 1 year after negotiations begin and runs concurrently with negotiations) | 15 years |
| 5) | Eminent Domain Proceedings (begins 1 year after negotiations begin and ends 1 year after the end of negotiations) | 15 years |

## FACILITY/UTILITY RELOCATIONS

Relocation data was collected and detailed by the USACE New Orleans District, Engineering Division, Design Services Branch Relocations Team, to a feasibility level of design. A separate Relocations Report, containing relocations costs, was submitted as a reference to the Engineering Appendix of the PAC Report. Maps of potential relocations can be referenced in that appendix. Those relocation costs represent a feasibility level of design and will be further refined during the development of the project P&S.

The project is traversed by numerous crude oil and natural gas pipelines, and by utilities and minor public highways. These facilities are listed and discussed in detail in the "Preliminary Attorney's Investigation and Report of Compensable Interest" (CIR), which was prepared on March 12, 2012 for the Post Authorization Change Report by District Office of Counsel. Based on the limited information available, all of the relocations were found to be compensable.

The Non-Federal Sponsor will perform these relocations as a part of its responsibility under the project authority. The conclusions are preliminary only. The Government will make a final determination of the relocations necessary for the construction, operation or maintenance of the project after further analysis, and completion and approval of the Final Attorney's Opinion of Compensability for each of the impacted utilities and facilities.

There are numerous schools, cemeteries and churches within the project area, but none will be adversely impacted by this project. It is not known at this time whether areas impacted by induced flooding include schools, cemeteries and churches.

## HAZARDOUS, TOXIC AND RADIOACTIVE WASTE

As the result of project changes such as larger levee footprints, all project-related benefits and impacts must be reviewed, including benefits and impacts to environmental habitat, navigation and industry, commercial and recreational fishing, salinity intrusion, and freshwater and sediment diversion. A Final Phase I Environmental Site Assessment was conducted in May, 2011 for the Morganza to the Gulf Project. A Revised Programmatic Environmental Impact Statement (RPEIS) was prepared to document the environmental changes. In summary, there is a low probability that HTRW would alter the project design or alignment in the PAC levee reaches. No environmental studies have been completed for the additional levee features associated with Larose to Lockport or Larose C-North. Based on the land types/uses impacted by the additional right-of-way (wetlands, agricultural, woodlands and residential), HTRW is not suspected. If the project is re-authorized, Phase I studies would be conducted in these areas. There is one area in the Larose C-North which is industrial. If the project is re-authorized, Phase II investigations would be conducted in this area during PED.

Environmental studies have not been conducted over areas to be acquired as a result of induced flooding. These studies will be conducted during PED phase.

## LANDOWNER CONCERNS

There have been many public meetings regarding the original PAC alignment, and the project has received wide-spread support from the community; however, the attitudes of the landowners who will be directly affected by its construction is not known. The Non-Federal Sponsor is confident that landowner support will be high, and they will be able to acquire the LER required for the project. However, it is anticipated that there will not be strong landowner support for acquisition of properties outside the levee areas, as a result of induced flooding nor for the acquisition of areas impacted by Larose C-North which displace residences.

Prepared by:

Karen E. Vance
Realty Specialist
Real Estate Region South Division
March 26, 2013

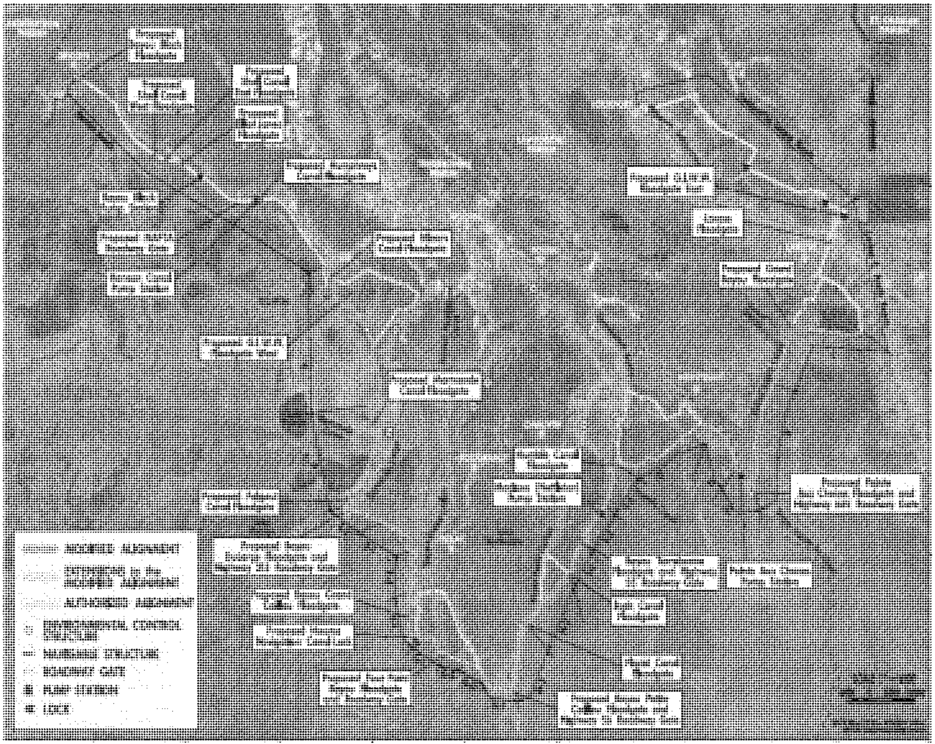
Recommended for Approval By:

Judith Y. Gutierrez
Chief, Appraisal & Planning Branch
Real Estate Region South Division
March 26, 2013

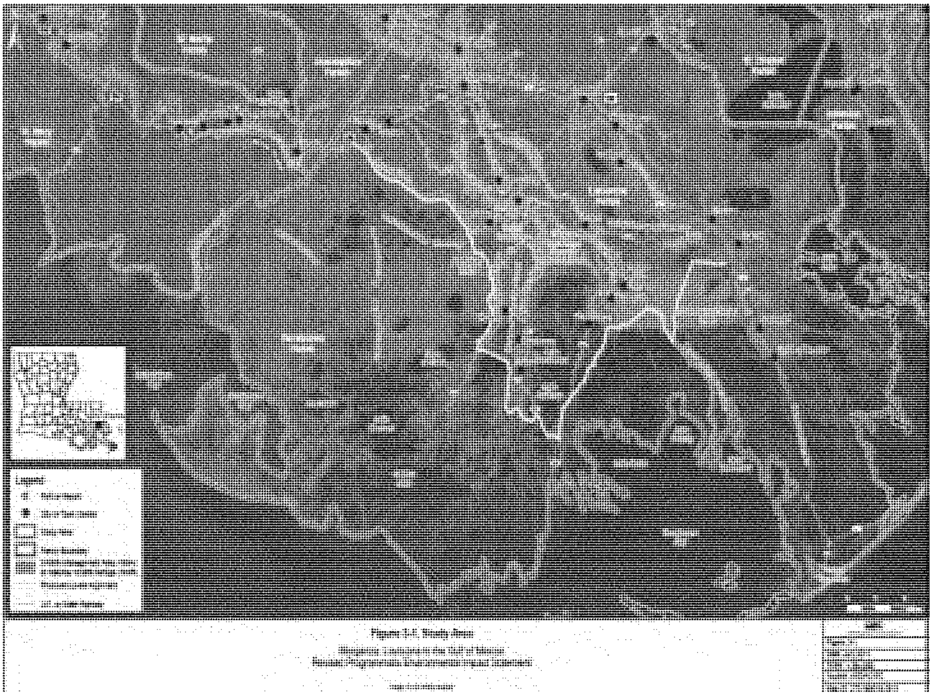
# EXHIBIT A

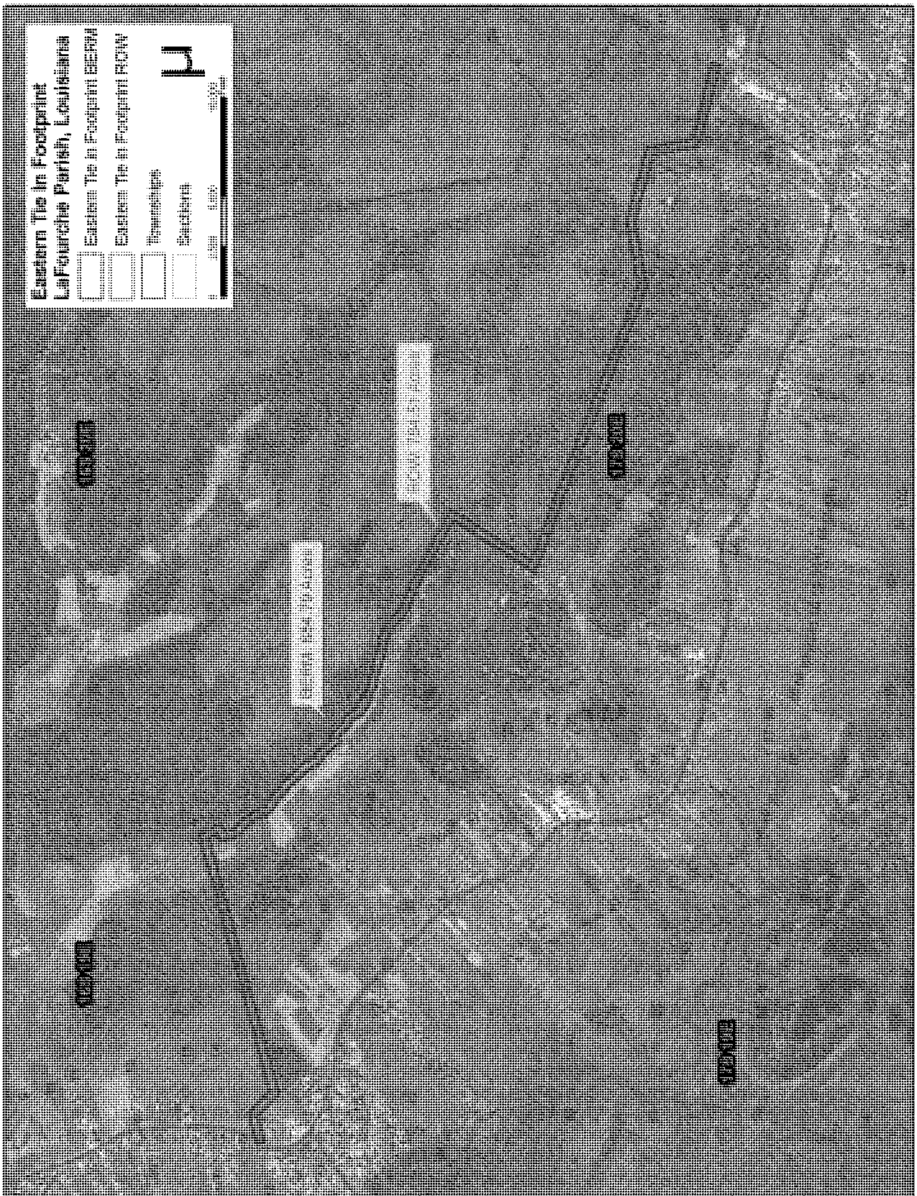
# PROJECT MAPS

MORGANZA TO THE GULF



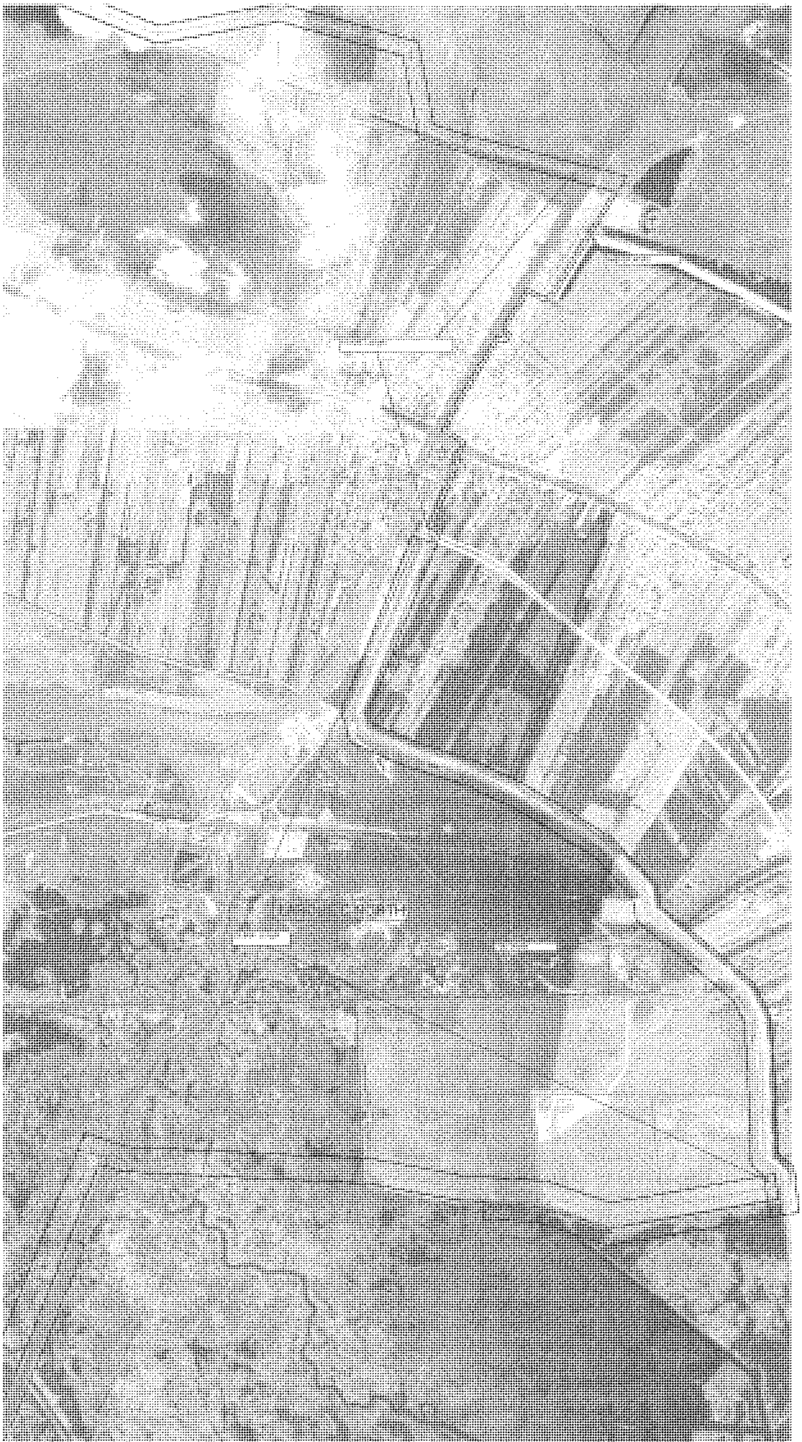
PROJECT STUDY AREA

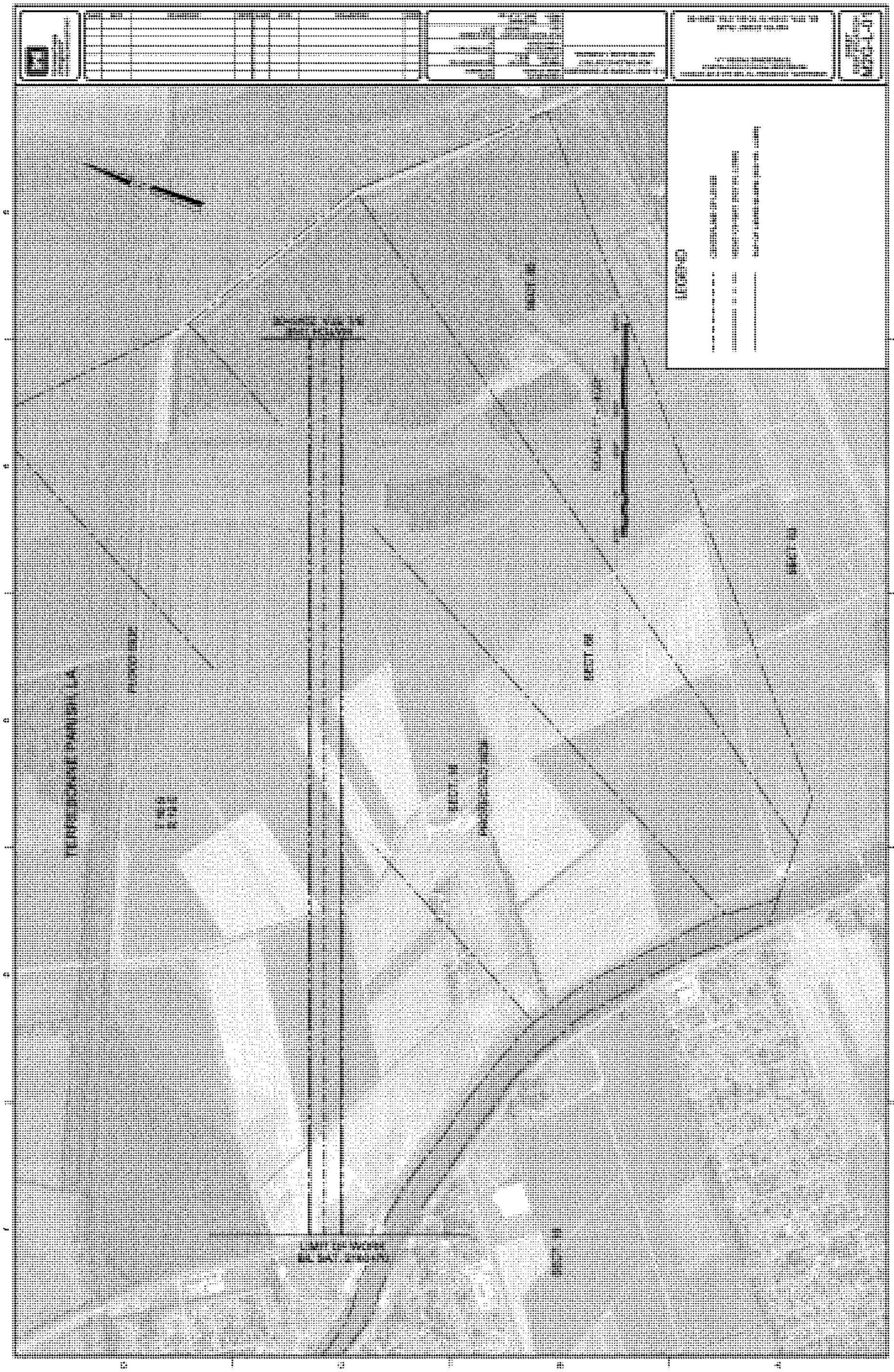


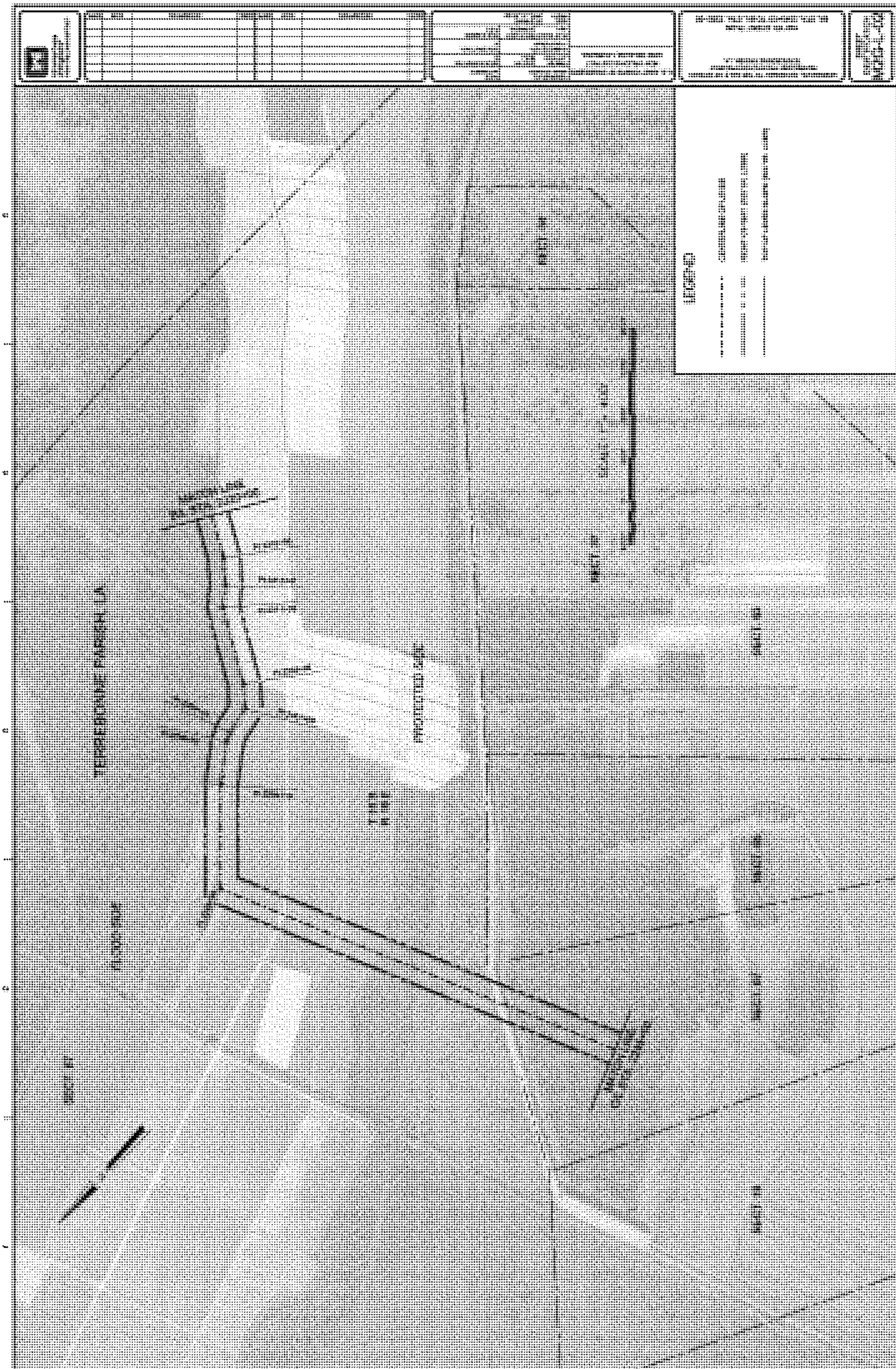


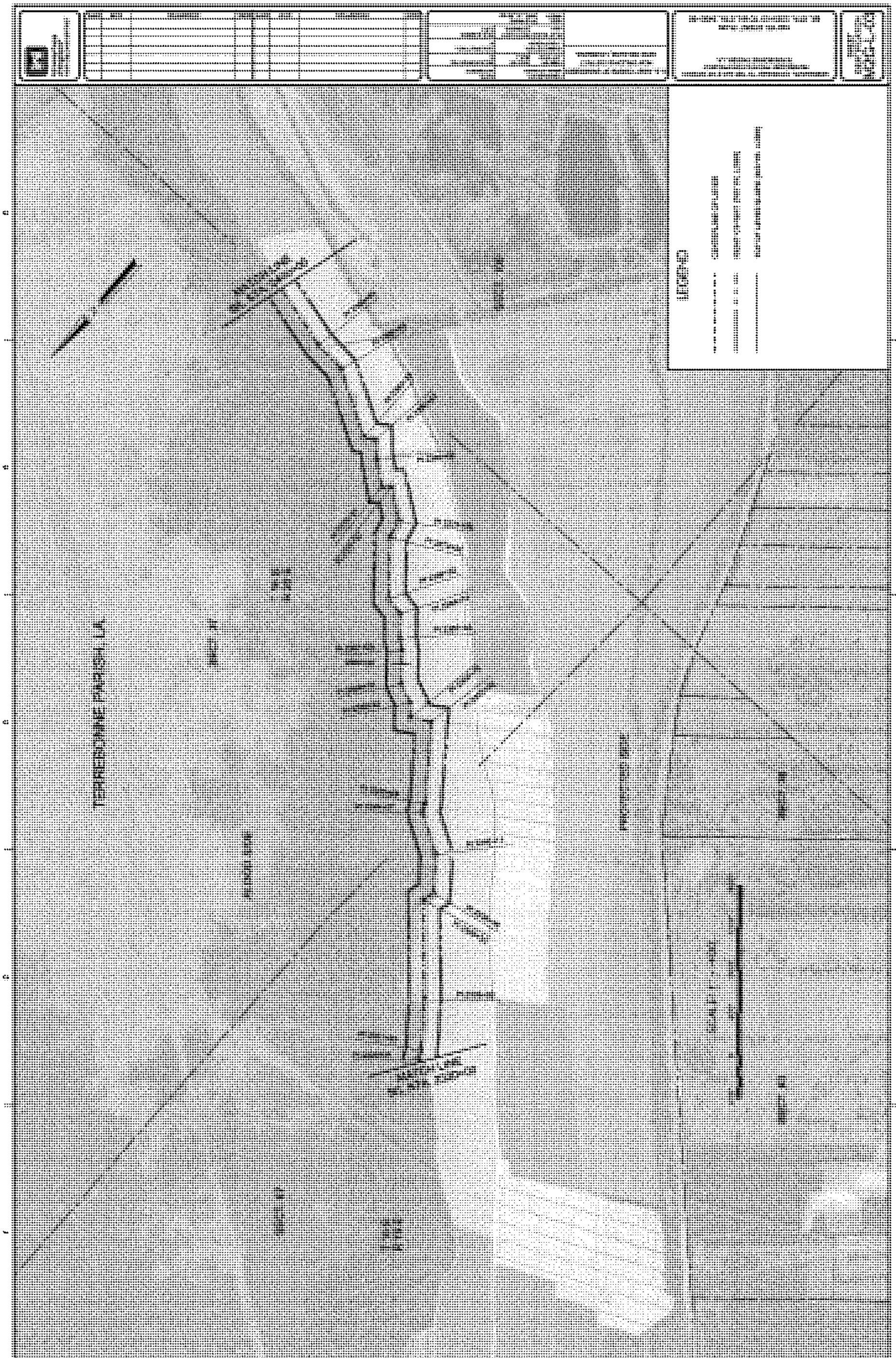

H:\Ree\Jo Kemper\JUNE6_JUDI_ Footprint For Eastern Tie-In - Morg To The Gulf

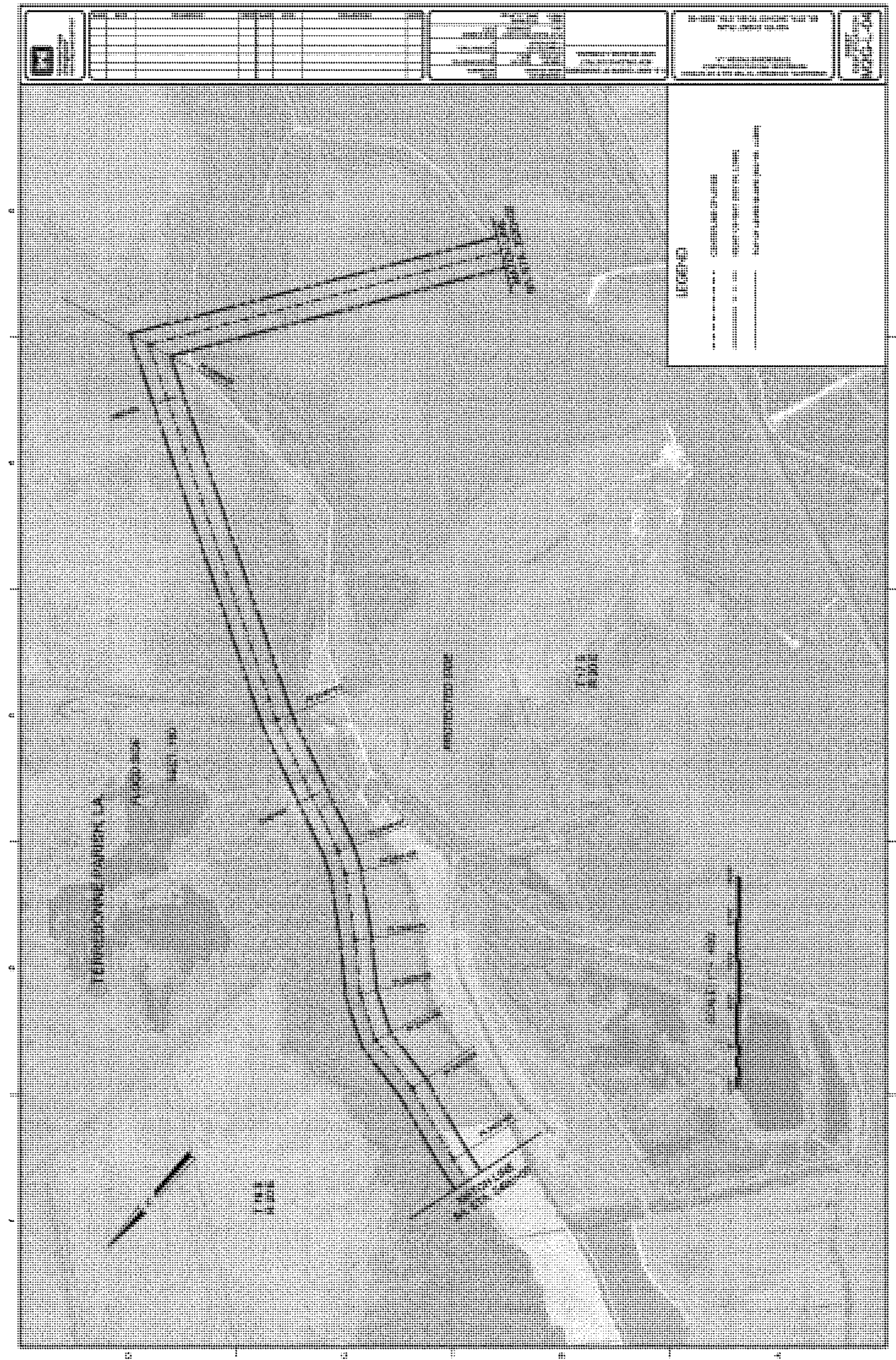
1801

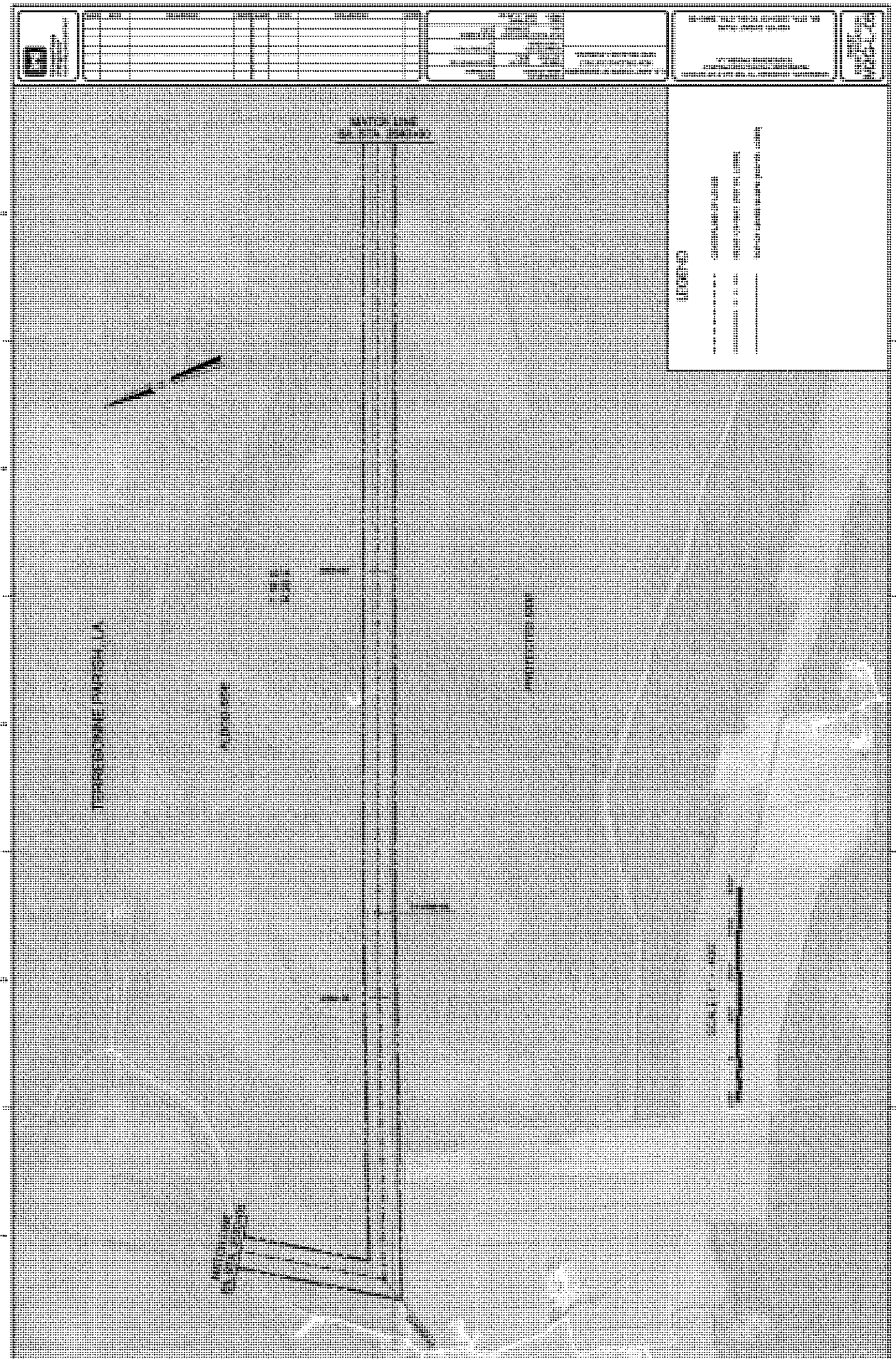


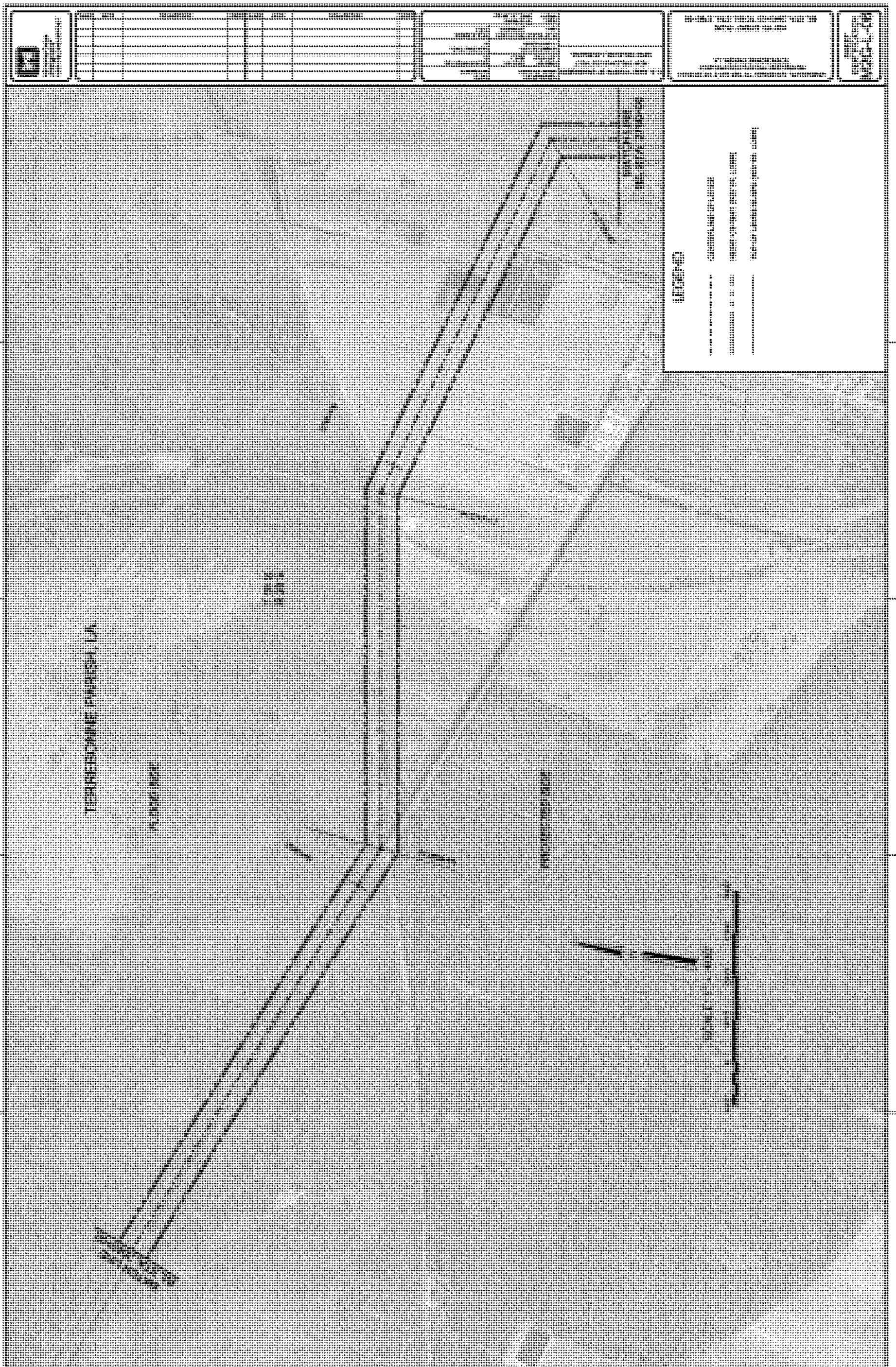


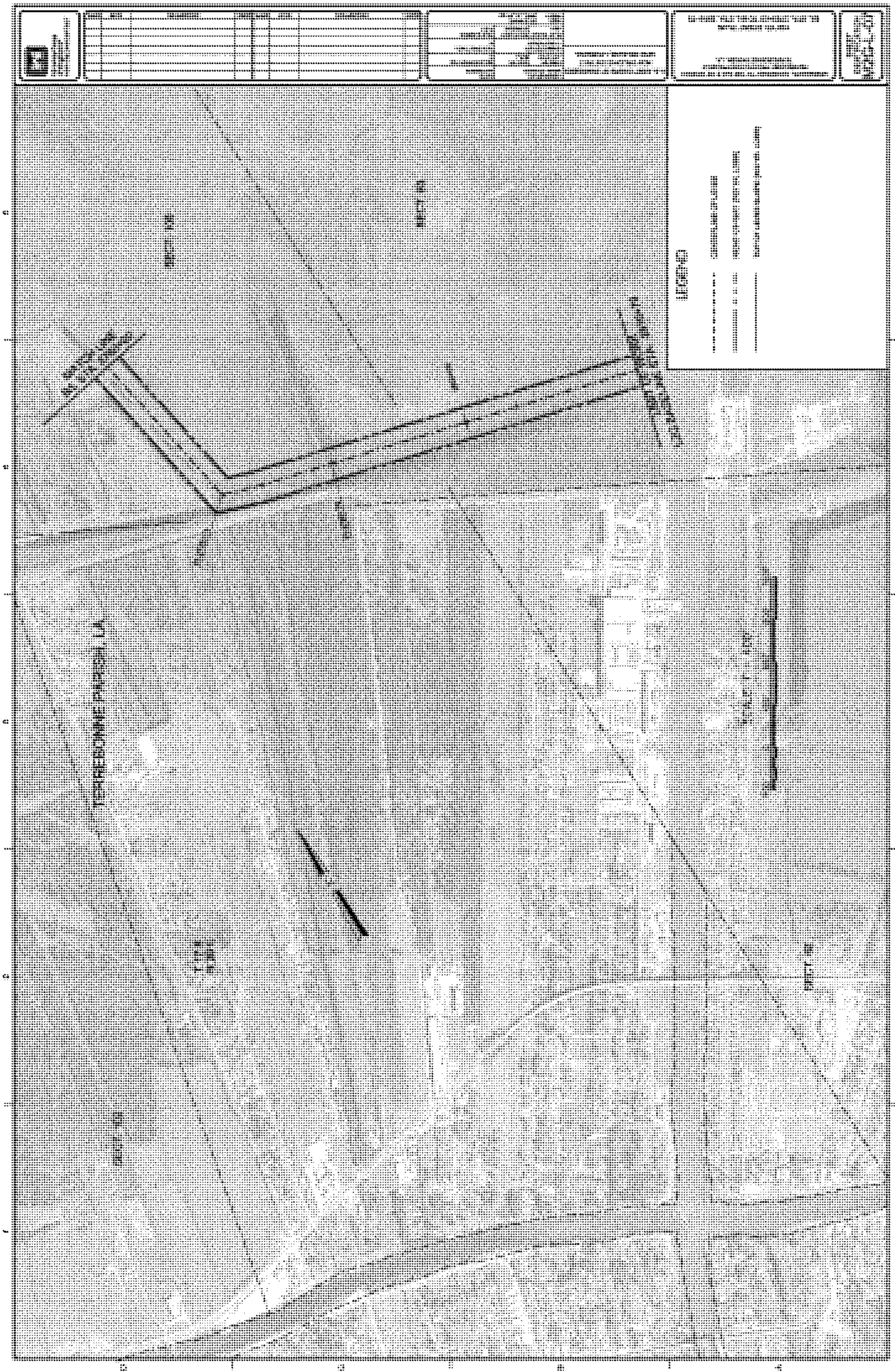

TERREBONNE PARISH, LA
FLOOD SIDE
PROTECTED SIDE
LEGEND

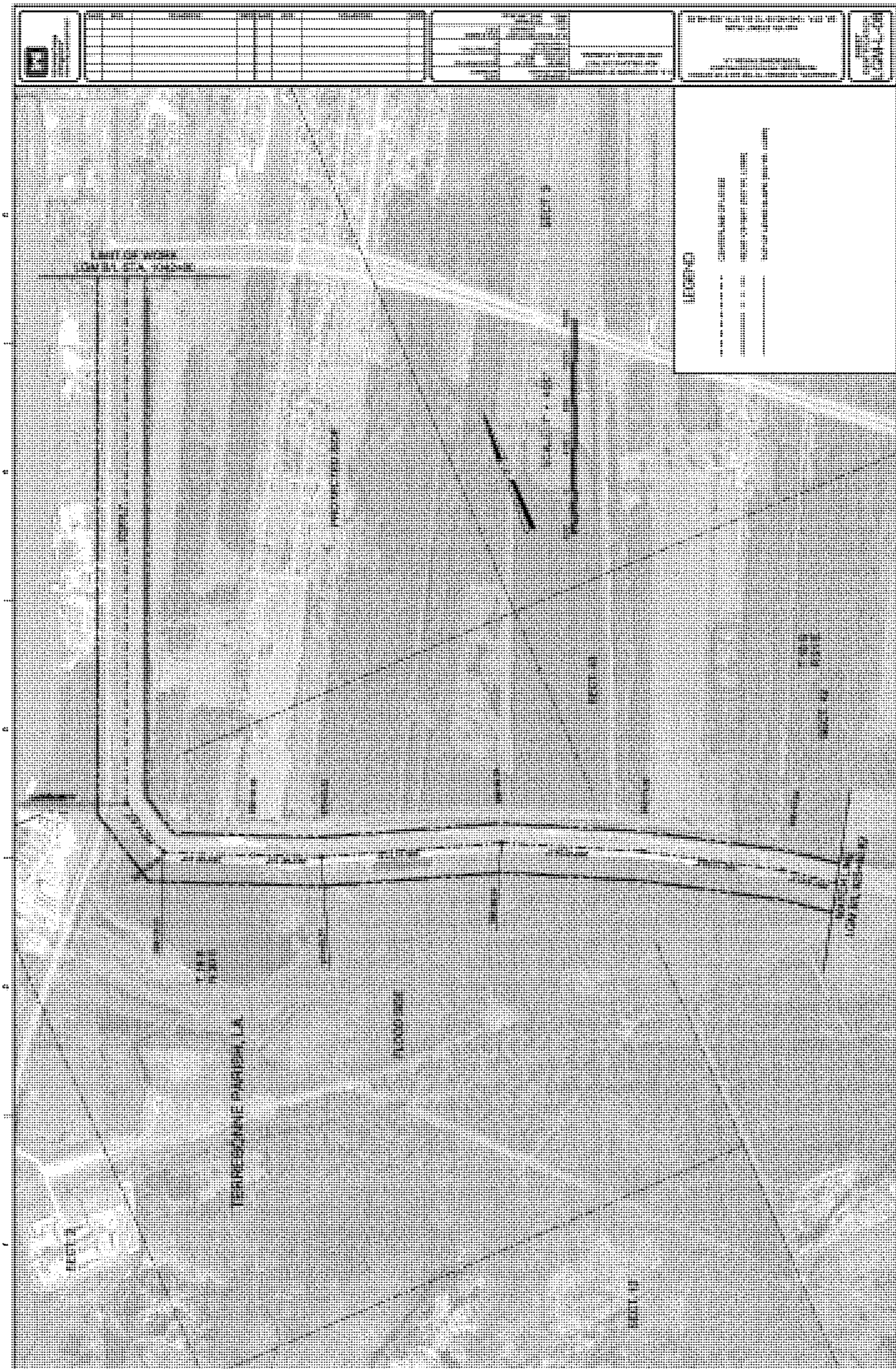

TERREBONNE PARISH, LA.
LEGEND

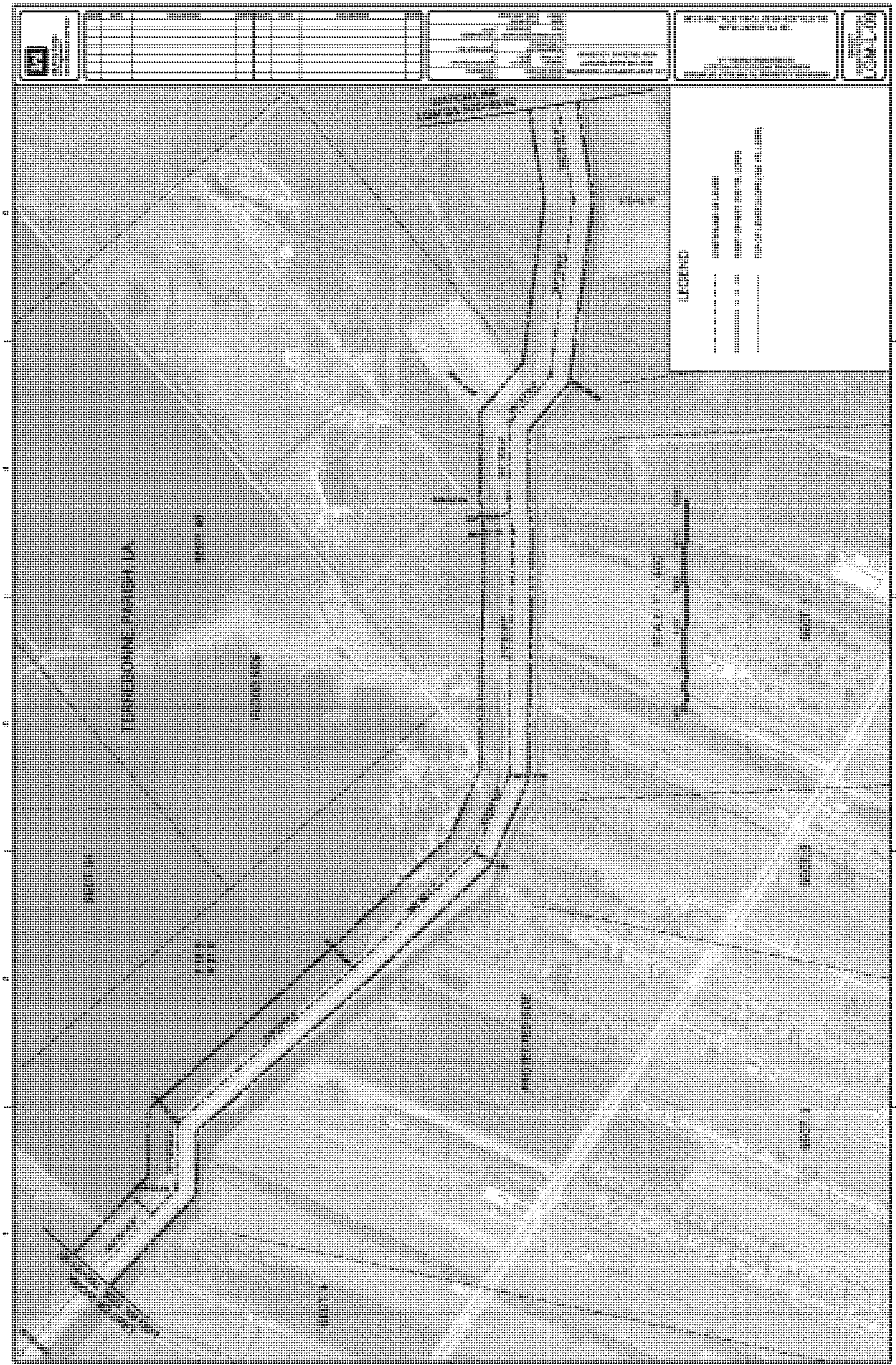



TERREBONNE PARISH, LA
FLOOD SIDE
PROTECTED SIDE
LEGEND


TERREBONNE PARISH, LA.


TERREBONNE PARISH, LA.





LEGEND
TERREBONNE PARISH, LA

# EXHIBIT B

# ASSESSMENT OF NON-FEDERAL SPONSOR'S ACQUISITION CAPABILITY

# ASSESSMENT OF NON-FEDERAL SPONSOR'S REAL ESTATE ACQUISITION CAPABILITY

# COASTAL PROTECTION AND RESTORATION AUTHORITY (CPRA)

I. Legal Authority:

a. Does the sponsor have legal authority to acquire and hold title to real property for project purposes? **YES, if property title is required for the purpose of this project.**

b. Does the sponsor have the power of eminent domain for this project?
**NO. Although the Sponsor does not have eminent domain authority, if this should be needed for the project, the Sponsor may partner with a Levee District or Parish Government which has that authority (Act 225 RS38:301.1 and Act 320), if they agree.**

c. Does the sponsor have "quick-take" authority for this project?
**NO. Although the Sponsor does not have quick take authority, if this should be needed for the project, the Sponsor may partner with a Levee District or Parish Government which has that authority (Act 225 RS38:301.1 and Act 320), if they agree.**

d. Are any of the lands/interests in land required for the project located outside the sponsor's political boundary? **NO**

e. Are any of the lands/interests in land required for the project owned by an entity whose property the sponsor cannot condemn? **YES**

**The United States owns fee title to lands within the Mandalay National Wildlife Refuge, located within Reach A. The U.S. Fish and Wildlife Service is the managing agency for these lands. Some of the LER required for the project within Reach A is located within this area. It is expected that the U.S. Fish and Wildlife Service will support the project and grant the necessary real estate interests required for the project.**

II. Human Resource Requirements:

a. Will the sponsor's in-house staff require training to become familiar with the real estate requirements of Federal projects including P.L. 91-646, as amended? **NO**

b. If the answer to II.a. is "yes," has a reasonable plan been developed to provide such training? **N/A**

c. Does the sponsor's in-house staff have sufficient real estate acquisition experience to meet its responsibilities for the project? **YES**

d. Is the sponsor's projected in-house staffing level sufficient considering its other workload, if any, and the project schedule? **Not at this time. However, CPRA has numerous contracts in place which provide ample resources.**

**CPRA is presently under development. It is expected that the staff will continue to grow in the upcoming months/years, provided sufficient budget and proper legal authorities.**

e. Can the sponsor obtain contractor support, if required in a timely fashion? **YES, contracts are in place now.**

f. Will the sponsor likely request USACE assistance in acquiring real estate? **It is not likely that the Sponsor will request assistance.**

III. Other Project Variables:

a. Will the sponsor's staff be located within reasonable proximity to the project site? **YES**

b. Has the sponsor approved the project/real estate schedule/milestones? **At the feasibility level, there are too many unknowns to develop a definite project schedule. Once project designs are finalized, the Sponsor will be requested to provide an acquisition schedule.**

IV. Overall Assessment:

a. Has the sponsor performed satisfactorily on other USACE projects? **YES**

b. With regard to this project, the sponsor is anticipated to be: highly capable/fully capable/moderately capable/marginally capable/insufficiently capable. **Highly capable**

V. Coordination:

a. Has this assessment been coordinated with the sponsor?
**YES**

b. Does the sponsor concur with this assessment?
**YES**

| Prepared by: | Approved by: |
| --- | --- |
| Judith Y. Gutierrez | CWallace |
| Judith Y. Gutierrez<br>Chief, Appraisal & Planning Branch<br>Real Estate Region South Division<br>USACE | Cynthia Wallace<br>Chief, Real Estate/Land Rights Division<br>Office of Coastal Protection & Restoration |

# ASSESSMENT OF NON-FEDERAL SPONSOR'S REAL ESTATE ACQUISITION CAPABILITY TERREBONNE LEVEE AND CONSERVATION DISTRICT

I. Legal Authority:

a. Does the sponsor have legal authority to acquire and hold title to real property for project purposes? (yes/no)

**Yes**

b. Does the sponsor have the power of eminent domain for this project? (yes/no)

**Yes**

c. Does the sponsor have "quick-take" authority for this project? (yes/no)

**Yes**

d. Are any of the lands/interests in land required for the project located outside the sponsor's political boundary (yes/no)

**No**

e. Are any of the lands/interests in land required for the project owned by an entity whose property the sponsor cannot condemn? (yes/no)

**Yes** - The United States owns fee title to lands within the Mandalay National Wildlife Refuge, located within Reach A. The U.S. Fish and Wildlife Service is the managing agency for these lands. Some of the LER required for the project within Reach A is located within this area. It is expected that the U.S. Fish and Wildlife Service will support the project and grant the necessary real estate interests required for the project.

II. Human Resource Requirements:

a. Will the sponsor's in-house staff require training to become familiar with the real estate requirements of Federal projects including P.L. 91-646, as amended? (yes/no)

**No**

b. If the answer to II.a. is "yes," has a reasonable plan been developed to provide such training? (yes/no)

**N/A**

c. Does the sponsor's in-house staff have sufficient real estate acquisition experience to meet its responsibilities for the project? (yes/no)

**Yes**

d. Is the sponsor's projected in-house staffing level sufficient considering its other workload, if any, and the project schedule? (yes/no)

**Yes**

e. Can the sponsor obtain contractor support, if required in a timely fashion? (yes/no)

**Yes**

f. Will the sponsor likely request USACE assistance in acquiring real estate? (yes/no – If yes provide description)

**No**

III. Other Project Variables:

a. Will the sponsor's staff be located within reasonable proximity to the project site? (yes/no)

**Yes**

b. Has the sponsor approved the project/real estate schedule/milestones? (yes/no)

**Yes**

IV. Overall Assessment:

a. Has the sponsor performed satisfactorily on other USACE projects? (yes/no/not applicable)

**Yes**

b. With regard to this project, the sponsor is anticipated to be: highly capable/fully capable/moderately capable/marginally capable/insufficiently capable. (If sponsor is believed to be "insufficiently capable," provide explanation.)

**Fully Capable**

V. Coordination:

a. Has this assessment been coordinated with the sponsor? (yes/no)

**Yes**

b. Does the sponsor concur with this assessment? (yes/no)

Yes

Prepared by:

3-11-11
Date

Karen Vance
Karen Vance
Realty Specialist

Reviewed by:

3-11-11
Date

Al J. Levron
Al Levron
Parish Manager
Terrebonne Parish Consolidated Govt.

Approved by:

3-17-11
Date

Linda C. LaBure
Chief, Real Estate Division

# ASSESSMENT OF NON-FEDERAL SPONSOR'S REAL ESTATE ACQUISITION CAPABILITY

**North Lafourche Conservation, Levee & Drainage District**

**June 2012**

I. Legal Authority:

a. Does the sponsor have legal authority to acquire and hold title to real property for project purposes? **YES**

b. Does the sponsor have the power of eminent domain for this project? **YES**

c. Does the sponsor have "quick-take" authority for this project? **YES**

d. Are any of the lands/interests in land required for the project located outside the sponsor's political boundary ? **NO**

e. Are any of the lands/interests in land required for the project owned by an entity whose property the sponsor cannot condemn? **YES**

The United States owns fee title to lands within the Mandalay National Wildlife Refuge, located within Reach A. The U.S. Fish and Wildlife Service is the managing agency for these lands. Some of the LER required for the project within Reach A is located within this area.

II. Human Resource Requirements:

a. Will the sponsor's in-house staff require training to become familiar with the real estate requirements of Federal projects including P.L. 91-646, as amended? **NO**

b. If the answer to II.a. is "yes," has a reasonable plan been developed to provide such training? **N/A**

c. Does the sponsor's in-house staff have sufficient real estate acquisition experience to meet its responsibilities for the project? **YES**

d. Is the sponsor's projected in-house staffing level sufficient considering its other workload, if any, and the project schedule? **NO**

e. Can the sponsor obtain contractor support, if required in a timely fashion? **YES, contracts are in place now.**

f. Will the sponsor likely request USACE assistance in acquiring real estate?
**It is not likely that the sponsor will request assistance.**

III. <u>Other Project Variables</u>:

a. Will the sponsor's staff be located within reasonable proximity to the project site? **YES**

b. Has the sponsor approved the project/real estate schedule/milestones?

**At the feasibility level there are too many unknowns to develop a definite project schedule. Once project designs are finalized, the sponsor will be requested to provide an acquisition schedule.**

IV. <u>Overall Assessment</u>:

**a.** Has the sponsor performed satisfactorily on other USACE projects? **YES**

b. With regard to this project, the sponsor is anticipated to be: highly capable/fully capable/moderately capable/marginally capable/insufficiently capable.

**Fully capable**

V. Coordination:

a. Has this assessment been coordinated with the sponsor?
**YES**

b. Does the sponsor concur with this assessment?
**YES**

Prepared by:

Judith Y. Gutierrez
Chief, Appraisal & Planning Branch
Real Estate Region South Division
USACE

Approved by:

Dwayne Bourgeois
Executive Director
North Lafourche Conservation,
Levee & Drainage District

# ASSESSMENT OF NON-FEDERAL SPONSOR'S REAL ESTATE ACQUISITION CAPABILITY

**South Lafourche Levee District**

**June 2012**

I. Legal Authority:

a. Does the sponsor have legal authority to acquire and hold title to real property for project purposes? **YES**

b. Does the sponsor have the power of eminent domain for this project? **YES**

c. Does the sponsor have "quick-take" authority for this project? **YES**

d. Are any of the lands/interests in land required for the project located outside the sponsor's political boundary ? **NO**

e. Are any of the lands/interests in land required for the project owned by an entity whose property the sponsor cannot condemn? **NO**

II. Human Resource Requirements:

a. Will the sponsor's in-house staff require training to become familiar with the real estate requirements of Federal projects including P.L. 91-646, as amended? **NO**

b. If the answer to II.a. is "yes," has a reasonable plan been developed to provide such training? **N/A**

c. Does the sponsor's in-house staff have sufficient real estate acquisition experience to meet its responsibilities for the project? **YES**

d. Is the sponsor's projected in-house staffing level sufficient considering its other workload, if any, and the project schedule? **NO**

e. Can the sponsor obtain contractor support, if required in a timely fashion? **YES, contracts are in place now.**

f. Will the sponsor likely request USACE assistance in acquiring real estate?
**It is not likely that the sponsor will request assistance.**

III. Other Project Variables:

a. Will the sponsor's staff be located within reasonable proximity to the project site? **YES**

b. Has the sponsor approved the project/real estate schedule/milestones?

**At the feasibility level there are too many unknowns to develop a definite project schedule. Once project designs are finalized, the sponsor will be requested to provide an acquisition schedule.**

IV. Overall Assessment:

**a.** Has the sponsor performed satisfactorily on other USACE projects? **YES**

b. With regard to this project, the sponsor is anticipated to be: highly capable/fully capable/moderately capable/marginally capable/insufficiently capable.

**Fully capable**

V. Coordination:

a. Has this assessment been coordinated with the sponsor?
**YES**

b. Does the sponsor concur with this assessment?
**YES**

Prepared by:

Judith Y. Gutierrez
Chief, Appraisal & Planning Branch
Real Estate Region South Division
USACE

Approved by:

Windell Curole
General Manager
South Lafourche Levee District

# EXHIBIT C

## NON-MATERIAL DEVIATION FROM STANDARD ESTATE

## TEMPORARY ACCESS EASEMENT

**TEMPORARY ACCESS EASEMENT**

A non-exclusive and assignable temporary easement for a period not to exceed _____years beginning with date possession of the land is granted to the United States, for use by the United States, its representatives, agents, and contractors as an access route and/or right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____); together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions and other vegetation, structures, or obstacles within the limits of the right-of-way, reserving, however, to the owners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired, including the right to cross over the right-of-way as access to their adjoining land; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

*In accordance with paragraph 12-9 c. of ER 405-1-12, the District Chief of Real Estate may approve a non-standard estate if it serves the intended project purpose, substantially conforms with and does not materially deviate from a corresponding standard estate, and does not increase the costs or potential liability of the Government. The foregoing estate complies with those requirements as it achieves the project purpose in as narrow a manner as practical, and is a minor modification of the standard Road Easement, adding language for a temporary term and replacing the word "road" with the words "access route and/or right of way.*

**Reviewed by:**

Marco Rosamano
Marco Rosamano
Assistant District Counsel
New Orleans District

**Approved by:**

Linda Labure
Chief, Real Estate Division
New Orleans District

# EXHIBIT D

# BASELINE COST ESTIMATES/ CHARTS OF ACCOUNTS

CEMVN-RE-E
REAL ESTATE DIVISION

MORGANZA TO THE GULF PROJECT
REAL ESTATE CHART OF ACCOUNTS SUMMARY
(SEPARATED BY REACH)

OCTOBER 17, 2012

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **TOTAL ALL REACHES** | | | | | AMOUNT | CONTINGENCY | PROJECT COST |
| | | | | | | ROUNDED | **354,826,000** |
| | **TOTAL PROJECT COSTS** | | | | 282,436,700 | 72,389,090 | 354,825,790 |
| 01 | **LANDS AND DAMAGES** | | CONTINGENCY | PROJECT COST | 282,436,700 | 72,389,090 | 354,825,790 |
| 01B | **ACQUISITIONS** | | | | | | |
| 01B10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01B20 | BY LOCAL SPONSOR (LS) | 15,430,900 | 3,857,780 | 19,288,680 | | | |
| 01B30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01B40 | REVIEW OF LS | 8,135,119 | 2,033,820 | 10,168,939 | | | |
| 01C | **CONDEMNATIONS** | | | | | | |
| 01C10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01C20 | BY LS | 7,611,000 | 1,902,750 | 9,513,750 | | | |
| 01C30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01C40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01E | **APPRAISAL** | | | | | | |
| 01E10 | BY GOVT (IN HOUSE) | 0 | 0 | 0 | | | |
| 01E20 | BY GOVT (CONTRACT) | 0 | 0 | 0 | | | |
| 01E30 | BY LS | 5,661,000 | 1,415,250 | 7,076,250 | | | |
| 01E40 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01E50 | REVIEW OF LS | 1,887,000 | 471,750 | 2,358,750 | | | |
| 01F | **PL 91-646 ASSISTANCE** | | | | | | |
| 01F10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01F20 | BY LS | 53,063,500 | 13,265,880 | 66,329,380 | | | |
| 01F30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01F40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01R | **REAL ESTATE PAYMENTS** | | | | | | |
| 01R1 | **LAND PAYMENTS** | 0 | 0 | 0 | | | |
| 01R1A | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01R1B | BY LS | 185,260,934 | 48,095,230 | 233,356,164 | | | |
| 01R1C | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01R1D | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01R2 | **PL 91-646 ASSISTANCE PAYMENTS** | | | | | | |
| 01R2A | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01R2B | BY LS | 4,191,200 | 1,047,800 | 5,239,000 | | | |
| 01R2C | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01R2D | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01O | **OYSTER LEASES** | | | | | | |
| 01O20 | OYSTER LEASE ACQUISITION | 253,050 | 63,270 | 316,320 | | | |
| 01T | **LERRD CREDITING** | | | | | | |
| 01T20 | ADMINISTRATIVE COSTS | 348,500 | 87,180 | 435,680 | | | |

CEMVN-RE-E
REAL ESTATE DIVISION

MORGANZA TO THE GULF PROJECT
REAL ESTATE CHART OF ACCOUNTS SUMMARY
(SEPARATED BY REACH)

OCTOBER 17, 2012

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **REACH - BARRIER ALIGNMENT** | | | | | AMOUNT | CONTINGENCY | PROJECT |
| | | | | | | | COST |
| | | | | | | ROUNDED | **3,702,000** |
| | **TOTAL PROJECT COSTS** | | | | 2,961,500 | 740,380 | 3,701,880 |
| 01 | **LANDS AND DAMAGES** | | CONTINGENCY | PROJECT | 2,961,500 | 740,380 | 3,701,880 |
| | | | | COST | | | |
| 01B | **ACQUISITIONS** | | | | | | |
| 01B10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01B20 | BY LOCAL SPONSOR (LS) | 425,000 | 106,250 | 531,250 | | | |
| 01B30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01B40 | REVIEW OF LS | 225,000 | 56,250 | 281,250 | | | |
| 01C | **CONDEMNATIONS** | | | | | | |
| 01C10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01C20 | BY LS | 25,000 | 6,250 | 31,250 | | | |
| 01C30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01C40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01E | **APPRAISAL** | | | | | | |
| 01E10 | BY GOVT (IN HOUSE) | 0 | 0 | 0 | | | |
| 01E20 | BY GOVT (CONTRACT) | 0 | 0 | 0 | | | |
| 01E30 | BY LS | 225,000 | 56,250 | 281,250 | | | |
| 01E40 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01E50 | REVIEW OF LS | 75,000 | 18,750 | 93,750 | | | |
| 01F | **PL 91-646 ASSISTANCE** | | | | | | |
| 01F10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01F20 | BY LS | 0 | 0 | 0 | | | |
| 01F30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01F40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01R | **REAL ESTATE PAYMENTS** | | | | | | |
| 01R1 | **LAND PAYMENTS** | | | | | | |
| 01R1A | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01R1B | BY LS | 1,949,000 | 487,250 | 2,436,250 | | | |
| 01R1C | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01R1D | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01T | **LERRD CREDITING** | | | | | | |
| 01T20 | ADMINISTRATIVE COSTS | 37,500 | 9,380 | 46,880 | | | |
| ASSUMES 75 OWNERS | | | | | | | |

CEMVN-RE-E
REAL ESTATE DIVISION

MORGANZA TO THE GULF PROJECT
REAL ESTATE CHART OF ACCOUNTS SUMMARY
(SEPARATED BY REACH)

OCTOBER 17, 2012

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **REACH - A** | | | | | AMOUNT | CONTINGENCY | PROJECT COST |
| | | | | | | ROUNDED | **896,000** |
| | **TOTAL PROJECT COSTS** | | | | 716,420 | 179,110 | 895,530 |
| 01 | **LANDS AND DAMAGES** | | CONTINGENCY | PROJECT COST | 716,420 | 179,110 | 895,530 |
| 01B | **ACQUISITIONS** | | | | | | |
| 01B10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01B20 | BY LOCAL SPONSOR (LS) | 154,700 | 38,680 | 193,380 | | | |
| 01B30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01B40 | REVIEW OF LS | 82,719 | 20,680 | 103,399 | | | |
| 01C | **CONDEMNATIONS** | | | | | | |
| 01C10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01C20 | BY LS | 78,000 | 19,500 | 97,500 | | | |
| 01C30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01C40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01E | **APPRAISAL** | | | | | | |
| 01E10 | BY GOVT (IN HOUSE) | 0 | 0 | 0 | | | |
| 01E20 | BY GOVT (CONTRACT) | 0 | 0 | 0 | | | |
| 01E30 | BY LS | 78,000 | 19,500 | 97,500 | | | |
| 01E40 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01E50 | REVIEW OF LS | 26,000 | 6,500 | 32,500 | | | |
| 01F | **PL 91-646 ASSISTANCE** | | | | | | |
| 01F10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01F20 | BY LS | 0 | 0 | 0 | | | |
| 01F30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01F40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01R | **REAL ESTATE PAYMENTS** | | | | | | |
| 01R1 | **LAND PAYMENTS** | | | | | | |
| 01R1A | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01R1B | BY LS | 284,000 | 71,000 | 355,000 | | | |
| 01R1C | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01R1D | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01T | **LERRD CREDITING** | | | | | | |
| 01T20 | ADMINISTRATIVE COSTS | 13,000 | 3,250 | 16,250 | | | |
| ASSUMES 26 OWNERS | | | | | | | |

CEMVN-RE-E
REAL ESTATE DIVISION

MORGANZA TO THE GULF PROJECT
REAL ESTATE CHART OF ACCOUNTS SUMMARY
(SEPARATED BY REACH)

OCTOBER 17, 2012

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **REACH - B** | | | | | AMOUNT | CONTINGENCY | PROJECT COST |
| | | | | | | ROUNDED | **1,045,000** |
| | **TOTAL PROJECT COSTS** | | | | 835,800 | 208,960 | 1,044,760 |
| 01 | **LANDS AND DAMAGES** | | CONTINGENCY | PROJECT COST | 835,800 | 208,960 | 1,044,760 |
| 01B | **ACQUISITIONS** | | | | | | |
| 01B10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01B20 | BY LOCAL SPONSOR (LS) | 196,350 | 49,090 | 245,440 | | | |
| 01B30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01B40 | REVIEW OF LS | 103,950 | 25,990 | 129,940 | | | |
| 01C | **CONDEMNATIONS** | | | | | | |
| 01C10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01C20 | BY LS | 99,000 | 24,750 | 123,750 | | | |
| 01C30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01C40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01E | **APPRAISAL** | | | | | | |
| 01E10 | BY GOVT (IN HOUSE) | 0 | 0 | 0 | | | |
| 01E20 | BY GOVT (CONTRACT) | 0 | 0 | 0 | | | |
| 01E30 | BY LS | 99,000 | 24,750 | 123,750 | | | |
| 01E40 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01E50 | REVIEW OF LS | 33,000 | 8,250 | 41,250 | | | |
| 01F | **PL 91-646 ASSISTANCE** | | | | | | |
| 01F10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01F20 | BY LS | 0 | 0 | 0 | | | |
| 01F30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01F40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01R | **REAL ESTATE PAYMENTS** | | | | | | |
| 01R1 | **LAND PAYMENTS** | | | | | | |
| 01R1A | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01R1B | BY LS | 288,000 | 72,000 | 360,000 | | | |
| 01R1C | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01R1D | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01T | **LERRD CREDITING** | | | | | | |
| 01T20 | ADMINISTRATIVE COSTS | 16,500 | 4,130 | 20,630 | | | |
| ASSUMES 33 OWNERS | | | | | | | |

CEMVN-RE-E
REAL ESTATE DIVISION

MORGANZA TO THE GULF PROJECT
REAL ESTATE CHART OF ACCOUNTS SUMMARY
(SEPARATED BY REACH)

OCTOBER 17, 2012

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **REACH E-1** | | | | | AMOUNT | CONTINGENCY | PROJECT |
| | | | | | | | COST |
| | | | | | | ROUNDED | **435,000** |
| | **TOTAL PROJECT COSTS** | | | | 348,000 | 87,010 | 435,010 |
| 01 | **LANDS AND DAMAGES** | | CONTINGENCY | PROJECT | 348,000 | 87,010 | 435,010 |
| | | | | COST | | | |
| 01B | **ACQUISITIONS** | | | | | | |
| 01B10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01B20 | BY LOCAL SPONSOR (LS) | 59,500 | 14,880 | 74,380 | | | |
| 01B30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01B40 | REVIEW OF LS | 31,500 | 7,880 | 39,380 | | | |
| 01C | **CONDEMNATIONS** | | | | | | |
| 01C10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01C20 | BY LS | 30,000 | 7,500 | 37,500 | | | |
| 01C30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01C40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01E | **APPRAISAL** | | | | | | |
| 01E10 | BY GOVT (IN HOUSE) | 0 | 0 | 0 | | | |
| 01E20 | BY GOVT (CONTRACT) | 0 | 0 | 0 | | | |
| 01E30 | BY LS | 30,000 | 7,500 | 37,500 | | | |
| 01E40 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01E50 | REVIEW OF LS | 10,000 | 2,500 | 12,500 | | | |
| 01F | **PL 91-646 ASSISTANCE** | | | | | | |
| 01F10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01F20 | BY LS | 0 | 0 | 0 | | | |
| 01F30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01F40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01R | **REAL ESTATE PAYMENTS** | | | | | | |
| 01R1 | **LAND PAYMENTS** | | | | | | |
| 01R1A | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01R1B | BY LS | 182,000 | 45,500 | 227,500 | | | |
| 01R1C | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01R1D | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01T | **LERRD CREDITING** | | | | | | |
| 01T20 | ADMINISTRATIVE COSTS | 5,000 | 1,250 | 6,250 | | | |
| ASSUMES 10 OWNERS | | | | | | | |

CEMVN-RE-E
REAL ESTATE DIVISION

MORGANZA TO THE GULF PROJECT
REAL ESTATE CHART OF ACCOUNTS SUMMARY
(SEPARATED BY REACH)

OCTOBER 17, 2012

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **REACH E-2** | | | | | AMOUNT | CONTINGENCY | PROJECT COST |
| | | | | | | ROUNDED | **566,000** |
| | **TOTAL PROJECT COSTS** | | | | 453,000 | 113,260 | 566,260 |
| 01 | **LANDS AND DAMAGES** | | CONTINGENCY | PROJECT COST | 453,000 | 113,260 | 566,260 |
| 01B | **ACQUISITIONS** | | | | | | |
| 01B10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01B20 | BY LOCAL SPONSOR (LS) | 59,500 | 14,880 | 74,380 | | | |
| 01B30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01B40 | REVIEW OF LS | 31,500 | 7,880 | 39,380 | | | |
| 01C | **CONDEMNATIONS** | | | | | | |
| 01C10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01C20 | BY LS | 30,000 | 7,500 | 37,500 | | | |
| 01C30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01C40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01E | **APPRAISAL** | | | | | | |
| 01E10 | BY GOVT (IN HOUSE) | 0 | 0 | 0 | | | |
| 01E20 | BY GOVT (CONTRACT) | 0 | 0 | 0 | | | |
| 01E30 | BY LS | 30,000 | 7,500 | 37,500 | | | |
| 01E40 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01E50 | REVIEW OF LS | 10,000 | 2,500 | 12,500 | | | |
| 01F | **PL 91-646 ASSISTANCE** | | | | | | |
| 01F10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01F20 | BY LS | 0 | 0 | 0 | | | |
| 01F30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01F40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01R | **REAL ESTATE PAYMENTS** | | | | | | |
| 01R1 | **LAND PAYMENTS** | | | | | | |
| 01R1A | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01R1B | BY LS | 287,000 | 71,750 | 358,750 | | | |
| 01R1C | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01R1D | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01T | **LERRD CREDITING** | | | | | | |
| 01T20 | ADMINISTRATIVE COSTS | 5,000 | 1,250 | 6,250 | | | |
| ASSUMES 10 OWNERS | | | | | | | |

CEMVN-RE-E
REAL ESTATE DIVISION

MORGANZA TO THE GULF PROJECT
REAL ESTATE CHART OF ACCOUNTS SUMMARY
(SEPARATED BY REACH)

OCTOBER 17, 2012

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **REACH F-1** | | | | | AMOUNT | CONTINGENCY | PROJECT COST |
| | | | | | | ROUNDED | **1,139,000** |
| | **TOTAL PROJECT COSTS** | | | | 910,800 | 227,710 | 1,138,510 |
| 01 | **LANDS AND DAMAGES** | | CONTINGENCY | PROJECT COST | 910,800 | 227,710 | 1,138,510 |
| 01B | **ACQUISITIONS** | | | | | | |
| 01B10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01B20 | BY LOCAL SPONSOR (LS) | 107,100 | 26,780 | 133,880 | | | |
| 01B30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01B40 | REVIEW OF LS | 56,700 | 14,180 | 70,880 | | | |
| 01C | **CONDEMNATIONS** | | | | | | |
| 01C10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01C20 | BY LS | 54,000 | 13,500 | 67,500 | | | |
| 01C30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01C40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01E | **APPRAISAL** | | | | | | |
| 01E10 | BY GOVT (IN HOUSE) | 0 | 0 | 0 | | | |
| 01E20 | BY GOVT (CONTRACT) | 0 | 0 | 0 | | | |
| 01E30 | BY LS | 54,000 | 13,500 | 67,500 | | | |
| 01E40 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01E50 | REVIEW OF LS | 18,000 | 4,500 | 22,500 | | | |
| 01F | **PL 91-646 ASSISTANCE** | | | | | | |
| 01F10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01F20 | BY LS | 0 | 0 | 0 | | | |
| 01F30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01F40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01R | **REAL ESTATE PAYMENTS** | | | | | | |
| 01R1 | **LAND PAYMENTS** | | | | | | |
| 01R1A | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01R1B | BY LS | 612,000 | 153,000 | 765,000 | | | |
| 01R1C | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01R1D | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01T | **LERRD CREDITING** | | | | | | |
| 01T20 | ADMINISTRATIVE COSTS | 9,000 | 2,250 | 11,250 | | | |
| ASSUMES 18 OWNERS | | | | | | | |

CEMVN-RE-E
REAL ESTATE DIVISION

MORGANZA TO THE GULF PROJECT
REAL ESTATE CHART OF ACCOUNTS SUMMARY
(SEPARATED BY REACH)

OCTOBER 17, 2012

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **REACH F-2** | | | | | AMOUNT | CONTINGENCY | PROJECT COST |
| | | | | | | ROUNDED | **150,000** |
| | **TOTAL PROJECT COSTS** | | | | 119,800 | 29,950 | 149,750 |
| 01 | **LANDS AND DAMAGES** | | CONTINGENCY | PROJECT COST | 119,800 | 29,950 | 149,750 |
| 01B | **ACQUISITIONS** | | | | | | |
| 01B10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01B20 | BY LOCAL SPONSOR (LS) | 17,850 | 4,460 | 22,310 | | | |
| 01B30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01B40 | REVIEW OF LS | 9,450 | 2,360 | 11,810 | | | |
| 01C | **CONDEMNATIONS** | | | | | | |
| 01C10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01C20 | BY LS | 9,000 | 2,250 | 11,250 | | | |
| 01C30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01C40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01E | **APPRAISAL** | | | | | | |
| 01E10 | BY GOVT (IN HOUSE) | 0 | 0 | 0 | | | |
| 01E20 | BY GOVT (CONTRACT) | 0 | 0 | 0 | | | |
| 01E30 | BY LS | 9,000 | 2,250 | 11,250 | | | |
| 01E40 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01E50 | REVIEW OF LS | 3,000 | 750 | 3,750 | | | |
| 01F | **PL 91-646 ASSISTANCE** | | | | | | |
| 01F10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01F20 | BY LS | 0 | 0 | 0 | | | |
| 01F30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01F40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01R | **REAL ESTATE PAYMENTS** | | | | | | |
| 01R1 | **LAND PAYMENTS** | | | | | | |
| 01R1A | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01R1B | BY LS | 70,000 | 17,500 | 87,500 | | | |
| 01R1C | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01R1D | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01T | **LERRD CREDITING** | | | | | | |
| 01T20 | ADMINISTRATIVE COSTS | 1,500 | 380 | 1,880 | | | |
| ASSUMES 3 OWNERS | | | | | | | |

CEMVN-RE-E
REAL ESTATE DIVISION

MORGANZA TO THE GULF PROJECT
REAL ESTATE CHART OF ACCOUNTS SUMMARY
(SEPARATED BY REACH)

OCTOBER 17, 2012

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **REACH G-1** | | | | | AMOUNT | CONTINGENCY | PROJECT COST |
| | | | | | | ROUNDED | **198,000** |
| | **TOTAL PROJECT COSTS** | | | | 158,000 | 39,510 | 197,510 |
| 01 | **LANDS AND DAMAGES** | | CONTINGENCY | PROJECT COST | 158,000 | 39,510 | 197,510 |
| 01B | **ACQUISITIONS** | | | | | | |
| 01B10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01B20 | BY LOCAL SPONSOR (LS) | 29,750 | 7,440 | 37,190 | | | |
| 01B30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01B40 | REVIEW OF LS | 15,750 | 3,940 | 19,690 | | | |
| 01C | **CONDEMNATIONS** | | | | | | |
| 01C10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01C20 | BY LS | 15,000 | 3,750 | 18,750 | | | |
| 01C30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01C40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01E | **APPRAISAL** | | | | | | |
| 01E10 | BY GOVT (IN HOUSE) | 0 | 0 | 0 | | | |
| 01E20 | BY GOVT (CONTRACT) | 0 | 0 | 0 | | | |
| 01E30 | BY LS | 15,000 | 3,750 | 18,750 | | | |
| 01E40 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01E50 | REVIEW OF LS | 5,000 | 1,250 | 6,250 | | | |
| 01F | **PL 91-646 ASSISTANCE** | | | | | | |
| 01F10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01F20 | BY LS | 0 | 0 | 0 | | | |
| 01F30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01F40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01R | **REAL ESTATE PAYMENTS** | | | | | | |
| 01R1 | **LAND PAYMENTS** | | | | | | |
| 01R1A | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01R1B | BY LS | 75,000 | 18,750 | 93,750 | | | |
| 01R1C | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01R1D | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01T | **LERRD CREDITING** | | | | | | |
| 01T20 | ADMINISTRATIVE COSTS | 2,500 | 630 | 3,130 | | | |
| ASSUMES 5 OWNERS | | | | | | | |

CEMVN-RE-E
REAL ESTATE DIVISION

MORGANZA TO THE GULF PROJECT
REAL ESTATE CHART OF ACCOUNTS SUMMARY
(SEPARATED BY REACH)

OCTOBER 17, 2012

| | | | | | AMOUNT | CONTINGENCY | PROJECT COST |
|---|---|---|---|---|---|---|---|
| **REACH G-2** | | | | | | | |
| | | | | | | ROUNDED | **233,000** |
| | **TOTAL PROJECT COSTS** | | | | 186,000 | 46,510 | 232,510 |
| 01 | **LANDS AND DAMAGES** | | CONTINGENCY | PROJECT COST | 186,000 | 46,510 | 232,510 |
| 01B | **ACQUISITIONS** | | | | | | |
| 01B10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01B20 | BY LOCAL SPONSOR (LS) | 29,750 | 7,440 | 37,190 | | | |
| 01B30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01B40 | REVIEW OF LS | 15,750 | 3,940 | 19,690 | | | |
| 01C | **CONDEMNATIONS** | | | | | | |
| 01C10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01C20 | BY LS | 15,000 | 3,750 | 18,750 | | | |
| 01C30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01C40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01E | **APPRAISAL** | | | | | | |
| 01E10 | BY GOVT (IN HOUSE) | 0 | 0 | 0 | | | |
| 01E20 | BY GOVT (CONTRACT) | 0 | 0 | 0 | | | |
| 01E30 | BY LS | 15,000 | 3,750 | 18,750 | | | |
| 01E40 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01E50 | REVIEW OF LS | 5,000 | 1,250 | 6,250 | | | |
| 01F | **PL 91-646 ASSISTANCE** | | | | | | |
| 01F10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01F20 | BY LS | 0 | 0 | 0 | | | |
| 01F30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01F40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01R | **REAL ESTATE PAYMENTS** | | | | | | |
| 01R1 | **LAND PAYMENTS** | | | | | | |
| 01R1A | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01R1B | BY LS | 103,000 | 25,750 | 128,750 | | | |
| 01R1C | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01R1D | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01T | **LERRD CREDITING** | | | | | | |
| 01T20 | ADMINISTRATIVE COSTS | 2,500 | 630 | 3,130 | | | |
| ASSUMES 5 OWNERS | | | | | | | |

CEMVN-RE-E
REAL ESTATE DIVISION

MORGANZA TO THE GULF PROJECT
REAL ESTATE CHART OF ACCOUNTS SUMMARY
(SEPARATED BY REACH)

OCTOBER 17, 2012

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **REACH G-3** | | | | | AMOUNT | CONTINGENCY | PROJECT |
| | | | | | | | COST |
| | | | | | | ROUNDED | **154,000** |
| | **TOTAL PROJECT COSTS** | | | | 123,000 | 30,760 | 153,760 |
| 01 | **LANDS AND DAMAGES** | | CONTINGENCY | PROJECT | 123,000 | 30,760 | 153,760 |
| | | | | COST | | | |
| 01B | **ACQUISITIONS** | | | | | | |
| 01B10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01B20 | BY LOCAL SPONSOR (LS) | 29,750 | 7,440 | 37,190 | | | |
| 01B30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01B40 | REVIEW OF LS | 15,750 | 3,940 | 19,690 | | | |
| 01C | **CONDEMNATIONS** | | | | | | |
| 01C10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01C20 | BY LS | 15,000 | 3,750 | 18,750 | | | |
| 01C30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01C40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01E | **APPRAISAL** | | | | | | |
| 01E10 | BY GOVT (IN HOUSE) | 0 | 0 | 0 | | | |
| 01E20 | BY GOVT (CONTRACT) | 0 | 0 | 0 | | | |
| 01E30 | BY LS | 15,000 | 3,750 | 18,750 | | | |
| 01E40 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01E50 | REVIEW OF LS | 5,000 | 1,250 | 6,250 | | | |
| 01F | **PL 91-646 ASSISTANCE** | | | | | | |
| 01F10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01F20 | BY LS | 0 | 0 | 0 | | | |
| 01F30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01F40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01R | **REAL ESTATE PAYMENTS** | | | | | | |
| 01R1 | **LAND PAYMENTS** | | | | | | |
| 01R1A | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01R1B | BY LS | 40,000 | 10,000 | 50,000 | | | |
| 01R1C | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01R1D | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01T | **LERRD CREDITING** | | | | | | |
| 01T20 | ADMINISTRATIVE COSTS | 2,500 | 630 | 3,130 | | | |
| ASSUMES 5 OWNERS | | | | | | | |

CEMVN-RE-E
REAL ESTATE DIVISION

MORGANZA TO THE GULF PROJECT
REAL ESTATE CHART OF ACCOUNTS SUMMARY
(SEPARATED BY REACH)

OCTOBER 17, 2012

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **REACH H-1** | | | | | AMOUNT | CONTINGENCY | PROJECT COST |
| | | | | | | ROUNDED | **2,929,000** |
| | **TOTAL PROJECT COSTS** | | | | 2,343,200 | 585,800 | 2,929,000 |
| 01 | **LANDS AND DAMAGES** | | CONTINGENCY | PROJECT COST | 2,343,200 | 585,800 | 2,929,000 |
| 01B | **ACQUISITIONS** | | | | | | |
| 01B10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01B20 | BY LOCAL SPONSOR (LS) | 89,250 | 22,310 | 111,560 | | | |
| 01B30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01B40 | REVIEW OF LS | 47,250 | 11,810 | 59,060 | | | |
| 01C | **CONDEMNATIONS** | | | | | | |
| 01C10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01C20 | BY LS | 45,000 | 11,250 | 56,250 | | | |
| 01C30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01C40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01E | **APPRAISAL** | | | | | | |
| 01E10 | BY GOVT (IN HOUSE) | 0 | 0 | 0 | | | |
| 01E20 | BY GOVT (CONTRACT) | 0 | 0 | 0 | | | |
| 01E30 | BY LS | 45,000 | 11,250 | 56,250 | | | |
| 01E40 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01E50 | REVIEW OF LS | 15,000 | 3,750 | 18,750 | | | |
| 01F | **PL 91-646 ASSISTANCE** | | | | | | |
| 01F10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01F20 | BY LS | 21,000 | 5,250 | 26,250 | | | |
| 01F30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01F40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01R | **REAL ESTATE PAYMENTS** | | | | | | |
| 01R1 | **LAND PAYMENTS** | | | | | | |
| 01R1A | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01R1B | BY LS | 1,430,000 | 357,500 | 1,787,500 | | | |
| 01R1C | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01R1D | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01R2 | **PL 91-646 ASSISTANCE PAYMENTS** | | | | | | |
| 01R2A | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01R2B | BY LS | 643,200 | 160,800 | 804,000 | | | |
| 01R2C | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01R2D | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01T | **LERRD CREDITING** | | | | | | |
| 01T20 | ADMINISTRATIVE COSTS | 7,500 | 1,880 | 9,380 | | | |
| ASSUMES 15 OWNERS | | | | | | | |

CEMVN-RE-E
REAL ESTATE DIVISION

MORGANZA TO THE GULF PROJECT
REAL ESTATE CHART OF ACCOUNTS SUMMARY
(SEPARATED BY REACH)

OCTOBER 17, 2012

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **REACH H-2** | | | | | AMOUNT | CONTINGENCY | PROJECT COST |
| | | | | | | ROUNDED | **611,000** |
| | **TOTAL PROJECT COSTS** | | | | 489,000 | 122,250 | 611,250 |
| 01 | **LANDS AND DAMAGES** | | CONTINGENCY | PROJECT COST | 489,000 | 122,250 | 611,250 |
| 01B | **ACQUISITIONS** | | | | | | |
| 01B10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01B20 | BY LOCAL SPONSOR (LS) | 119,000 | 29,750 | 148,750 | | | |
| 01B30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01B40 | REVIEW OF LS | 63,000 | 15,750 | 78,750 | | | |
| 01C | **CONDEMNATIONS** | | | | | | |
| 01C10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01C20 | BY LS | 60,000 | 15,000 | 75,000 | | | |
| 01C30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01C40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01E | **APPRAISAL** | | | | | | |
| 01E10 | BY GOVT (IN HOUSE) | 0 | 0 | 0 | | | |
| 01E20 | BY GOVT (CONTRACT) | 0 | 0 | 0 | | | |
| 01E30 | BY LS | 60,000 | 15,000 | 75,000 | | | |
| 01E40 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01E50 | REVIEW OF LS | 20,000 | 5,000 | 25,000 | | | |
| 01F | **PL 91-646 ASSISTANCE** | | | | | | |
| 01F10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01F20 | BY LS | 0 | 0 | 0 | | | |
| 01F30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01F40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01R | **REAL ESTATE PAYMENTS** | | | | | | |
| 01R1 | **LAND PAYMENTS** | | | | | | |
| 01R1A | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01R1B | BY LS | 157,000 | 39,250 | 196,250 | | | |
| 01R1C | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01R1D | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01T | **LERRD CREDITING** | | | | | | |
| 01T20 | ADMINISTRATIVE COSTS | 10,000 | 2,500 | 12,500 | | | |
| ASSUMES 20 OWNERS | | | | | | | |

CEMVN-RE-E
REAL ESTATE DIVISION

MORGANZA TO THE GULF PROJECT
REAL ESTATE CHART OF ACCOUNTS SUMMARY
(SEPARATED BY REACH)

OCTOBER 17, 2012

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **REACH H-3** | | | | | AMOUNT | CONTINGENCY | PROJECT |
| | | | | | | | COST |
| | | | | | | ROUNDED | **1,088,000** |
| | **TOTAL PROJECT COSTS** | | | | 870,900 | 217,470 | 1,088,370 |
| 01 | **LANDS AND DAMAGES** | | CONTINGENCY | PROJECT | 870,900 | 217,470 | 1,088,370 |
| | | | | COST | | | |
| 01B | **ACQUISITIONS** | | | | | | |
| 01B10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01B20 | BY LOCAL SPONSOR (LS) | 208,250 | 52,060 | 260,310 | | | |
| 01B30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01B40 | REVIEW OF LS | 110,250 | 27,560 | 137,810 | | | |
| 01C | **CONDEMNATIONS** | | | | | | |
| 01C10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01C20 | BY LS | 105,000 | 26,250 | 131,250 | | | |
| 01C30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01C40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01E | **APPRAISAL** | | | | | | |
| 01E10 | BY GOVT (IN HOUSE) | 0 | 0 | 0 | | | |
| 01E20 | BY GOVT (CONTRACT) | 0 | 0 | 0 | | | |
| 01E30 | BY LS | 105,000 | 26,250 | 131,250 | | | |
| 01E40 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01E50 | REVIEW OF LS | 35,000 | 8,750 | 43,750 | | | |
| 01F | **PL 91-646 ASSISTANCE** | | | | | | |
| 01F10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01F20 | BY LS | 0 | 0 | 0 | | | |
| 01F30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01F40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01R | **REAL ESTATE PAYMENTS** | | | | | | |
| 01R1 | **LAND PAYMENTS** | | | | | | |
| 01R1A | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01R1B | BY LS | 212,000 | 53,000 | 265,000 | | | |
| 01R1C | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01R1D | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01O | **OYSTER LEASES** | | | | | | |
| 01O20 | OYSTER LEASE ACQUISITION | 78,400 | 19,600 | 98,000 | | | |
| 01T | **LERRD CREDITING** | | | | | | |
| 01T20 | ADMINISTRATIVE COSTS | 17,000 | 4,000 | 21,000 | | | |
| ASSUMES 35 OWNERS | | | | | | | |

CEMVN-RE-E
REAL ESTATE DIVISION

MORGANZA TO THE GULF PROJECT
REAL ESTATE CHART OF ACCOUNTS SUMMARY
(SEPARATED BY REACH)

OCTOBER 17, 2012

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **REACH I-1** | | | | | AMOUNT | CONTINGENCY | PROJECT |
| | | | | | | | COST |
| | | | | | | ROUNDED | **322,000** |
| | | | | | | | |
| | **TOTAL PROJECT COSTS** | | | | 257,850 | 64,470 | 322,320 |
| 01 | **LANDS AND DAMAGES** | | CONTINGENCY | PROJECT | 257,850 | 64,470 | 322,320 |
| | | | | COST | | | |
| 01B | **ACQUISITIONS** | | | | | | |
| 01B10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01B20 | BY LOCAL SPONSOR (LS) | 59,500 | 14,880 | 74,380 | | | |
| 01B30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01B40 | REVIEW OF LS | 31,500 | 7,880 | 39,380 | | | |
| | | | | | | | |
| 01C | **CONDEMNATIONS** | | | | | | |
| 01C10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01C20 | BY LS | 30,000 | 7,500 | 37,500 | | | |
| 01C30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01C40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| | | | | | | | |
| 01E | **APPRAISAL** | | | | | | |
| 01E10 | BY GOVT (IN HOUSE) | 0 | 0 | 0 | | | |
| 01E20 | BY GOVT (CONTRACT) | 0 | 0 | 0 | | | |
| 01E30 | BY LS | 30,000 | 7,500 | 37,500 | | | |
| 01E40 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01E50 | REVIEW OF LS | 10,000 | 2,500 | 12,500 | | | |
| | | | | | | | |
| 01F | **PL 91-646 ASSISTANCE** | | | | | | |
| 01F10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01F20 | BY LS | 0 | 0 | 0 | | | |
| 01F30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01F40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| | | | | | | | |
| 01R | **REAL ESTATE PAYMENTS** | | | | | | |
| 01R1 | **LAND PAYMENTS** | | | | | | |
| 01R1A | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01R1B | BY LS | 74,000 | 18,500 | 92,500 | | | |
| 01R1C | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01R1D | REVIEW OF LS | 0 | 0 | 0 | | | |
| | | | | | | | |
| 01O | **OYSTER LEASES** | | | | | | |
| 01O20 | OYSTER LEASE ACQUISITION | 17,850 | 4,460 | 22,310 | | | |
| | | | | | | | |
| 01T | **LERRD CREDITING** | | | | | | |
| 01T20 | ADMINISTRATIVE COSTS | 5,000 | 1,250 | 6,250 | | | |
| | | | | | | | |
| ASSUMES 10 OWNERS | | | | | | | |

CEMVN-RE-E
REAL ESTATE DIVISION

MORGANZA TO THE GULF PROJECT
REAL ESTATE CHART OF ACCOUNTS SUMMARY
(SEPARATED BY REACH)

OCTOBER 17, 2012

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **REACH I-2** | | | | | AMOUNT | CONTINGENCY | PROJECT COST |
| | | | | | | ROUNDED | **1,901,000** |
| | **TOTAL PROJECT COSTS** | | | | 1,520,990 | 380,260 | 1,901,250 |
| 01 | **LANDS AND DAMAGES** | | CONTINGENCY | PROJECT COST | 1,520,990 | 380,260 | 1,901,250 |
| 01B | **ACQUISITIONS** | | | | | | |
| 01B10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01B20 | BY LOCAL SPONSOR (LS) | 196,350 | 49,090 | 245,440 | | | |
| 01B30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01B40 | REVIEW OF LS | 103,950 | 25,990 | 129,940 | | | |
| 01C | **CONDEMNATIONS** | | | | | | |
| 01C10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01C20 | BY LS | 99,000 | 24,750 | 123,750 | | | |
| 01C30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01C40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01E | **APPRAISAL** | | | | | | |
| 01E10 | BY GOVT (IN HOUSE) | 0 | 0 | 0 | | | |
| 01E20 | BY GOVT (CONTRACT) | 0 | 0 | 0 | | | |
| 01E30 | BY LS | 99,000 | 24,750 | 123,750 | | | |
| 01E40 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01E50 | REVIEW OF LS | 33,000 | 8,250 | 41,250 | | | |
| 01F | **PL 91-646 ASSISTANCE** | | | | | | |
| 01F10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01F20 | BY LS | 3,000 | 750 | 3,750 | | | |
| 01F30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01F40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01R | **REAL ESTATE PAYMENTS** | | | | | | |
| 01R1 | **LAND PAYMENTS** | | | | | | |
| 01R1A | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01R1B | BY LS | 864,694 | 216,170 | 1,080,864 | | | |
| 01R1C | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01R1D | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01R2 | **PL 91-646 ASSISTANCE PAYMENTS** | | | | | | |
| 01R2A | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01R2B | BY LS | 37,600 | 9,400 | 47,000 | | | |
| 01R2C | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01R2D | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01O | **OYSTER LEASES** | | | | | | |
| 01O20 | OYSTER LEASE ACQUISITION | 67,900 | 16,980 | 84,880 | | | |
| 01T | **LERRD CREDITING** | | | | | | |
| 01T20 | ADMINISTRATIVE COSTS | 16,500 | 4,130 | 20,630 | | | |
| ASSUMES 33 OWNERS | | | | | | | |

CEMVN-RE-E
REAL ESTATE DIVISION

MORGANZA TO THE GULF PROJECT
REAL ESTATE CHART OF ACCOUNTS SUMMARY
(SEPARATED BY REACH)

OCTOBER 17, 2012

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **REACH I-3** | | | | | AMOUNT | CONTINGENCY | PROJECT COST |
| | | | | | | ROUNDED | **1,203,000** |
| | **TOTAL PROJECT COSTS** | | | | 962,700 | 240,680 | 1,203,380 |
| 01 | **LANDS AND DAMAGES** | | CONTINGENCY | PROJECT COST | 962,700 | 240,680 | 1,203,380 |
| 01B | **ACQUISITIONS** | | | | | | |
| 01B10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01B20 | BY LOCAL SPONSOR (LS) | 255,850 | 63,960 | 319,810 | | | |
| 01B30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01B40 | REVIEW OF LS | 135,450 | 33,860 | 169,310 | | | |
| 01C | **CONDEMNATIONS** | | | | | | |
| 01C10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01C20 | BY LS | 129,000 | 32,250 | 161,250 | | | |
| 01C30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01C40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01E | **APPRAISAL** | | | | | | |
| 01E10 | BY GOVT (IN HOUSE) | 0 | 0 | 0 | | | |
| 01E20 | BY GOVT (CONTRACT) | 0 | 0 | 0 | | | |
| 01E30 | BY LS | 129,000 | 32,250 | 161,250 | | | |
| 01E40 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01E50 | REVIEW OF LS | 43,000 | 10,750 | 53,750 | | | |
| 01F | **PL 91-646 ASSISTANCE** | | | | | | |
| 01F10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01F20 | BY LS | 0 | 0 | 0 | | | |
| 01F30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01F40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01R | **REAL ESTATE PAYMENTS** | | | | | | |
| 01R1 | **LAND PAYMENTS** | | | | | | |
| 01R1A | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01R1B | BY LS | 160,000 | 40,000 | 200,000 | | | |
| 01R1C | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01R1D | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01O | **OYSTER LEASES** | | | | | | |
| 01O20 | OYSTER LEASE ACQUISITION | 88,900 | 22,230 | 111,130 | | | |
| 01T | **LERRD CREDITING** | | | | | | |
| 01T20 | ADMINISTRATIVE COSTS | 21,500 | 5,380 | 26,880 | | | |
| ASSUMES 43 OWNERS | | | | | | | |

CEMVN-RE-E
REAL ESTATE DIVISION

MORGANZA TO THE GULF PROJECT
REAL ESTATE CHART OF ACCOUNTS SUMMARY
(SEPARATED BY REACH)

OCTOBER 17, 2012

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **REACH J-1** | | | | | AMOUNT | CONTINGENCY | PROJECT COST |
| | | | | | | ROUNDED | **0** |
| | **TOTAL PROJECT COSTS** | | | | 0 | 0 | 0 |
| 01 | **LANDS AND DAMAGES** | | CONTINGENCY | PROJECT COST | 0 | 0 | 0 |
| 01B | **ACQUISITIONS** | | | | | | |
| 01B10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01B20 | BY LOCAL SPONSOR (LS) | 0 | 0 | 0 | | | |
| 01B30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01B40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01C | **CONDEMNATIONS** | | | | | | |
| 01C10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01C20 | BY LS | 0 | 0 | 0 | | | |
| 01C30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01C40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01E | **APPRAISAL** | | | | | | |
| 01E10 | BY GOVT (IN HOUSE) | 0 | 0 | 0 | | | |
| 01E20 | BY GOVT (CONTRACT) | 0 | 0 | 0 | | | |
| 01E30 | BY LS | 0 | 0 | 0 | | | |
| 01E40 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01E50 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01F | **PL 91-646 ASSISTANCE** | | | | | | |
| 01F10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01F20 | BY LS | 0 | 0 | 0 | | | |
| 01F30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01F40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01R | **REAL ESTATE PAYMENTS** | | | | | | |
| 01R1 | **LAND PAYMENTS** | | | | | | |
| 01R1A | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01R1B | BY LS | 0 | 0 | 0 | | | |
| 01R1C | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01R1D | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01O | **OYSTER LEASES** | | | | | | |
| 01O20 | OYSTER LEASE ACQUISITION | 0 | 0 | 0 | | | |
| 01T | **LERRD CREDITING** | | | | | | |
| 01T20 | ADMINISTRATIVE COSTS | 0 | 0 | 0 | | | |

ASSUMES ALL ROW IS OWNED BY POINTE AUX CHENES WMA AND
A GRANT OF PARTICULAR USE WILL BE ISSUED BY STATE OF LOUISIANA.

CEMVN-RE-E
REAL ESTATE DIVISION

MORGANZA TO THE GULF PROJECT
REAL ESTATE CHART OF ACCOUNTS SUMMARY
(SEPARATED BY REACH)

OCTOBER 17, 2012

| | | | | | AMOUNT | CONTINGENCY | PROJECT COST |
|---|---|---|---|---|---|---|---|
| **REACH J-2** | | | | | | | |
| | | | | | | ROUNDED | **0** |
| | **TOTAL PROJECT COSTS** | | | | 0 | 0 | 0 |
| 01 | **LANDS AND DAMAGES** | | CONTINGENCY | PROJECT COST | 0 | 0 | 0 |
| 01B | **ACQUISITIONS** | | | | | | |
| 01B10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01B20 | BY LOCAL SPONSOR (LS) | 0 | 0 | 0 | | | |
| 01B30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01B40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01C | **CONDEMNATIONS** | | | | | | |
| 01C10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01C20 | BY LS | 0 | 0 | 0 | | | |
| 01C30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01C40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01E | **APPRAISAL** | | | | | | |
| 01E10 | BY GOVT (IN HOUSE) | 0 | 0 | 0 | | | |
| 01E20 | BY GOVT (CONTRACT) | 0 | 0 | 0 | | | |
| 01E30 | BY LS | 0 | 0 | 0 | | | |
| 01E40 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01E50 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01F | **PL 91-646 ASSISTANCE** | | | | | | |
| 01F10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01F20 | BY LS | 0 | 0 | 0 | | | |
| 01F30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01F40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01R | **REAL ESTATE PAYMENTS** | | | | | | |
| 01R1 | **LAND PAYMENTS** | | | | | | |
| 01R1A | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01R1B | BY LS | 0 | 0 | 0 | | | |
| 01R1C | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01R1D | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01O | **OYSTER LEASES** | | | | | | |
| 01O20 | OYSTER LEASE ACQUISITION | 0 | 0 | 0 | | | |
| 01T | **LERRD CREDITING** | | | | | | |
| 01T20 | ADMINISTRATIVE COSTS | 0 | 0 | 0 | | | |

ASSUMES ALL ROW IS OWNED BY POINTE AUX CHENES WMA AND
A GRANT OF PARTICULAR USE WILL BE ISSUED BY STATE OF LOUISIANA.

CEMVN-RE-E
REAL ESTATE DIVISION

MORGANZA TO THE GULF PROJECT
REAL ESTATE CHART OF ACCOUNTS SUMMARY
(SEPARATED BY REACH)

OCTOBER 17, 2012

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| REACH J-3 | | | | | AMOUNT | CONTINGENCY | PROJECT COST |
| | | | | | | ROUNDED | **1,120,000** |
| | **TOTAL PROJECT COSTS** | | | | 896,000 | 224,010 | 1,120,010 |
| 01 | **LANDS AND DAMAGES** | | CONTINGENCY | PROJECT COST | 896,000 | 224,010 | 1,120,010 |
| 01B | **ACQUISITIONS** | | | | | | |
| 01B10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01B20 | BY LOCAL SPONSOR (LS) | 59,500 | 14,880 | 74,380 | | | |
| 01B30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01B40 | REVIEW OF LS | 31,500 | 7,880 | 39,380 | | | |
| 01C | **CONDEMNATIONS** | | | | | | |
| 01C10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01C20 | BY LS | 30,000 | 7,500 | 37,500 | | | |
| 01C30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01C40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01E | **APPRAISAL** | | | | | | |
| 01E10 | BY GOVT (IN HOUSE) | 0 | 0 | 0 | | | |
| 01E20 | BY GOVT (CONTRACT) | 0 | 0 | 0 | | | |
| 01E30 | BY LS | 30,000 | 7,500 | 37,500 | | | |
| 01E40 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01E50 | REVIEW OF LS | 10,000 | 2,500 | 12,500 | | | |
| 01F | **PL 91-646 ASSISTANCE** | | | | | | |
| 01F10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01F20 | BY LS | 3,000 | 750 | 3,750 | | | |
| 01F30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01F40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01R | **REAL ESTATE PAYMENTS** | | | | | | |
| 01R1 | **LAND PAYMENTS** | | | | | | |
| 01R1A | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01R1B | BY LS | 635,000 | 158,750 | 793,750 | | | |
| 01R1C | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01R1D | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01R2 | **PL 91-646 ASSISTANCE PAYMENTS** | | | | | | |
| 01R2A | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01R2B | BY LS | 92,000 | 23,000 | 115,000 | | | |
| 01R2C | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01R2D | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01O | **OYSTER LEASES** | | | | | | |
| 01O20 | OYSTER LEASE ACQUISITION | 0 | 0 | 0 | | | |
| 01T | **LERRD CREDITING** | | | | | | |
| 01T20 | ADMINISTRATIVE COSTS | 5,000 | 1,250 | 6,250 | | | |
| ASSUMES 10 OWNERS | | | | | | | |

CEMVN-RE-E
REAL ESTATE DIVISION

MORGANZA TO THE GULF PROJECT
REAL ESTATE CHART OF ACCOUNTS SUMMARY
(SEPARATED BY REACH)

OCTOBER 17, 2012

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **REACH K** | | | | | AMOUNT | CONTINGENCY | PROJECT COST |
| | | | | | | ROUNDED | **1,136,000** |
| | **TOTAL PROJECT COSTS** | | | | 908,600 | 227,150 | 1,135,750 |
| 01 | **LANDS AND DAMAGES** | | CONTINGENCY | PROJECT COST | 908,600 | 227,150 | 1,135,750 |
| 01B | **ACQUISITIONS** | | | | | | |
| 01B10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01B20 | BY LOCAL SPONSOR (LS) | 71,400 | 17,850 | 89,250 | | | |
| 01B30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01B40 | REVIEW OF LS | 37,800 | 9,450 | 47,250 | | | |
| 01C | **CONDEMNATIONS** | | | | | | |
| 01C10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01C20 | BY LS | 36,000 | 9,000 | 45,000 | | | |
| 01C30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01C40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01E | **APPRAISAL** | | | | | | |
| 01E10 | BY GOVT (IN HOUSE) | 0 | 0 | 0 | | | |
| 01E20 | BY GOVT (CONTRACT) | 0 | 0 | 0 | | | |
| 01E30 | BY LS | 36,000 | 9,000 | 45,000 | | | |
| 01E40 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01E50 | REVIEW OF LS | 12,000 | 3,000 | 15,000 | | | |
| 01F | **PL 91-646 ASSISTANCE** | | | | | | |
| 01F10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01F20 | BY LS | 12,000 | 3,000 | 15,000 | | | |
| 01F30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01F40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01R | **REAL ESTATE PAYMENTS** | | | | | | |
| 01R1 | **LAND PAYMENTS** | | | | | | |
| 01R1A | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01R1B | BY LS | 567,000 | 141,750 | 708,750 | | | |
| 01R1C | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01R1D | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01R2 | **PL 91-646 ASSISTANCE PAYMENTS** | | | | | | |
| 01R2A | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01R2B | BY LS | 130,400 | 32,600 | 163,000 | | | |
| 01R2C | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01R2D | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01O | **OYSTER LEASES** | | | | | | |
| 01O20 | OYSTER LEASE ACQUISITION | 0 | 0 | 0 | | | |
| 01T | **LERRD CREDITING** | | | | | | |
| 01T20 | ADMINISTRATIVE COSTS | 6,000 | 1,500 | 7,500 | | | |
| ASSUMES 12 OWNERS | | | | | | | |

CEMVN-RE-E
REAL ESTATE DIVISION

MORGANZA TO THE GULF PROJECT
REAL ESTATE CHART OF ACCOUNTS SUMMARY
(SEPARATED BY REACH)

OCTOBER 17, 2012

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ESTIMATED FUTURE LIFT BORROW | | | | | AMOUNT | CONTINGENCY | PROJECT COST |
| | | | | | | ROUNDED | **17,424,000** |
| | **TOTAL PROJECT COSTS** | | | | 12,515,000 | 4,908,760 | 17,423,760 |
| 01 | **LANDS AND DAMAGES** | | CONTINGENCY | PROJECT COST | 12,515,000 | 4,908,760 | 17,423,760 |
| 01B | **ACQUISITIONS** | | | | | | |
| 01B10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01B20 | BY LOCAL SPONSOR (LS) | 1,933,750 | 483,440 | 2,417,190 | | | |
| 01B30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01B40 | REVIEW OF LS | 1,023,750 | 255,940 | 1,279,690 | | | |
| 01C | **CONDEMNATIONS** | | | | | | |
| 01C10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01C20 | BY LS | 975,000 | 243,750 | 1,218,750 | | | |
| 01C30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01C40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01E | **APPRAISAL** | | | | | | |
| 01E10 | BY GOVT (IN HOUSE) | 0 | 0 | 0 | | | |
| 01E20 | BY GOVT (CONTRACT) | 0 | 0 | 0 | | | |
| 01E30 | BY LS | 975,000 | 243,750 | 1,218,750 | | | |
| 01E40 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01E50 | REVIEW OF LS | 325,000 | 81,250 | 406,250 | | | |
| 01F | **PL 91-646 ASSISTANCE** | | | | | | |
| 01F10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01F20 | BY LS | 0 | 0 | 0 | | | |
| 01F30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01F40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01R | **REAL ESTATE PAYMENTS** | | | | | | |
| 01R1 | **LAND PAYMENTS** | | | | | | |
| 01R1A | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01R1B | BY LS | 7,120,000 | 3,560,000 | 10,680,000 | | | |
| 01R1C | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01R1D | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01O | **OYSTER LEASES** | | | | | | |
| 01O20 | OYSTER LEASE ACQUISITION | 0 | 0 | 0 | | | |
| 01T | **LERRD CREDITING** | | | | | | |
| 01T20 | ADMINISTRATIVE COSTS | 162,500 | 40,630 | 203,130 | | | |
| ASSUMES 3,250 ACRES ADDITIONAL BORROW REQUIRED AND ESTIMATED 325 LANDOWNERS | | | | | | | |

CEMVN-RE-E
REAL ESTATE DIVISION

MORGANZA TO THE GULF PROJECT
REAL ESTATE CHART OF ACCOUNTS SUMMARY
(SEPARATED BY REACH)

OCTOBER 17, 2012

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **LAROSE FLOODGATE** | | | | | AMOUNT | CONTINGENCY | PROJECT |
| | | | | | | | COST |
| | | | | | | ROUNDED | **159,000** |
| | | | | | | | |
| | | | | | | | |
| | **TOTAL PROJECT COSTS** | | | | 127,200 | 31,810 | 159,010 |
| | | | | | | | |
| 01 | **LANDS AND DAMAGES** | | CONTINGENCY | PROJECT | 127,200 | 31,810 | 159,010 |
| | | | | COST | | | |
| 01B | **ACQUISITIONS** | | | | | | |
| 01B10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01B20 | BY LOCAL SPONSOR (LS) | 11,900 | 2,980 | 14,880 | | | |
| 01B30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01B40 | REVIEW OF LS | 6,300 | 1,580 | 7,880 | | | |
| | | | | | | | |
| 01C | **CONDEMNATIONS** | | | | | | |
| 01C10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01C20 | BY LS | 6,000 | 1,500 | 7,500 | | | |
| 01C30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01C40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| | | | | | | | |
| 01E | **APPRAISAL** | | | | | | |
| 01E10 | BY GOVT (IN HOUSE) | 0 | 0 | 0 | | | |
| 01E20 | BY GOVT (CONTRACT) | 0 | 0 | 0 | | | |
| 01E30 | BY LS | 6,000 | 1,500 | 7,500 | | | |
| 01E40 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01E50 | REVIEW OF LS | 2,000 | 500 | 2,500 | | | |
| | | | | | | | |
| 01F | **PL 91-646 ASSISTANCE** | | | | | | |
| 01F10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01F20 | BY LS | 3,000 | 750 | 3,750 | | | |
| 01F30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01F40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| | | | | | | | |
| 01R | **REAL ESTATE PAYMENTS** | | | | | | |
| 01R1 | **LAND PAYMENTS** | | | | | | |
| 01R1A | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01R1B | BY LS | 91,000 | 22,750 | 113,750 | | | |
| 01R1C | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01R1D | REVIEW OF LS | 0 | 0 | 0 | | | |
| | | | | | | | |
| 01O | **OYSTER LEASES** | | | | | | |
| 01O20 | OYSTER LEASE ACQUISITION | 0 | 0 | 0 | | | |
| | | | | | | | |
| 01T | **LERRD CREDITING** | | | | | | |
| 01T20 | ADMINISTRATIVE COSTS | 1,000 | 250 | 1,250 | | | |
| | | | | | | | |
| | | | | | | | |
| ASSUMES 2 OWNERS | | | | | | | |

CEMVN-RE-E
REAL ESTATE DIVISION

MORGANZA TO THE GULF PROJECT
REAL ESTATE CHART OF ACCOUNTS SUMMARY
(SEPARATED BY REACH)

OCTOBER 17, 2012

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **INDUCED FLOODING BUY-OUT ESTIMATE** | | | | | AMOUNT | CONTINGENCY | PROJECT COST |
| | | | | | | ROUNDED | **305,115,000** |
| | **TOTAL PROJECT COSTS** | | | | 244,092,240 | 61,023,060 | 305,115,300 |
| 01 | **LANDS AND DAMAGES** | | CONTINGENCY | PROJECT COST | 244,092,240 | 61,023,060 | 305,115,300 |
| 01B | **ACQUISITIONS** | | | | | | |
| 01B10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01B20 | BY LOCAL SPONSOR (LS) | 9,595,000 | 2,398,750 | 11,993,750 | | | |
| 01B30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01B40 | REVIEW OF LS | 5,050,000 | 1,262,500 | 6,312,500 | | | |
| 01C | **CONDEMNATIONS** | | | | | | |
| 01C10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01C20 | BY LS | 5,000,000 | 1,250,000 | 6,250,000 | | | |
| 01C30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01C40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01E | **APPRAISAL** | | | | | | |
| 01E10 | BY GOVT (IN HOUSE) | 0 | 0 | 0 | | | |
| 01E20 | BY GOVT (CONTRACT) | 0 | 0 | 0 | | | |
| 01E30 | BY LS | 3,030,000 | 757,500 | 3,787,500 | | | |
| 01E40 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01E50 | REVIEW OF LS | 1,010,000 | 252,500 | 1,262,500 | | | |
| 01F | **PL 91-646 ASSISTANCE** | | | | | | |
| 01F10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01F20 | BY LS | 52,818,000 | 13,204,500 | 66,022,500 | | | |
| 01F30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01F40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01R | **REAL ESTATE PAYMENTS** | | | | | | |
| 01R1 | **LAND PAYMENTS** | | | | | | |
| 01R1A | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01R1B | BY LS | 167,084,240 | 41,771,060 | 208,855,300 | | | |
| 01R1C | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01R1D | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01T | **LERRD CREDITING** | | | | | | |
| 01T20 | ADMINISTRATIVE COSTS | 505,000 | 126,250 | 631,250 | | | |
| ASSUMES 1010 OWNERS | | | | | | | |

CEMVN-RE-E
REAL ESTATE DIVISION

MORGANZA TO THE GULF PROJECT
REAL ESTATE CHART OF ACCOUNTS SUMMARY
(SEPARATED BY REACH)

OCTOBER 17, 2012

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **REACH - LAROSE TO LOCKPORT - 1% ALTERNATIVE** | | | | | AMOUNT | CONTINGENCY | PROJECT COST |
| | | | | | | ROUNDED | **2,931,000** |
| | **TOTAL PROJECT COSTS** | | | | 2,345,000 | 586,260 | 2,931,260 |
| 01 | **LANDS AND DAMAGES** | | CONTINGENCY | PROJECT COST | 2,345,000 | 586,260 | 2,931,260 |
| 01B | **ACQUISITIONS** | | | | | | |
| 01B10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01B20 | BY LOCAL SPONSOR (LS) | 712,500 | 178,130 | 890,630 | | | |
| 01B30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01B40 | REVIEW OF LS | 375,000 | 93,750 | 468,750 | | | |
| 01C | **CONDEMNATIONS** | | | | | | |
| 01C10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01C20 | BY LS | 300,000 | 75,000 | 375,000 | | | |
| 01C30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01C40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01E | **APPRAISAL** | | | | | | |
| 01E10 | BY GOVT (IN HOUSE) | 0 | 0 | 0 | | | |
| 01E20 | BY GOVT (CONTRACT) | 0 | 0 | 0 | | | |
| 01E30 | BY LS | 225,000 | 56,250 | 281,250 | | | |
| 01E40 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01E50 | REVIEW OF LS | 75,000 | 18,750 | 93,750 | | | |
| 01F | **PL 91-646 ASSISTANCE** | | | | | | |
| 01F10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01F20 | BY LS | 0 | 0 | 0 | | | |
| 01F30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01F40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01R | **REAL ESTATE PAYMENTS** | | | | | | |
| 01R1 | **LAND PAYMENTS** | | | | | | |
| 01R1A | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01R1B | BY LS | 620,000 | 155,000 | 775,000 | | | |
| 01R1C | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01R1D | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01R2 | **PL 91-646 ASSISTANCE PAYMENTS** | | | | | | |
| 01R2A | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01R2B | BY LS | 0 | 0 | 0 | | | |
| 01R2C | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01R2D | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01T | **LERRD CREDITING** | | | | | | |
| 01T20 | ADMINISTRATIVE COSTS | 37,500 | 9,380 | 46,880 | | | |
| ASSUMES 75 OWNERS | | | | | | | |

CEMVN-RE-E
REAL ESTATE DIVISION

MORGANZA TO THE GULF PROJECT
REAL ESTATE CHART OF ACCOUNTS SUMMARY
(SEPARATED BY REACH)

OCTOBER 17, 2012

| | | | | | AMOUNT | CONTINGENCY | PROJECT COST |
|---|---|---|---|---|---|---|---|
| **REACH - LAROSE C NORTH** | | | | | | | |
| | | | | | | ROUNDED | **10,088,000** |
| | **TOTAL PROJECT COSTS** | | | | 8,070,500 | 2,017,640 | 10,088,140 |
| 01 | **LANDS AND DAMAGES** | | CONTINGENCY | PROJECT COST | 8,070,500 | 2,017,640 | 10,088,140 |
| 01B | **ACQUISITIONS** | | | | | | |
| 01B10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01B20 | BY LOCAL SPONSOR (LS) | 997,500 | 249,380 | 1,246,880 | | | |
| 01B30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01B40 | REVIEW OF LS | 525,000 | 131,250 | 656,250 | | | |
| 01C | **CONDEMNATIONS** | | | | | | |
| 01C10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01C20 | BY LS | 420,000 | 105,000 | 525,000 | | | |
| 01C30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01C40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01E | **APPRAISAL** | | | | | | |
| 01E10 | BY GOVT (IN HOUSE) | 0 | 0 | 0 | | | |
| 01E20 | BY GOVT (CONTRACT) | 0 | 0 | 0 | | | |
| 01E30 | BY LS | 315,000 | 78,750 | 393,750 | | | |
| 01E40 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01E50 | REVIEW OF LS | 105,000 | 26,250 | 131,250 | | | |
| 01F | **PL 91-646 ASSISTANCE** | | | | | | |
| 01F10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01F20 | BY LS | 203,500 | 50,880 | 254,380 | | | |
| 01F30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01F40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01R | **REAL ESTATE PAYMENTS** | | | | | | |
| 01R1 | **LAND PAYMENTS** | | | | | | |
| 01R1A | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01R1B | BY LS | 2,164,000 | 541,000 | 2,705,000 | | | |
| 01R1C | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01R1D | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01R2 | **PL 91-646 ASSISTANCE PAYMENTS** | | | | | | |
| 01R2A | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01R2B | BY LS | 3,288,000 | 822,000 | 4,110,000 | | | |
| 01R2C | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01R2D | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01T | **LERRD CREDITING** | | | | | | |
| 01T20 | ADMINISTRATIVE COSTS | 52,500 | 13,130 | 65,630 | | | |
| ASSUMES 105 OWNERS | | | | | | | |

CEMVN-RE-E
REAL ESTATE DIVISION

MORGANZA TO THE GULF PROJECT
REAL ESTATE CHART OF ACCOUNTS SUMMARY
(SEPARATED BY REACH)

OCTOBER 17, 2012

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **REACH L** | | | | | AMOUNT | CONTINGENCY | PROJECT COST |
| | | | | | | ROUNDED | **282,000** |
| | **TOTAL PROJECT COSTS** | | | | 225,200 | 56,310 | 281,510 |
| 01 | **LANDS AND DAMAGES** | | CONTINGENCY | PROJECT COST | 225,200 | 56,310 | 281,510 |
| 01B | **ACQUISITIONS** | | | | | | |
| 01B10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01B20 | BY LOCAL SPONSOR (LS) | 11,900 | 2,980 | 14,880 | | | |
| 01B30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01B40 | REVIEW OF LS | 6,300 | 1,580 | 7,880 | | | |
| 01C | **CONDEMNATIONS** | | | | | | |
| 01C10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01C20 | BY LS | 6,000 | 1,500 | 7,500 | | | |
| 01C30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01C40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01E | **APPRAISAL** | | | | | | |
| 01E10 | BY GOVT (IN HOUSE) | 0 | 0 | 0 | | | |
| 01E20 | BY GOVT (CONTRACT) | 0 | 0 | 0 | | | |
| 01E30 | BY LS | 6,000 | 1,500 | 7,500 | | | |
| 01E40 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01E50 | REVIEW OF LS | 2,000 | 500 | 2,500 | | | |
| 01F | **PL 91-646 ASSISTANCE** | | | | | | |
| 01F10 | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01F20 | BY LS | 0 | 0 | 0 | | | |
| 01F30 | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01F40 | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01R | **REAL ESTATE PAYMENTS** | | | | | | |
| 01R1 | **LAND PAYMENTS** | | | | | | |
| 01R1A | BY GOVERNMENT | 0 | 0 | 0 | | | |
| 01R1B | BY LS | 192,000 | 48,000 | 240,000 | | | |
| 01R1C | BY GOVT ON BEHALF OF LS | 0 | 0 | 0 | | | |
| 01R1D | REVIEW OF LS | 0 | 0 | 0 | | | |
| 01O | **OYSTER LEASES** | | | | | | |
| 01O20 | OYSTER LEASE ACQUISITION | 0 | 0 | 0 | | | |
| 01T | **LERRD CREDITING** | | | | | | |
| 01T20 | ADMINISTRATIVE COSTS | 1,000 | 250 | 1,250 | | | |
| ASSUMES 2 OWNERS | | | | | | | |

# EXHIBIT E

# QUALITY CONTROL CHECKLIST

## Quality Control Plan Checklist

# MISSISSIPPI RIVER AND TRIBUTARIES
# MORGANZA TO THE GULF OF MEXICO
# HURRICANE PROTECTION PROJECT
# TERREBONNE AND LAFOURCHE PARISHES, LA

## REAL ESTATE PLAN

1. **Purpose of the REP.** __√___

a. Describe the purpose of the REP in relation to the project document that it supports.

b. Describe the project for the Real Estate reviewer.

c. Describe any previous REPs for the project.

2. **Describe LER.** __√___

a. Account for all lands, easements, and rights-of-way underlying and required for the construction, OMRR&R of the project, including mitigation, relocations, borrow material and dredged or excavated material disposal, whether or not it will need to be acquired or will be credited to the NFS.

b. Provide description of total LER required for each project purpose and feature.

c. Include LER already owned by the Government, the NFS and within the navigation servitude.

d. Show acreage, estates, number of tracts and ownerships, and estimated value.

e. Break down total acreage into fee and the various types and durations of easements.

f. Break down acreage by Government, NFS, other public entity, and private ownership, and lands within the navigation servitude.

3. **NFS-Owned LER.**__√___

a. Describe NFS-owned acreage and interest and whether or not it is sufficient and available for project requirements.

b. Discuss any crediting issues and describe NFS views on such issues.

4. Include any proposed **Non-Standard Estates.** __√__

a. Use Standard Estates where possible.

b. Non-standard estates must be approved by HQ to assure they meet DOJ standards for use in condemnations.

c. Provide justification for use of the proposed non-standard estates.

d. Request approval of the non-standard estates as part of document approval.

e. If the document is to be approved at MSC level, the District must seek approval of the non-standard estate by separate request to HQ. This should be stated in the REP.

f. Exception to HQ approval is District Chiefs of RE approval of non-standard estate if it serves intended project purposed, substantially conforms with and does not materially deviate from the standard estates found in the RE Handbook, and does not increase cost or potential liability to the Government. A copy of this approval should be included in the REP. (See Section 12-10c. of RE 405-1-12)

g. Although estates are discussed generally in topic 2, it is a good idea to also state in this section which standard estates are to be acquired and attach a copy as an appendix. The duration of any temporary estates should be stated.

5. **Existing Federal Projects.** __√___

a. Discuss whether there is any existing Federal project that lies fully of partially within LER required for the project.

b. Describe the existing project, all previously-provided interests that are to be included in the current project, and identify the sponsor.

c. Interest in land provided as an item of local cooperation for a previous Federal project is not eligible for credit.

d. Additional interest in the same land is eligible for credit.

6. **Federally-Owned Lands** _√____

a. Discuss whether there is any Federally owned land included within the LER required for the project.

b. Describe the acreage and interest owned by the Government.

c. Provide description of the views of the local agency representatives toward use of the land for the project and issues raised by the requirement for this land.

7. **Navigation Servitude.** __√___

a. Identify LER required for the project that lies below the Ordinary High Water Mark, or Mean High Water Mark, as the case may be, of a navigable watercourse.

b. Discuss whether navigation servitude is available

c. Will it be exercised for project purposes? Discuss why or why not.

d. Lands over which the navigation servitude is exercised are not to be acquired nor eligible for credit for a Federal navigation or flood control project or other project to which a navigation nexus can be shown.

e. See paragraph 12-7 of ER 405-1-12.

8. **Map** _√____

a. An aid to understanding

b. Clearly depicting project area and tracts required, including existing LER, LER to be acquired, and lands within the navigation servitude.

c. Depicts significant utilities and facilities to be relocated, any known or potential HTRW lands.

9. **Induced Flooding** can create a requirement for real estate acquisition. ___√___

a. Discuss whether there will be flooding induced by the construction and OMRR&R of the project.

b. If reasonably anticipated, describe nature, extent and whether additional acquisition of LER must or should occur.

c. Physical Takings Analysis (separate from the REP) must be done if significant induced flooding anticipated considering depth, frequency, duration, and extent of induced flooding.

. d. Summarize findings of Takings Analysis in REP. Does it rise to the level of a taking for which just compensation is owed?

10. **Baseline Cost Estimate** as described in paragraph 12-18. __√___

a. Provides information for the project cost estimates.

b. Gross Appraisal includes the fair market value of all lands required for project construction and OMRR&R.

c. PL 91-646 costs

d. Incidental acquisition costs

e. Incremental real estate costs discussed/supported.

f. Is Gross Appraisal current? Does Gross Appraisal need to be updated due to changes in project LER requirements or time since report was prepared?

11. **Relocation Assistance Benefits** Anticipated. __√___

a. Number of persons, farms, and businesses to be displaced and estimated cost of moving and reestablishment.

b. Availability of replacement housing for owners/tenants

c. Need for Last Resort Housing benefits

d. Real Estate closing costs

e. See current 49 CFR Part 24

12. **Mineral Activity**. __√___

a. Description of present or anticipated mineral activity in vicinity that may affect construction, OMRR&R of project.

b. Recommendation, including rationale, regarding acquisition of mineral rights or interest, including oil or gas.

c. Discuss other surface or subsurface interests/timber harvesting activity

d. Discuss effect of outstanding 3rd party mineral interests.

e. Does estate properly address mineral rights in relation to the project?

13. **NFS Assessment** _√____

a. Assessment of legal and professional capability and experience to acquire and provide LER for construction, OMRR&R of the Project.

b. Condemnation authority

c. Quick-take capability

d. NFS advised of URA requirements

e. NFS advised of requirements for documenting expenses for credit.

f. If proposed that Government will acquire project LER on behalf of NFS, fully explain the reasons for the Government performing work.

g. A copy of the signed and dated Assessment of Non-Federal Sponsor's Real Estate Acquisition Capability (Appendix 12-E) is attached to the REP.

14. **Zoning** in Lieu of Acquisition __√___

a. Discuss type and intended purpose

b. Determine whether the proposed zoning proposal would amount to a taking for which compensation will be due.

15. **Schedule** __√___
    a. Reasonable and detailed Schedule of land acquisition milestones, including LER certification.
    b. Dates mutually agreed upon by Real Estate, PM, and NFS. _____

16. **Facility or Utility Relocations** __√___
    a. Describe the relocations, identity of owners, purpose of facilities/utilities, whether owners have compensable real property interest.
    b. A synopsis of the findings of the Preliminary Attorney's Investigation and Report of Compensable Interest is included in the REP as well as statements required by Sections 12-17c.(5) and (6).
    c. Erroneous determinations can affect the accuracy of the project cost estimate and can confuse Congressional authorization.
    d. Eligibility for substitute facility
        1. Project impact
        2. Compensable interest
        3. Public utility or facility
        4. Duty to replace
        5. Fair market value too difficult to determine or its application would result in an injustice to the landowner or the public.
    e. See Sections 12-8, 12-17, and 12-22 of ER 405-1-12.

17. **HTRW** and Other Environmental Considerations __√____
    a. Discussion the impacts on the Real Estate acquisition process and LER value estimate due to known or suspected presence of contaminants.
    b. Status of District's investigation of contaminants.
    c. Are contaminants regulated under CERCLA, other statues, or State law?
    d. Is clean-up or other response required of non-CERCLA regulated material?
    e. If cost share, who is responsible for performing and paying cost of work?
    f. Status of NEPA and NHPA compliances
    g. See ER 1165-2-132, Hazardous, Toxic, and Radioactive Waste (HTRW) Guidance for Civil Works Projects.

18. **Landowner Attitude.** _√____
    a. Is there support, apathy, or opposition toward the project?
    b. Discuss any landowner concerns on issues such as condemnation, willing seller provisions, estates, acreages, etc.?

19. A statement that the **NFS has been notified in writing about the risks of acquiring LER before the execution of the PPA**. If not applicable, so state. _√____

20. **Other Relevant Real Estate Issues**. Anything material to the understanding of the RE aspects of the project. ___√____

A copy of the completed Checklist is attached to the REP. _√___

(Draft REPs must contain a draft checklist and draft Technical Review Guide)

**I have prepared and thoroughly reviewed the REP and all information, as required by Section 12-16 of ER 405-1-12, is contained in the Plan.**

Karen Vance 1-24-12

Preparer Date

**A copy of the Real Estate Internal Technical Review Guide for Civil Works Decision Documents is attached and signed by me as the Reviewer**

Judith [signature] 1/24/12

RE Internal Technical Reviewer Date

**The REP has been signed and dated by the Preparer and the District Chief of Real Estate.**
√