Mississippi River and Tributaries Project

Levee System Evaluation Report
for the
National Flood Insurance Program

United States Army Corps of Engineers
Mississippi Valley Division
Memphis District
Vicksburg District
New Orleans District

April 2014

U.S Army Corps
of Engineers
Mississippi Valley Division

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for the
National Flood Insurance Program

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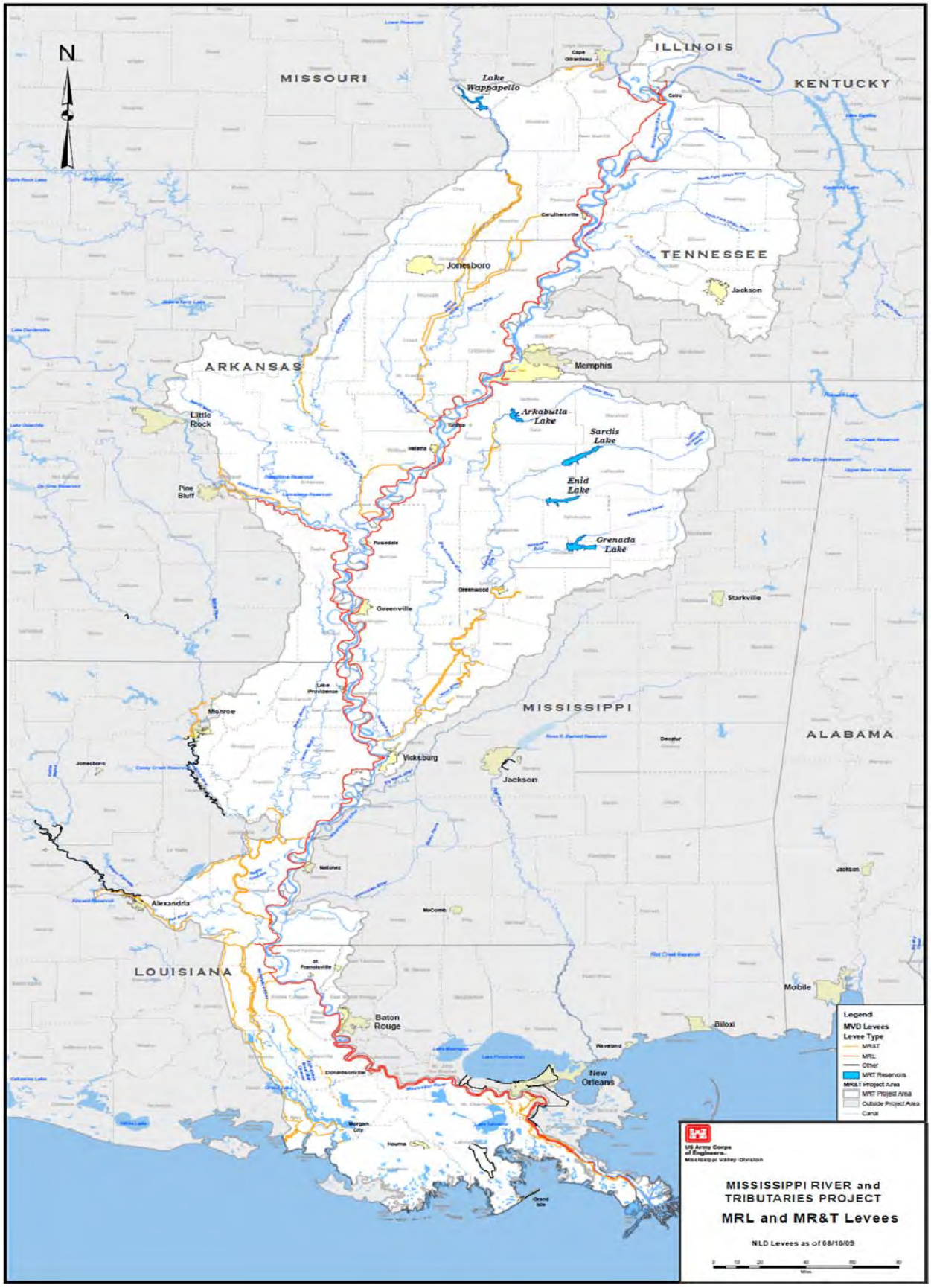
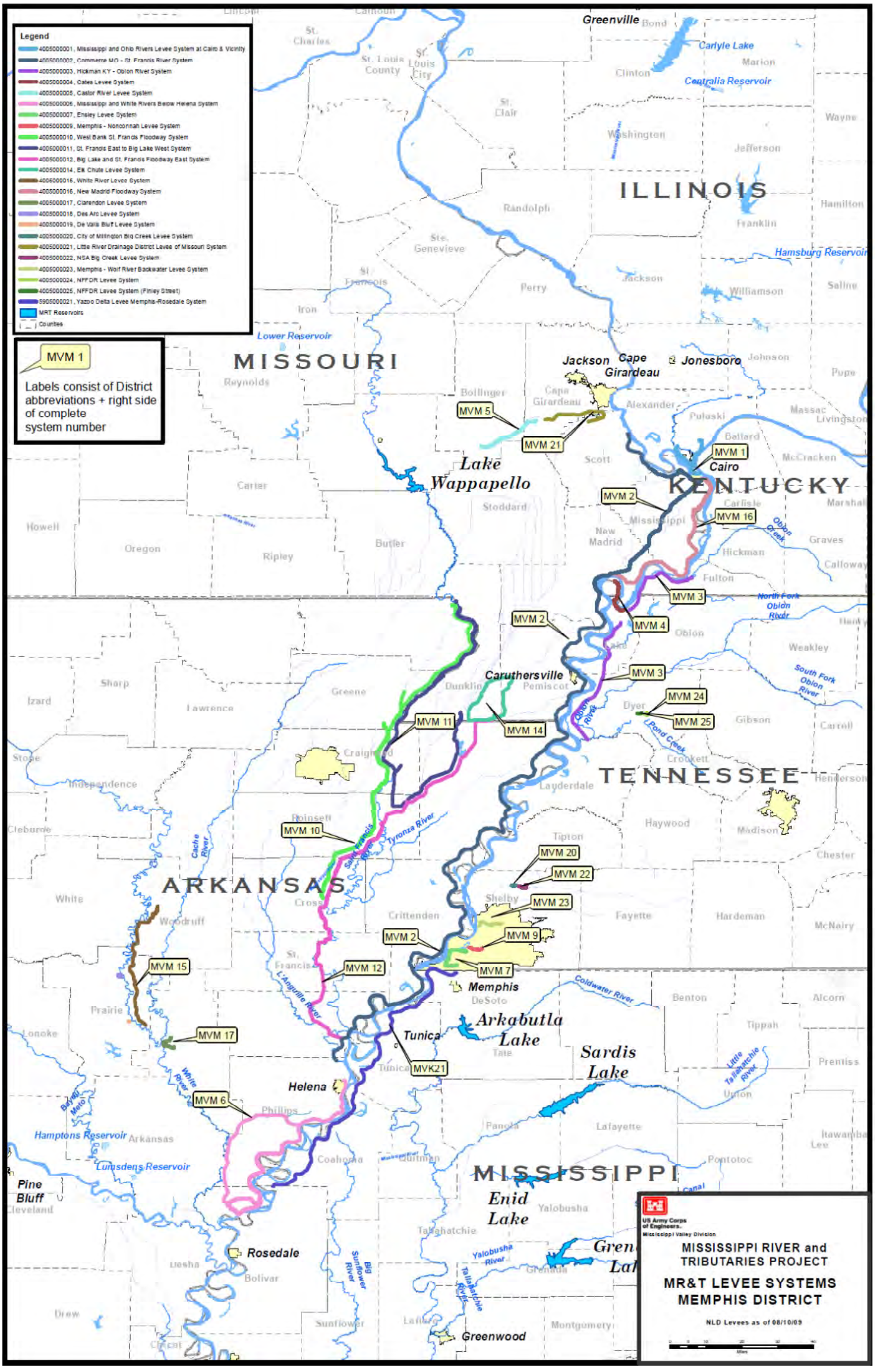
Appendices

1. Executive Summary

This report presents the results of investigations performed for the evaluation of the Mississippi River and Tributaries (MR&T) Project for use by the National Flood Insurance Program (NFIP). In 2010, EC 1110-2-6067 entitled "*USACE Process for the National Flood Insurance Program (NFIP) Levee System Evaluation*", dated 31 August 2010 provided guidance on performing these levee evaluations with instructions on how the United States Army Corps of Engineers (USACE) would conduct the evaluation for the Federal Emergency Management Agency (FEMA). As stated in EC 1110-2-6067, the objective of the NFIP levee system evaluation is to verify that the levee system performs as an integrated set of features and components, functioning individually and collectively to provide reasonable assurance that the 1% annual chance exceedance flood will be excluded from the leveed area. The MR&T Project was authorized by the Flood Control Act of 15 May 1928, as modified and amended in subsequent Acts of 23 April 1934, 15 June 1936, 18 August 1941, 24 July 1946, and 27 October 1965. USACE has major maintenance responsibility on the MR&T Project levees and structures. Maintenance of project channels, major maintenance of structures, and major maintenance of the project levees are federal responsibilities while minor maintenance of the levees and structures are non-federal sponsor responsibilities. Since USACE has major maintenance responsibilities for the MR&T Project levees and structures, the approval to perform NFIP levee system evaluation for the MR&T Project was granted by the Commander, Mississippi Valley Division (MVD).

As shown on pages 2 and 3, the main stem levees on the west bank for the Mississippi River begin just south of Cape Girardeau, Missouri, and except for gaps at points where tributaries enter the Mississippi River, extend continuously to Venice, Louisiana, approximately 10 miles above the Head of Passes. On the east bank, the levees are not continuous because of the high bluff lines near the riverbank where levees are not necessary. They extend intermittently from the vicinity of Hickman, Kentucky, to a point above Vicksburg, Mississippi. The MR&T Project levee system includes 3,787 miles of authorized embankments and floodwalls. Of this number, nearly 2,216 miles are along the main stem Mississippi River and the remaining levees are backwater, tributary (or distributary) and floodway levees. To this date, no project levee built to Mississippi River Commission (MRC) standards has ever failed, despite floods in 1937, 1945, 1950, 1973, 1975, 1979, 1983, 1997, 2008 and 2011. This report is a summary of the procedures, processes and findings of the MR&T Project Levee System Evaluation Reports.


N
MISSOURI
ILLINOIS
KENTUCKY
TENNESSEE
ARKANSAS
MISSISSIPPI
ALABAMA
LOUISIANA
Lake Wappapello
Cape Girardeau
Cairo
Jonesboro
Jackson
Memphis
Little Rock
Arkabutla Lake
Sardis Lake
Enid Lake
Grenada Lake
Pine Bluff
Greenville
Starkville
Monroe
Vicksburg
Jackson
Alexandria
Natchez
Baton Rouge
New Orleans
Mobile
Biloxi
Legend
MVD Levees
Levee Type
MR&T
MRL
Other
MRT Reservoirs
MR&T Project Area
MRT Project Area
Outside Project Area
Canal
US Army Corps of Engineers
Mississippi Valley Division
MISSISSIPPI RIVER and TRIBUTARIES PROJECT
MRL and MR&T Levees
NLD Levees as of 08/10/09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4005000001, Mississippi and Ohio Rivers Levee System at Cairo & Vicinity
4005000002, Commerce MO - St. Francis River System
4005000003, Hickman KY - Obion River System
4005000004, Cates Levee System
4005000005, Castor River Levee System
4005000006, Mississippi and White Rivers Below Helena System
4005000007, Ensley Levee System
4005000009, Memphis - Nonconnah Levee System
4005000010, West Bank St. Francis Floodway System
4005000011, St. Francis East to Big Lake West System
4005000012, Big Lake and St. Francis Floodway East System
4005000014, Elk Chute Levee System
4005000015, White River Levee System
4005000016, New Madrid Floodway System
4005000017, Clarendon Levee System
4005000018, Des Arc Levee System
4005000019, De Valls Bluff Levee System
4005000020, City of Millington Big Creek Levee System
4005000021, Little River Drainage District Levee of Missouri System
4005000022, NSA Big Creek Levee System
4005000023, Memphis - Wolf River Backwater Levee System
4005000024, NFFDR Levee System
4005000025, NFFDR Levee System (Finley Street)
5905000021, Yazoo Delta Levee Memphis-Rosedale System
MRT Reservoirs
Counties
MVM 1
Labels consist of District abbreviations + right side of complete system number
Greenville
Carlyle Lake
Centralia Reservoir
ILLINOIS
Hamsburg Reservoir
Lower Reservoir
MISSOURI
Jackson
Cape Girardeau
Jonesboro
Lake Wappapello
Cairo
KENTUCKY
Caruthersville
TENNESSEE
ARKANSAS
Memphis
Arkabutla Lake
Tunica
Sardis Lake
Helena
Hamptons Reservoir
Lunsdens Reservoir
Pine Bluff
Rosedale
MISSISSIPPI
Enid Lake
Greenwood
US Army Corps of Engineers
Mississippi Valley Division
MISSISSIPPI RIVER and TRIBUTARIES PROJECT
MR&T LEVEE SYSTEMS
MEMPHIS DISTRICT
NLD Levees as of 08/10/09


Legend
4405000516, West of Atchafalaya Basin
5905000001, AR-LA MS River
5905000002, Jackson Fairgrounds MS
5905000003, Aloha-Rigolette LA
5905000004, AR River North Bank
5905000005, Bossier Levee LA
5905000006, Caddo North LA
5905000007, Coldwater West MS
5905000008, Chula Lake MS
5905000009, Campti-Clarence AR
5905000010, Caddo South LA
5905000011, Coldwater East MS
5905000012, Greenwood MS, West
5905000013, Natchitoches LA
5905000015, East Jackson MS
5905000017, Ouachita River LA
5905000018, Sicily Island LA
5905000019, Yazoo Levees LB South MS
5905000020, Satartia Area MS
5905000021, MS East
5905000022, Red River BW LA
5905000023, Larto-Jonesville LA
5905000024, Wit Aux South MS
5905000025, Hempstead County AR
5905000026, Long Prairie AR
5905000027, RR RB Miller-Garland
5905000028, Red River LB AR
5905000029, Yazoo Levees LB Central MS
5905000030, Calion Protection Works AR
5905000031, Rocky Bayou Area
5905000032, Vicksburg Protection Works
5905000033, West Monroe Area
5905000034, Bawcomville Area
5905000035, East Point Area
5905000036, Bayou Nicholas - Coushatta, La
5905000037, Columbia Local Protection Works
5905000038, Pineville La
5905000039, Red River - West Agurs
5905000040, Peludia Creek South
5905000041, Yazoo Backwater-Yazoo River RB
5905000042, Coffeeville MS
5905000043, Panola-Quitman MS
5905000044, Ascalmore-Tippo South MS
5905000045, Ascalmore-Tippo North MS
5905000046, Teoc Creek North MS
5905000047, Big Sand, Yalobusha, Teoc Creek MS
5905000048, Greenwood MS, East
5905000049, Hillside Floodway North MS
5905000050, Hillside Floodway South MS
5905000051, Natchez Port MS
5905000052, McKinney Bayou - Mid - North
5905000053, McKinney Bayou - South
5905000054, Red Chute Bayou
5905000055, Black Bayou-Pine Island
5905000056, Twelve Mile Bayou
5905000057, Jonesville Local Protection
MRT Reservoirs
Counties
MVK 1
Labels consist of District abbreviations + right side of complete system number
MISSOURI
ARKANSAS
LOUISIANA
TEXAS
MISSISSIPPI
Greers Ferry Lake
Lake Ouachita
Millwood Lake
De Gray Reservoir
Cypress Bayou Reservoir
Toledo Bend Reservoir
Kincaid Reservoir
Sam Rayburn Reservoir
Caney Creek Reservoir
Hamptons Reservoir
Lumsdens Reservoir
Calcasieu Lake
Sabine Lake
White Lake
Arkabutla Lake
Sardis Lake
Enid Lake
Grenada Lake
Ross R. Barnett Reservoir
Lake Providence
Grand Lake
Little Rock
Pine Bluff
Helena
Memphis
Tunica
Jonesboro
Caruthersville
Rosedale
Greenville
Morgan City
Monroe
Natchez
Alexandria
Vicksburg
Jackson
St. Francisville
Baton Rouge
Donaldsonville
McComb
Saint Francis River
Cache River
L'Anguille River
White River
Bayou Meto
Little Missouri River
Caddo River
Red River
Saline River
Saline Bayou
Ouachita River
Bayou Macon
Tensas Bayou
Steele Bayou
Big Black River
Yazoo River
Coldwater River
Sunflower River
Yalobusha River
Tyronza River
Bayou Pierre
Pearl River
Hamochitto River
Atchafalaya River
Atchafalaya Basin Main Channel
Bayou Rigolette
Bayou Cocodrie
MVK 4
MVK 7
MVK 11
MVK 43
MVK 44&45
MVK 47
MVK 12
MVK 46
MVK 48
MVK 40
MVK 21
MVK 8
MVK 50
MVK 49
MVK 29
MVK 24
MVK 19
MVK 31
MVK 41
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MVK 2
MVK 15
MVK 32
MVK 33
MVK 17
MVK 34
MVK 37
MVK 18
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MVK 23
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MVK 27
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MVK 28
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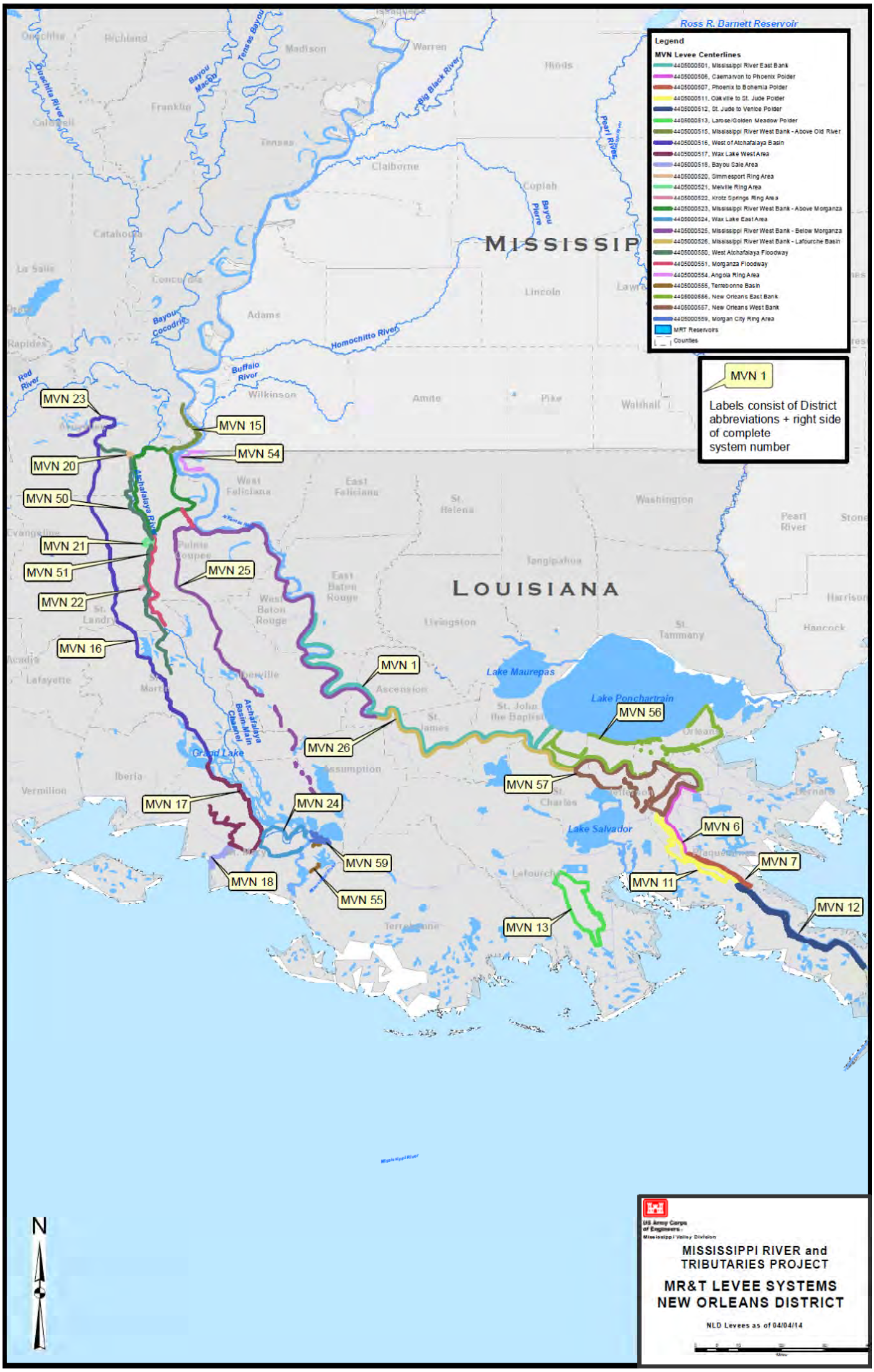
MVK 26
MVK 56
MVK 6
MVK 39
MVK 54
MVK 5
MVK 10
MVK 35
MVK 36
MVK 9
MVK 13
MVK 3
MVK 38
MVN 516
N
US Army Corps of Engineers.
Mississippi Valley Division
MISSISSIPPI RIVER and TRIBUTARIES PROJECT
MR&T LEVEE SYSTEMS
VICKSBURG DISTRICT
NLD Levees as of 04/04/14
Miles


Ross R. Barnett Reservoir
Legend
MVN Levee Centerlines
4405000501, Mississippi River East Bank
4405000506, Caernarvon to Phoenix Polder
4405000507, Phoenix to Bohemia Polder
4405000511, Oakville to St. Jude Polder
4405000512, St. Jude to Venice Polder
4405000513, Larose/Golden Meadow Polder
4405000515, Mississippi River West Bank - Above Old River
4405000516, West of Atchafalaya Basin
4405000517, Wax Lake West Area
4405000518, Bayou Sale Area
4405000520, Simmesport Ring Area
4405000521, Melville Ring Area
4405000522, Krotz Springs Ring Area
4405000523, Mississippi River West Bank - Above Morganza
4405000524, Wax Lake East Area
4405000525, Mississippi River West Bank - Below Morganza
4405000526, Mississippi River West Bank - Lafourche Basin
4405000550, West Atchafalaya Floodway
4405000551, Morganza Floodway
4405000554, Angola Ring Area
4405000555, Terrebonne Basin
4405000556, New Orleans East Bank
4405000557, New Orleans West Bank
4405000559, Morgan City Ring Area
MRT Reservoirs
Counties
MVN 1
Labels consist of District abbreviations + right side of complete system number
MISSISSIP
LOUISIANA
Ouachita River
Bayou Macon
Tensas Bayou
Big Black River
Pearl River
Bayou Pierre
Red River
Buffalo River
Homochitto River
Bayou Cocodrie
Atchafalaya River
Atchafalaya Basin-Main Channel
Grand Lake
Lake Maurepas
Lake Pontchartrain
Lake Salvador
Mississippi River
Richland
Madison
Warren
Franklin
Tensas
Claiborne
Copiah
Catahoula
La Salle
Concordia
Adams
Rapides
Wilkinson
Amite
Pike
Walthall
West Feliciana
East Feliciana
St. Helena
Washington
Pearl River
Stone
Tangipahoa
East Baton Rouge
West Baton Rouge
Livingston
St. Tammany
Hancock
Lafayette
St. Martin
Ascension
St. John the Baptist
St. James
Assumption
Iberia
Vermilion
St. Charles
Lafourche
Terrebonne
MVN 23
MVN 15
MVN 54
MVN 20
MVN 50
MVN 21
MVN 51
MVN 25
MVN 22
MVN 16
MVN 1
MVN 26
MVN 56
MVN 57
MVN 17
MVN 24
MVN 59
MVN 18
MVN 55
MVN 6
MVN 7
MVN 11
MVN 12
MVN 13
N
US Army Corps of Engineers
Mississippi Valley Division
MISSISSIPPI RIVER and TRIBUTARIES PROJECT
MR&T LEVEE SYSTEMS
NEW ORLEANS DISTRICT
NLD Levees as of 04/04/14

2. Purpose and Scope

The purpose of this document is to consolidate and present all the information used to develop the MR&T Project Levee System Evaluation Reports (LSER) for the NFIP. This includes technical data, documentation from the 2011 flood, and the most recent routine or periodic inspection for each levee segment authorized by the MR&T Project. A total of 57 evaluation reports were completed and the findings for each MVD District are shown in Table 2-1.

Table 2-1
Levee System Evaluation Report Results

District (Reports Complete)	Positive Reports	Negative Reports
Memphis-MVM (10)	6	4
Vicksburg-MVK (25)	3	22
New Orleans-MVN (22)	10	12

The reasons for the negative reports are summarized in paragraph 12 of this report. In an effort to not be redundant and minimize the content in this report, Appendices A through C includes each individual LSER produced by each respective district. As stated above, the evaluations were conducted for NFIP certification and accreditation. Pertinent topics needed to obtain this goal are provided in the paragraphs that follow.

3. Certification by FEMA National Flood Insurance Program (NFIP) Title 44 Code of Federal Regulations (CFR) Section 65.10

The U.S. Department of Homeland Security's (FEMA) is the federal agency responsible for administering the NFIP. As part of the NFIP, FEMA develops Flood Insurance Rate Maps (FIRMS) to identify areas that may be subject to flooding, for both determining flood insurance rates and flood plain management activities. Starting in 2003, FEMA embarked on a nationwide program called the Flood Map Modernization (Map Mod) Program. As part of the process, FEMA worked with federal, state and local agencies to ensure that the most up-to-date information possible was incorporated into the final product. FEMA recognized that many levees may have changed considerably or deteriorated since the previous effective maps were published. This finding prompted FEMA to verify that all levees recognized on previous FIRMS meet the requirements outlined in Title 44 of the Code of Federal Regulations, Section 65.10 (Title 44 CFR 65.10), "*Mapping Areas Protected by Levee Systems*". Title 44 CFR 65.10 identifies specific structural requirements that must be certified by a registered professional engineer or a federal agency with responsibility for levee design, such as USACE. The certification should state that the levee has been adequately designed and constructed to provide a reasonable assurance of excluding the base flood (1% annual chance exceedance) from the leveed area and thus meet NFIP levee system evaluation requirements. USACE was tasked to perform NFIP levee evaluations for the MR&T Project levee system primarily because of the major maintenance authorization. The USACE review covers all components of the entire levee system as outlined in EC 1110-2-6067 "*USACE Process for the NFIP Levee System Evaluation*", including design and construction issues as noted in the CFR. In summary, the general items of concern for 44 CFR 65.10 certification are listed below:

- Levee minimum freeboard
- Levee structural adequacy
- Interior drainage system adequacy
- Adopted Operation and Maintenance (O&M) manual
- O&M being performed by public entity or NFIP participant

4. EC 1110-2-6067 Certification of Levee Systems for NFIP Levee System Evaluation

USACE has chosen to use the phrase NFIP Levee System Evaluation rather than certification to emphasize that EC 1110-2-6067 is focused on the complete levee system's status with regard to requirement of both 44 CFR 65.10 and USACE guidelines. This choice of terminology better respects the 44 CFR 65.10 definition of certification in Part 65.2 (b) – "For the purpose of this part, a certification by a registered professional engineer or other party does not constitute a warranty or guarantee of performance, expressed or implied. Certification of data is a statement that the data is accurate to the best of the certifier's knowledge. Certification of analyses is a statement that the analyses were performed correctly and in accordance with sound engineering practices. Certification of structural works is a statement that the works were designed in accordance with sound engineering practices to provide protection from the base flood. Certification of "as built" conditions is a statement that the structure(s) has been built according to the plans being certified, is in place, and is fully functioning". Levee certification is still appropriate for other than Corps efforts toward compliance with the 44 CFR 65.10.

NFIP levee system evaluation determination by USACE is a technical finding that, for the floodplain in question, there is a reasonable assurance that the levee system will exclude the 1% annual chance exceedance flood (or base flood) from the leveed area based on the condition of the system at the time the determination is made. NFIP levee system evaluation only addresses the levee system with regard to the 1% annual chance exceedance flood. If a levee meets NFIP levee system evaluation requirements as stated in EC 1110-2-6067, it may be "accredited" by FEMA and the area behind the levee thus mapped on the FIRM in accordance with 44 CFR 65.10.

USACE and FEMA policy states a NFIP levee system evaluation is the responsibility of the local levee sponsor or community seeking recognition of the levee system on the FIRM. In limited cases, USACE may perform the NFIP levee system evaluation. Upon request by the local community or sponsor, USACE may perform NFIP levee system evaluation for federally authorized levees that USACE operates and maintains (or has major maintenance responsibilities) and may be funded from project-appropriated funds, if available. Based on the Flood Control Act of 1928 and subsequent authorizations, USACE was granted major maintenance responsibility for the MR&T Project, as previously stated.

5. Main Stem and Backwater Features-Memphis District

Formulation and design of MR&T Project levees were completed in the early 1950's and the recommended plan was presented in "*House Document 308, Mississippi River and Tributaries Project, Volume I-IV*", dated May 1964. Descriptions of the leveed area, as presented in Volume II, Annex E of House Document 308, are shown in the following paragraphs. All information has been amended or updated to reflect changes in each system that has transpired since House Document 308 publication. Examples of updated information are authorized levels of protection, 1950 vs. 2013 population estimates and property value in the leveed area. Updated 2013 population, structural property values, and number of structures estimates were obtained by the *USACE Levee Screening Tool* (LST) version 3.2.1. The LST was developed by the USACE Risk Management Center. As stated previously, the individual LSERs are included in Appendices A through C and provide additional maps, project features, as-built drawings, and other information pertinent to specific systems.

5.1. MVM System #21-Little River Drainage District Levee of Missouri System

This levee extends from high ground at Allenville, Missouri, and ends at high ground in the vicinity of Ancell, Missouri and is located south of the Little River Diversion Channel. It is 21 miles long. The purpose of the levee is to protect the agricultural area south of the levee against both backwater flooding from the middle Mississippi River and headwater flooding from the Little River Diversion Channel. The approved grade is three feet above a flow line for 1,400,000 cfs meeting a stage of 59 feet on the Cairo gage. The levee height above original ground surface varies across the alignment but on average is approximately 20 feet in height. Some areas are as high as 25 feet. Most of the levee has a protected side slope of 1V on 5H and a riverside slope of 1V on 3.5H. The levee slopes vary based on the height of the levee.

The leveed area is referred to as the Little River Drainage District, consisting of parts of Bollinger, Cape Girardeau, Scott, Stoddard, New Madrid, Dunkin, and Pemiscot Counties in the southeast part of Missouri. There are no large cities in the leveed area. Principal towns in the area are Chaffee, Morehouse, Lilbourn, and Sikeston, Missouri. The total area leveed is 1,040 square miles and is served by the Missouri-Pacific Railroad, St. Louis-Southwestern Railway, and the St. Louis-San Francisco Railway. The population is scattered throughout the leveed area and the value of the farm lands is considered such as to warrant protection of the area against great floods. Without levees, the area would be flooded to some degree annually by the waters of the middle Mississippi River and the headwaters of the Little River. Based on the 2000 Census data, the population in the leveed area is approximately 33,099 people. The total estimated property value in the leveed area is approximately $0.9 billion. The number of structures in the leveed area is about 15,672.

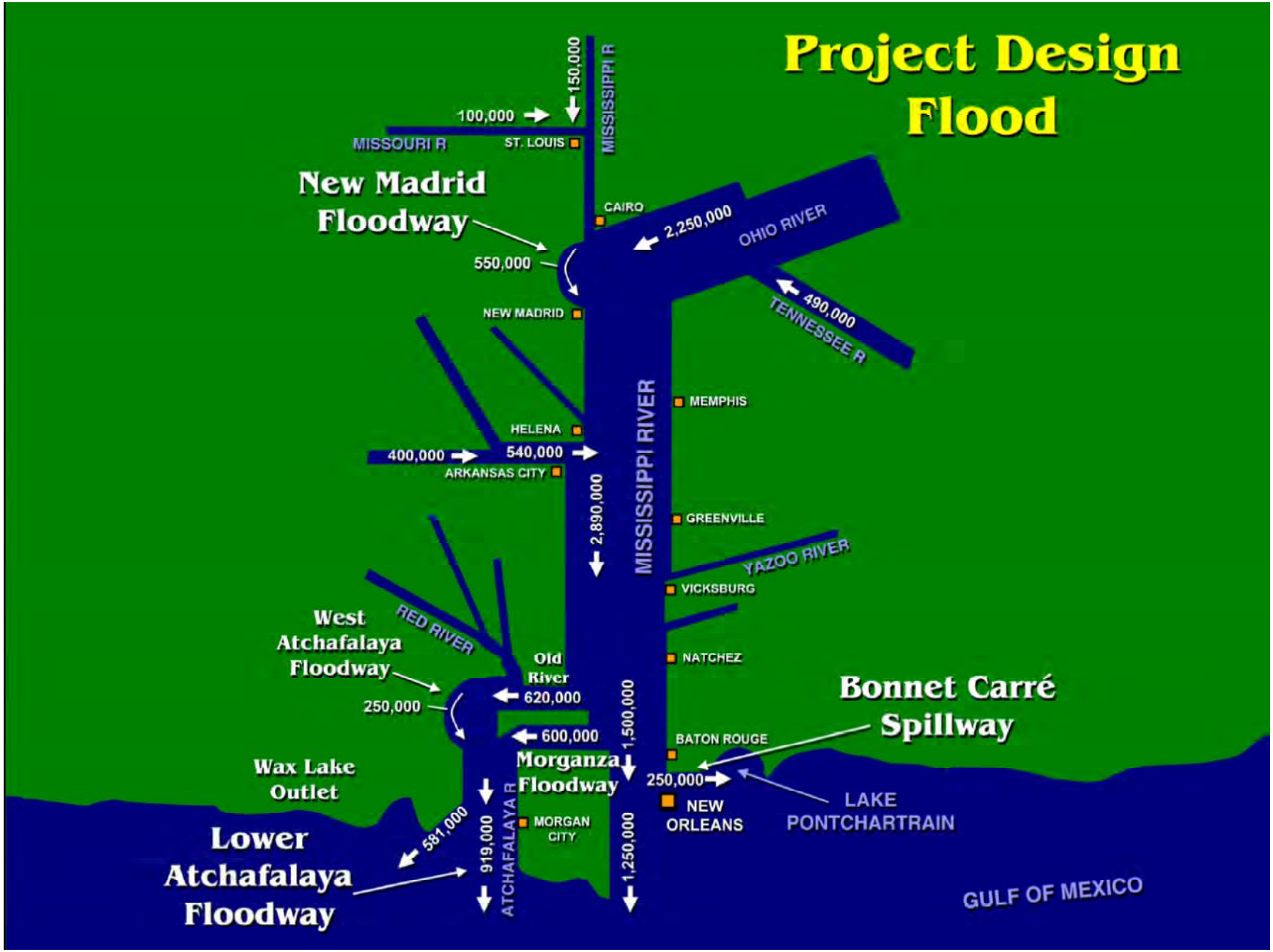
5.2. MVM System #1-Mississippi and Ohio Rivers Levee System at Cairo and Vicinity

Sponsors for this levee are the City of Cairo, the Cairo Drainage District, and the city of Mounds and Mound City, Illinois. The levee begins at high ground 2-1/2 miles north of Mound City, Illinois, and ends at high ground one mile east of Cache, Illinois. It is 21 miles long, including 3 miles of floodwall. The Cairo Drainage District Levee contains two pumping plants; the Cairo City levee contains three pumping plants; and the Mounds-Mound City levee contains major drainage structures at Cache River and Mounds Creek.

The levee provides protection from the Project Design Flood (PDF) as shown on the following page on the Mississippi and Ohio Rivers for Cairo, Mounds, and Mound City, Illinois, and the surrounding agricultural area. The present authorized criteria are as follows: Along the Ohio River front the levee grade would be three feet above the flow line for 2,250,000 cfs as a component of 2,360,000 cfs (computed to produce 62.5 feet on the Cairo gage). The danger from overtopping when applied to a floodwall would not threaten the integrity of the wall to the same degree as in the case of a levee. Along the Mississippi River to the junction with the Cairo North Levee, the recommended freeboard is three feet over 1,000,000 cfs as a component of 2,360,000 cfs, or four feet over 1,400,000 cfs meeting a stage of 59.5 feet on the Cairo gage, whichever results in the higher grade. Upstream from the junction, the grade would be two feet over 1,000,000 cfs, or three feet over 1,400,000 cfs, in combination as previously stated, whichever results in the higher grade.

This levee system's height above original ground surface varies across the alignment but on average is approximately 25 feet in height. Some areas are as high as 40 feet. Most of the levee has a protected side slope of 1V on 4H or 1V on 5H and a riverside slope of 1V on 3.5H. The levee slopes vary based on the height of the levee.

The total area leveed is 23 square miles. Population within the area is estimated to be 4,829 people and has declined over the past decades. The density of population and the value of both urban property and surrounding agricultural lands were sufficient to warrant protection against great floods, when the levee was originally built. Based on the 2010 Census, there are approximately 2,630 homes estimated at $141 million. With levees, the City of Cairo and the Cairo Drainage District have not been flooded since the adoption of the 1928 Act. The Mounds-Mound City area was flooded during the 1937 flood because the levee from Mounds to Mound City was substandard and was overtopped.


Project Design Flood
150,000
MISSISSIPPI R
100,000
MISSOURI R
ST. LOUIS
New Madrid Floodway
CAIRO
2,250,000
OHIO RIVER
550,000
490,000
TENNESSEE R
NEW MADRID
MEMPHIS
HELENA
400,000
540,000
ARKANSAS CITY
MISSISSIPPI RIVER
2,890,000
GREENVILLE
YAZOO RIVER
VICKSBURG
West Atchafalaya Floodway
RED RIVER
NATCHEZ
Old River
620,000
250,000
Bonnet Carré Spillway
600,000
1,500,000
BATON ROUGE
Wax Lake Outlet
Morganza Floodway
250,000
LAKE PONTCHARTRAIN
NEW ORLEANS
581,000
919,000
ATCHAFALAYA R
MORGAN CITY
1,250,000
Lower Atchafalaya Floodway
GULF OF MEXICO

5.3. MVM System #2-Commerce, Missouri – St. Francis River System (Commerce to New Madrid, Missouri)

This levee begins at high ground at Commerce, Missouri, and ends at the junction with the Lower St. Francis Levee at New Madrid, Missouri. It is discussed separately from the west bank Mississippi River levee below New Madrid because it protects a separate area. Between Commerce and Birds Point, Missouri, the levee is known as the Upper St. Francis Levee and below Birds Point, it is known as the Birds Point-New Madrid Setback Levee, except for the last two miles, which is called the St. Johns Bayou Levee. The total length of the levee is 67 miles. The Upper St. Francis Levee is authorized at a freeboard of three feet over a Mississippi River flow of 1,400,000 cfs meeting a Cairo stage of 59.5 feet, or a freeboard of two foot over a Mississippi River flow of 1,000,000 cfs meeting a Cairo stage of 62.5 feet. The 1,000,000 cfs is a component of 2,360,000 cfs and produces a Cairo stage of 62.5 feet on the gage. Of the two scenarios, the higher levee grade governs.

Between Birds Point and New Madrid, the present authorized freeboard is one foot over the 1941 Project Flood flow line. The levee was upgraded in 1993. An upgrade was necessary because private levee construction in Illinois (Len Small Levee) reduced the floodplain width and resulted in a rise in the computed Project Flood flow line. This increase in the computed Project Flood flow line encroached into the authorized freeboard, requiring the need to raise the levee.

The Upper St. Francis Levee contains a concrete culvert at Big Lake, consisting of two 5-foot, by 8-foot openings, equipped with lift gates on the riverside end. The Birds Point-New Madrid Setback Levee contains a concrete culvert at Brewers Lake having one 5-foot by 8-foot opening equipped with lift gates on the riverside end, and also contains the St. Johns Bayou Floodgate which is a concrete structure having six 10-foot by 10-foot openings, equipped with lift gates on the riverside end.

The height of the levee varies across the alignment but on average is approximately 25 feet. Some areas are as high as 35 feet. Most of the levee has a protected side slope of 1V on 4H or 1V on 5H and a riverside slope of 1V on 3.5H.

The leveed area is known as the Upper St. Francis Levee District and consists of portions of Scott, Mississippi, and New Madrid Counties, in the southeast part of Missouri, and contains 405 square miles most of which is predominantly cleared. Included in the area are the cities of New Madrid, Sikeston, Charleston, and East Prairie, Missouri. Wyatt, Diehlstadt, and Bertrand, Missouri, are the major towns and there are several other smaller settlements. The area is served by the Missouri-Pacific Railroad, St. Louis-San Francisco Railway, and the St. Louis Southwestern Railway. The area has not been flooded since the adoption of the 1928 Act except by backwater from the mouth of St. Johns Bayou prior to the completion of St. Johns Bayou Floodgate structure in 1953.

5.4. MVM System #16-New Madrid Floodway System

This levee is known as the Upper St. Francis Frontline Levee. It begins at the junction with the Birds Point-New Madrid Setback Levee at Birds Point, Missouri, and ends at a point about 1,800 feet east of the Birds Point-New Madrid Setback Levee. Its approximate length is 55 miles. The

purpose of the levee is to provide protection from Mississippi River floods for the agricultural area known as the Birds Point-New Madrid Floodway during periods when the floodway is not in operation. The 1928 Act authorized the degrading of the upper and lower fuseplug sections to a grade corresponding to 55 feet on the Cairo gage. The Flood Control Act of September 3, 1954 authorized the construction of a tie-in levee from the lower end of the Frontline Levee to the Birds Point-New Madrid Setback Levee and the construction of a floodgate to reduce overflow in the backwater portion of the floodway. The 11-mile upper fuseplug section has not been degraded and has an effective grade corresponding to 57 feet on the Cairo gage. A 24-mile section adjacent to and downstream from the upper fuseplug section has been completed to an effective grade corresponding to 60.5 feet on the Cairo gage. The 5-mile lower fuseplug section has an effective grade corresponding to 60.5 feet on the Cairo gage. The 24 miles of levee from the upper fuseplug downstream has a landside slope of 1V on 5H and a riverside slope of 1V on 3-1/2H, with a crown width of 10 feet. The remainder of the levee is an old banquette section with approximately 1V on 3H slopes on both sides and a variable crown width. Average heights of the lower fuseplug section range from 12 to 17 feet.

The area enclosed is known as the Birds Point-New Madrid Floodway and contains 205 square miles, of which the majority is cleared. A few small communities are located in the area but the population density is very low. The floodway was authorized by the Flood Control Act of 15 May 1928 as a means to protect areas adjacent and upstream of the floodway. Operation of the floodway may occur when the Cairo gage reaches 58 feet with a forecast to exceed 60 feet. Currently, the 1986 Plan of Operation is designed to accomplish this by artificially crevassing sections of the Frontline Levee. The value of the farm land in the area is such as to warrant protection when floodway operation is not required. Floodway operation has only occurred twice since being authorized; once during the 1937 flood and once during 2011 flood. Without levees, the area would be subject to annual flooding. With the authorized protection complete, the area would have protection against floods to a height corresponding to 60.5 feet on the Cairo gage, which is the authorized grade of the upper and lower fuseplug sections. With the floodgate closed, approximately 26,000 acres of lower, unimproved agricultural land will be subject to use as a sump area.

5.5. MVM System #2-Commerce, Missouri – St. Francis River System (New Madrid, Missouri to St. Francis River)

This levee is known as the Lower St. Francis Levee of Missouri and Arkansas. It begins at New Madrid, Missouri, where it connects to the downstream end of the St. Johns Levee and ends near the mouth of the St. Francis River, about six miles north of Helena, Arkansas. The length of the system is approximately 277.6 miles. Similar to the upper levee segment, the height of the levee varies across the alignment but on average is approximately 25 feet. Some areas are as high as 35 feet. Most of the levee has a protected side slope of 1V on 4H or 1V on 5H and a riverside slope of 1V on 3.5H. Levee slopes vary based on the height of the levee.

The leveed area is 3,760 square miles and is generally known as the Lower St. Francis Levee and Drainage District of Missouri and Arkansas. Portions of New Madrid and Pemiscot Counties, Missouri, and Mississippi, Craighead, Poinsett, Crittenden, St. Francis, and Lee Counties, Arkansas, are located within this area. The principal cities within the area are New Madrid,

Malden, Portageville, Caruthersville, Hayti, and Steele, Missouri, and Blytheville, West Memphis, Osceola, and Marianna, Arkansas. The major towns are Lilbourn, Marston, PaRiver Milea, Gideon, Wardell, Cooter, and Holland in Missouri, and Wilson, Lepanto, Luxora, Marion, Crawfordsville, and Hughes in Arkansas. The entire area, outside of the cities and towns, is a rich agricultural area that has not been flooded since the adoption of the 1928 Act.

Damages caused by a break in the Upper St. Francis Levee during an extreme flood would create a major disaster. A break in the lower end of the levee would cause less damage since a major portion of the lower end of the area is primarily agricultural.

The total population and homes protected by the Upper and Lower St. Francis District Levee is approximately 280,000 and the 107,000, respectively. Estimated property damages of $11 billion dollars could occur if the area was inundated.

5.6. MVM System #12-Big Lake and St. Francis Floodway East System

This levee's upper end begins near Parkin, Arkansas, where it connects to the downstream end of the Steep Gut Floodway Levee. From this point upstream, it is considered a continuous system intended to protect against extreme backwater and St. Francis Floodway headwaters. The system includes the St. Francis Floodway, Right Chute Little River and the Big Lake Floodway right bank levees.

Its lower end connects with the West Bank Mississippi River Levee (about five miles southwest of Whitehall). The total length of backwater levee is 47 miles, including nine miles of fuseplug levee. A pumping plant (W. G. Huxtable), with a 12,000 cfs capacity with a floodgate for gravity flow is located at a point where the fuseplug levee crosses the present channel of the St. Francis River. The fuseplug, which extends from near the junction with the Mississippi River Levee to a point near Marianna, Arkansas, is authorized to a grade three feet below the 1941 Project Flood stage for the Mississippi River. A lower elevation is intended to allow Mississippi River backwater to flow over the fuseplug and allow the area to store floods approaching the Project Flood. The remainder of the levee, from Marianna to Riverfront, Arkansas, is authorized at a grade one foot above the St. Francis River design flood meeting the Mississippi River 1941 Project Flood (209.9 NGVD), or three feet above design flood on the St. Francis meeting the maximum Mississippi River flood of record (206.4 NGVD); whichever is higher.

The area leveed is generally known as the St. Francis River Backwater Area. The levee benefits approximately 790 square miles, of which 70-80 percent is, cleared land, by protecting the area from floodwaters of the St. Francis River and backwater from the Mississippi River. Portions of Poinsett, Cross, Crittenden, St. Francis, and Lee Counties, Arkansas, are located in the leveed area. Major cities in the area are Marked Tree, Earl, and Marianna, and the major towns are Parkin, Tyronza, Hughes, and Madison, Arkansas. The area is served by the Missouri-Pacific Railroad, the St. Louis-San Francisco Railway, and the Chicago, Rock Island, and Pacific Railroad.

5.7. MVM System #6-Mississippi And White Rivers below Helena System

The Mississippi and White Rivers below Helena Levee System consists of levee protection beginning at high ground just north of Helena, Arkansas, and extending 61 miles southward

along the west bank of the Lower Mississippi River to its confluence with the White River. This levee, which includes the Laconia Back Circle Levee, is known as the White River Levee. It is 74 miles long, including the 8.3-mile length of Laconia Back Circle Levee. The continuous levee then turns and extends approximately 40 miles northward along the east bank of the White River forming a ring levee configuration in the southern portion. The system protects against Mississippi River headwater flooding and White River backwater flooding. A portion of the leveed area acts as an emergency reservoir during the Mississippi River Project Flood conditions.

There are two major drainage structures in the levee. One is a concrete culvert at Helena, Arkansas, having an 8-foot by 8-foot opening, equipped with a lift gate on the riverside end, and the other at Double Cabin Bayou, is similar except that it has a 6-foot by 6-foot opening. From Helena to Station 43/0 the grade of the levee is from one to three feet above the 1941 Project Flood flow line. This one to three foot variance is because the levees were constructed to the 1928 grade, and the design flow line was subsequently lowered by the Mississippi River cutoffs. From Station 43/0 to the Laconia Circle Levee, the grade is up to one foot below the 1941 design flow line. Freeboard on the Laconia Circle Levee is generally one foot above the 1941 design flow line.
A break in the upper end of the levee would cause considerable damage but the floodwaters would not necessarily top the backwater levee or the Laconia Circle Levee and, consequently, the damage would be confined to the upper part of the basin. In case of a break in the lower end of the levee, the damage might be confined to either the backwater area or the area enclosed by the Laconia Circ1e Levee and cause relatively little damage to the area. No differential in freeboard was needed. During great floods, storage in the backwater area is available if necessary, by overtopping or breaching of the fuseplugs in the White River Backwater Levee.

The height of this system varies across the alignment but on average is approximately 25 feet. Some areas are as high as 35 feet. Most of the levee has a protected side slope of 1V on 4H or 1V on 5H and a riverside slope of 1V on 3.5H. The levee slopes vary based on the height of the levee.

The leveed area is generally known as the White River Levee District of Arkansas, and consists of portions of Phillips, Desha, and Monroe Counties, Arkansas. The leveed area contains approximately 910 square miles of predominantly cleared land. Helena, West Helena, and Marvel, Arkansas, are the principal towns and communities. Other communities are Elaine, Mellwood, Crumrod, Wabash, Oneida, Poplar Grove, Henrico, and Snow Lake, Arkansas. The area is served by the Missouri-Pacific Railroad. Total population within the area is estimated at 6,247 people. Structural property is estimated to be $483 billion. The area has not been flooded since the adoption of the 1928 Act, except in the lower reaches, which were subject to flooding by backwater from the mouth of White River prior to the construction of the White River Backwater Levee.

5.8. MVM System #6-Mississippi And White Rivers Below Helena System (White River Backwater Levee)

This levee begins at Station 20/49+80 of the Mississippi River main line levee in the vicinity of Old Town, Arkansas, and ends at the junction with the Mississippi River main line (Laconia Circle) levee at Station 64/47+60 in the vicinity of Snow Lake, Arkansas. The levee contains a

concrete outlet structure at Little Island Bayou, consisting of ten 8-foot by 10-foot openings having lift gates on the riverside end, and a concrete culvert at Deep Bayou, having two 6-foot by 6-foot openings with lift gates on the riverside end. An emergency reservoir, authorized under the Flood Control Act of 1936, was the intended use of this area. The grade of the levee has been set equal to the Project Flood flowline of the White River meeting the 1941 Project Flood flowline of the Mississippi River. An exception is the fuseplug section, which total 13,000 linear feet and is set 2.4 feet below the old project flowline. The leveed area is generally known as the White River Backwater Area, and consists of portions of Phillips, Monroe, and Desha Counties, Arkansas. It contains 227 square miles of which the majority is cleared. The largest community within the area is Elaine, Arkansas, with a Hazus population of 865. Hazus is a geographic information system-based natural hazard loss estimation software package developed by FEMA. Other rural communities include Mellwood, Wabash, Crumrod, Ferguson, and Deerfield, Arkansas. The area is served by the Missouri-Pacific Railroad.

The population is scattered but the value of the fertile farm land is such as to warrant protection against floods, except those of great magnitude, under which condition the backwater levee could be overtopped or breached, if necessary. It is contemplated that the area will be flooded during the occurrence of the Project Flood. The area has not been inundated since the backwater levee was constructed except by impounded water when the floodgates of the drainage structures are closed during high stages of the White and Mississippi Rivers.

5.9. MVM System #3-Hickman, Kentucky – Obion River System (Hickman – Reelfoot)

The Hickman, Kentucky, to Obion River Levee System is located in Fulton County, Kentucky, and Lake and Dyer Counties, Tennessee, and provides levee protection on the east bank of the Lower Mississippi River beginning at high ground just north of Hickman, Kentucky, and extending to the Obion River. The system is composed of two separate continuous levees separated by high ground in Lake County, Tennessee. Together these two levees and the section of high ground form a continuous system that protects the cities, communities and primarily agricultural land on the east bank of the Mississippi River. This 60-mile levee system was constructed under the authority of the Flood Control Act of 1928. This upper reach of the levee system begins at high ground at Hickman, Kentucky, and ends at high ground l-1/2 miles east of Cates, Tenn. The levee includes the Hickman City Levee that is 23 miles long. The entire levee is complete to the 1941 approved grade and section. There is a 4-foot by 6-foot storm water outlet in the Hickman City Levee at Station 0/14+28, and a 6-foot by 6-foot concrete culvert in the Reelfoot Levee at Station 0/18.

The height of the levee varies across the alignment but on average is approximately 25 feet. Most of the levee has a crown width of 20 to 25 feet and a protected side slope ranging from 1V on 4H to 1V on 5H and a riverside slope ranging from 1V on 3.5H to 1V on 4H.

A uniform freeboard of three feet is authorized for this levee, with the exception of the one-mile length of floodwall, which has a one-foot freeboard above the new flowline. Construction was conducted in 1934. Final lengths for the line of protection consist of approximately 2,457 feet of concrete floodwall and approximately 2,142 feet of levee. Since its construction in 1934, the floodwall has been raised twice to a final elevation of 323.8 NGVD.

The leveed area is known as Hickman Front and the Reelfoot Levee District, consisting of portions of Fulton County, Kentucky, and Lake and Obion Counties, Tennessee. Hickman, Kentucky, is the only city protected. Bondurant, Kentucky, and Phillippy, Tennessee, are the major towns in the area and are located on the Illinois Central Railroad, which serves the area. The total area protected is 310 square miles. The population is somewhat scattered, except in Hickman, Kentucky. Value of the fertile farm lands is such as to warrant protection against major floods, which has not been flooded since the adoption of the 1928 Act.

5.10. MVM System #3-Hickman, Kentucky – Obion River System (Tiptonville, Tennessee to Obion River)

This levee begins at high ground at Tiptonville, Tennessee, and ends near the mouth of the Middle Fork of Forked Deer River. The levee was authorized by the Flood Control Act of 22 June 1936. In approving the plan set forth in the 1941 review report, the Flood Control Act of 18 August 1941 set the grade for the levee at three feet below that of the mainline levee on the opposite bank. This results in an authorized grade two feet below the Project Flood flowline. The Flood Control Act of 24 July 1946 authorized the extension of the levee to the location stated above. The levee contains seven drainage structures (see Table 5-1), consisting of reinforced concrete pipe culverts with gates on the riverside ends.

Table 5-1
Lake County, Tennessee Culverts

Station #	Culvert
0/33+37	Three 6-ft diameter pipes
2/12+60	Two 5-ft diameter pipe
5/12+58	Three 5-ft diameter pipes
8/49+00	Four 6-ft diameter pipes
11/41+45	Three 6-ft diameter pipes
0/31+10N	Two 6-ft diameter pipes
0/65+32N	Two 6-ft diameter pipes

The leveed area is composed of the Lake County Levee and Drainage District and Dyer County Levee and Drainage District No. 1, which includes portions of Lake, Dyer, and Lauderdale Counties in the northwest part of Tennessee. Tiptonville, Ridgely, and Dyersburg, Tennessee are the principal cities in the area but there are several small towns in the area. The leveed area totals 102 square miles. An additional area of 234 square miles is benefited by this project levee. The population of the area is relatively small and based on the 2000 Census is approximately 15,000 people but the value of the property is $1.3 billion. A break in the upper end of the levee would cause a great deal more damage than one near the lower end, in view of the fact that the population is denser. The lower portion of the leveed area is subject to backwater flooding from the Mississippi and Obion Rivers because the levee does not tie into high ground.

5.11. MVK System #21-Mississippi East (Yazoo Delta)

This levee begins at high ground near Walls, Mississippi, near Memphis, Tennessee, and extends to the Yazoo River, resulting in a total length of about 272 miles. This levee is partly in the Memphis District and partly in the Vicksburg District with the Coahoma-Bolivar county line in Mississippi as the divide. The portions in the two districts will be described separately.

The portion of the levee in the Memphis District is 94 miles long. There is one major structure along the levee, the McKinney Bayou pumping plant, which discharges over the levee through a 42-inch pipe. The authorized freeboard is two feet above the 1941 design flood. The average height of levee is 29 feet.

Since the design of the levees, the MR&T Project Flood flowline has been refined, once after the 1956 flood, and then again after the 1973 flood, when these floods clearly indicated channel deterioration was sufficient enough to influence a change in the Project Design flowline. The refined 1973 flowline should be used for all design purposes except in the case of the Yazoo Backwater Levee. The Yazoo Backwater Levee should be designed based on the Refined 1973 MR&T Project Flood flowline less the adjustment for future deterioration.
The length of levee in the Vicksburg District is 178.3 miles, of which 144 miles are complete to grade and section, 4.7 miles are under contract to complete, and 29.6 miles remain to be completed. The authorized freeboard is three feet above the Project Flood flowline. Most of the remaining sections to be raised are deficient in grade by an average of 2 and 3 feet. The average height of the levee is approximately 30 feet.

The Yazoo Basin behind the levee (in both Memphis and Vicksburg Districts) comprises 4,049 square miles. The population of the basin is 174,760 persons based on the National Levee Database (NLD). Cities and towns of over 2,500 populations are Belzoni, Clarksdale, Cleveland, Greenville, Greenwood, Indianola, and Leland, Mississippi.

Presently, authorized freeboard in the Memphis District is two feet, whereas freeboard in the Vicksburg District is three feet. It is believed that a uniform freeboard of three feet should be authorized throughout the length of the levee. The new Project Flood flowline is lower than the 1941 flowline by 2.2 feet at Memphis, Tennessee, one foot at Helena, Arkansas, 4.4 feet at Arkansas City, Arkansas, and 2.5 feet at the Vicksburg, Mississippi, canal gage. In addition, the levee top in both Districts is generally above the net grade; in the Memphis District, the top of levee is two feet above the present authorized grade throughout most of its length. An inspection of the flowline and levee top profiles has indicated that the proposed increase in freeboard authorization will necessitate very little, if any, construction work.

6. Main Stem and Backwater Features-Vicksburg District

6.1. MVK System #41-Yazoo Backwater – Yazoo River Right Bank

The Yazoo Backwater Levee System is located in west Mississippi in portions of Warren, Issaquena, Sharkey, Yazoo, Humphries, and LeFlore Counties. The Yazoo Backwater Levee System consists of two segments, the Yazoo Backwater Levee and the Whittington Right Bank Levee protecting approximately 1,550 square miles of land lying between the east bank Mississippi River Levee and the Yazoo Backwater Levee System. The Yazoo Backwater Levee

ties into the lower end of Mississippi River Levee near Eagle Lake and ties to high ground near Morgan City, Louisiana. The area is subject to flooding from the Mississippi River backwater, which can enter the area by overtopping the lower portion of the Yazoo Backwater Levee. It can also receive floodwaters from headwater flooding of the Yazoo River. Levee heights vary from 10 to 26 feet.

The Yazoo Backwater Levee provides protection from Mississippi River backwater to most of the area between the Mississippi River Levee and the hills extending from the latitude of Belzoni to Vicksburg, Mississippi. For a backwater levee grade of 107.0 feet, the entire area that could be affected by backwater flooding is approximately 1,860 square miles. The entire population of the area according to the NLD is approximately 41,900 persons.

The protection of the backwater area was proposed in House Document No. 359, 77th c., 1st s. (the 1941 review report). A principle enunciated was that the levee should not be carried to such grades as to add to the height of floods that would otherwise reach to within three feet of the mainline levee grade. Thus at a time when the grade being considered for the west bank Mississippi River Levee was three feet above the 1927 flood, this report recommended a grade of one foot below the flowline of a flood equal to 1927 confined under existing main river channel conditions with the Yazoo backwater not leveed. Subsequently, other backwater areas have been given or authorized protection greater than what elevation would be afforded by the 107.0-foot grade. In view of the fact that the grade of the west bank Mississippi River Levee is now set at one foot above the Project Flood, recommending of a higher grade for the backwater· levee has been under consideration for some time. It was recommended that the backwater levee grade be set two feet below the Project Flood flowline contingent upon the provision of three feet freeboard for the mainline levees.

6.2. MVK System #1-Arkansas – Louisiana Mississippi River (South Bank Arkansas River Levee and West Bank Mississippi River Levee to MVN District Line)

The discussions of the subject levees have been combined under one title because these levees protect the same area. The South Bank Arkansas River Levee begins at Pine Bluff, Arkansas, and ends at the junction with the Mississippi River Levee at a point 12 miles above Arkansas City, Arkansas. It is 85.5 miles long and all construction has been completed. The approved grade from Pine Bluff, Arkansas, to a point opposite the lower end of the north bank levee near Gillette, Arkansas, was designed to provide a 4-foot freeboard above the flowline for 813,000 cfs (1927 flood in Arkansas River) meeting a 1927-confined flood in the Mississippi River. For this levee, the existing grade provides from five to six feet of freeboard over the new Project Flood flowline, which is for 813,000 cfs, meeting the Project Flood flowline in the Mississippi River.

From the vicinity of Gillette to Yancopin, Arkansas, along the Arkansas River, the Mississippi River Project Flood flowline criteria controls the levee design grade due to the Mississippi River design flowline producing a backwater up the Arkansas River greater than the design flowline on the Arkansas River. This levee grade was designed to provide 3-foot of freeboard over the 813,000 cfs Arkansas River flood meeting a 1927-confined flood on the Mississippi River, or a 1-foot freeboard over the 813,000 cfs Arkansas River flood. Except for two short reaches where the 1931 adjusted levee grade is higher than that which would be provided by the above criteria, and a short transition provided below the end of the north bank levee as a tie-in between the 4-

foot and 3-foot freeboards, the recommended freeboard is three feet above the Mississippi River design flowline. The typical approved levee section is 1V on 4H riverside, 10-foot crown, and 1V on 5.5H landside. The average height of the levee is 23 feet.

The West Bank Mississippi River Levee, from Station 0+00, its junction with the South Bank Arkansas River Levee, extends to the New Orleans District line near Black Hawk, Louisiana.; a length of 274.3 miles. Of this distance, 165.3 miles are complete to grade and section, 22.5 miles are under contract, and 86.5 miles remain to be completed. The authorized freeboard is three feet above the Project Flood flowline. The recommended freeboard is three feet above the new design flowline. The new flowline is lower than the old by 4.4 feet at Arkansas City, Arkansas, 1.6 feet at the Vicksburg, Mississippi, bridge, 2.8 feet at Natchez, Mississippi, and 2.0 feet at Red River Landing. Most of the remaining sections to be raised are deficient in grade by an average of 2 to 3 feet.

The typical net levee section is lV on 4H riverside, 10-foot crown, and lV on 5.5H or 6H landside, depending on levee height. The average height of levee above natural ground is approximately 30 feet. To increase the levee height further would require the construction in some locations of stability berms or the flattening of riverside slopes, to prevent foundation failures.

The subject levees protect the Tensas Basin against the Project Flood. The protected area comprises 6,855 square miles based on data from the NLD. The population within the basin is approximately 233,122 persons based on the NLD. Principal towns of over 2,500 population are DeRiver Mileott, Dumas, Eudora and McGee, in Arkansas and Bastrop, Ferriday, Lake Providence, Monroe, Rayville, Tallulah, and Winnsboro, in Louisiana.

6.3. MVK System #22-Red River Backwater Louisiana

This levee, also known as the Tensas-Cocodrie Levee, begins at a junction with the Mississippi River West Bank Levee at approximate levee station 10470+65 near Black Hawk, Louisiana, and forms a loop, extending to high ground near the upper end of Lake St. John. It is 93.1 miles long. The levee contains two major drainage structures, the Bayou Cocodrie Floodgate and the Tensas-Cocodrie drainage structure and Pump Station. The Bayou Cocodrie Floodgate is a gated structure of the reinforced concrete box type, having five barrels 10-foot by 15-foot. The Tensas-Cocodrie structure is a gated structure of the reinforced concrete box type, having three barrels 10-foot by 12-foot and five pumps that has a total capacity of 4,000 cfs.

The levee has been constructed with fuseplug sections to control overtopping of the levee in certain areas. The fuseplug levee grade at the lower end of the Tensas-Cocodrie Levee is elevation 59.8 NGVD. The total length of the Tensas-Cocodrie Levee system is 93.1 miles, of which 36.8 miles is a fuseplug section. Approximately 17.9 miles of the fuseplug have been raised to the 1973 design grade (61.3 NGVD) while the remaining 18.9 miles is at elevation 59.8 NGVD.

A break at the upper end of the levee under maximum headwater conditions would result in greater damage than a break at the lower end. However, due to the fuseplug grade at the lower end, there exists a differential of freeboard, which is believed to be adequate.

From the floodgate to Hilson Landing, about nine miles upstream from Pullen Landing, the levee section is 1V on 4H riverside, 10-foot crown, and 1V on 5.5H landside. From Hilson Landing to the upper end of the levee the landside slope is 1V on 4H, 10-foot crown, and the riverside slope is 1V on 3H. The levee is complete. The levee height is greater at the lower end than at the upper end. The average height is 10 feet.

Based on the NLD, the leveed area provides protection to approximately 587 square miles and 20,000 persons. Towns in the protected area are Clayton, Vidalia, and Ferriday, Louisiana. Clayton, Vidalia, and all but a small portion of Ferriday are above the flood of record.

7. Main Stem and Backwater Features-New Orleans District

7.1. MVN System #15-Mississippi River West Bank – Above Old River (MVK District Line to Torras, Louisiana)

This is New Orleans District LSER System #15 Mississippi River West Bank – Above Old River. This levee includes the Fifth Louisiana and Atchafalaya Levee Districts and includes the Old River Control works (the Overbank Structure, the Low Sill Structure, the Auxiliary Structure, and Old River Lock). The levee begins at Black Hawk, Louisiana, at the terminus of the Red River Backwater Levee and extends across Old River to a junction with the Pointe Coupee Loop Levee. It is 16.6 miles long, including levees constructed under the Old River Project and including the Old River Crossing. The levee will function as a part of the project for Old River Control. The levee is built to the 1947 code section except at Old River Crossing downstream of Old River Lock. The authorized freeboard is three feet above the 1973 Refined Project Flood flowline. The height of the levee varies from 14 to 35 feet, with an average of 20 feet. The levees between Blackhawk and Torras were enlarged to the authorized design grade and section in the late 1970's. Plans are being prepared to raise the levees in areas where they have settled below the authorized design grade. In addition to the Old River Complex, the Sidney A. Murray Hydropower Facility was constructed in the early 1990's just upriver of the Old River Overbank Structure.

7.2. MVN System #23-Mississippi River West Bank – Above Morganza (Pointe Coupee Loop Levee)

This is New Orleans District LSER System #23 Mississippi River West Bank – Above Morganza. The Pointe Coupee Loop Levee includes the Mississippi River West Bank Levee from Torras, Louisiana, to the Morganza Upper Guide Levee; the Morganza Upper Guide Levee to the East Atchafalaya River Levee; the East Atchafalaya River Levee from the junction upstream to the junction with the Old River Levee at Barbe Landing (also called Three Rivers); and the Old River South Bank Levee to Torras, Louisiana. The loop is located within the parish of Pointe Coupee and protects several small rural communities in the area that is also known as the Upper Pointe Coupee Loop.

The West Bank Mississippi River Levee from Torras to the Morganza Upper Guide Levee is 18.2 miles long, including that part of the Morganza Floodway forebay levee, which now functions as a mainline Mississippi River Levee. The entire levee is complete to the 1947-code

section. The authorized freeboard is three feet above Project Flood. The levee height varies from 12 to 30 feet tall with 1V on 5.5H landside slopes and 1V on 4H riverside slopes. West Bank Mississippi River Levees were designed and built following USACE guidelines to a greater protection level than the present 1% annual chance exceedance flood.

The Morganza Floodway Upper Guide Levee from the structure embankment to the junction with the East Atchafalaya River Levee is about 8.9 miles long. The authorized freeboard is two feet above the Project Flood flowline through the floodway. The typical section is floodway side, 1V on 3.5H; 20-foot crown; and 1V on 5H landside slope. There are berms on the protected and floodway side. The interior area inside of the Pointe Coupee Upper Loop is drained by the Pointe Coupee Drainage Structure which is situated along the reach of the Pointe Coupee Upper Loop Levee that is exposed to Morganza Floodway stages and the Pointe Coupee Pumping Station that is situated along the reach of the Pointe Coupee Upper Loop levee that is exposed to Atchafalaya River stages. The gates of the Pointe Coupee Drainage Structure are open at all times and only closed in the event that the Morganza Spillway is operated. The Pointe Coupee Drainage Structure was completed in March 1942 and the Pointe Coupee Pumping Station was completed in August 1983.

The East Atchafalaya River Levee from the junction with the Upper Guide Levee near Red Cross, Louisiana, to Barbe Landing, Louisiana, is 24.8 miles long. The authorized freeboard is three feet above the Project Flood flowline. This section of the Atchafalaya River Levee is not intended to be overtopped under any conditions. The height of the levee varies between 10 and 30 feet.

The levee along the south bank of Old River between Barbe Landing and Torras is 4.1 miles long. The authorized freeboard is three feet above the Project Flood flowline. The height of the levee varies between 9 and 17 feet and averages 15 feet.

The afore-described levees protect and completely enclose the lands on the right bank of the Mississippi River in Pointe Coupee Parish, Louisiana. The area aggregates about 124 square miles, consisting of 67 square miles of cleared lands and 57 square miles of woodlands. There are no towns, but there are several small settlements comprised of a post office, a store, and a few homes.

The economy of the region is almost totally dependent upon agricultural production. Since the area is completely enclosed by levees, a levee break at any location would cause pooling to extreme depths resulting in severe damage and extreme hazard to life. This unusual condition warrants a degree of protection comparable to that normally provided in areas where developments other than agriculture are extensive.

7.3. MVN System #50-West Atchafalaya Floodway (Including Fuseplug Levee and part of System #16-West of Atchafalaya Basin)

This is New Orleans District LSER Systems #50 West Atchafalaya Floodway and part of #16 West of Atchafalaya Basin. Because the fuseplug levee across the head of the West Atchafalaya is contiguous with the river levee and protects the same area from the same waters, it will be

included in the following discussion. These levees begin at Hamburg, Louisiana; extend to Simmesport, Louisiana, and from thence along the west bank of the Atchafalaya River to Butte LaRose, Louisiana. The back levees for the Simmesport, Melville, and Krotz Springs Ring levees are included below.

The river and fuseplug levees have more in common than the fact that they protect the same area, as will be demonstrated by the following. Public Law No. 678, 74th Congress, approved June 15, 1936, Section 10, reads in part as follows: "… The fuseplug levees at the head of the Atchafalaya Basin on the west side shall be constructed to the 1914 grade and 1928 section …." The same Act authorized the purchase of flowage easements over lands and properties in the floodway west of the Atchafalaya River and lying above the approximate latitude of Krotz Springs. Paragraph 7 of the Flowage Easement Option used in the West Atchafalaya Floodway reads in part as follows: "The flowage easement referred to in 1 above will perpetually grant to the United States the right of unimpeded overflow of lands and improvements described above by the overtopping or the natural or artificial breaking of the levee or levees protecting said lands whenever the elevation of water surface at the head of said floodway exceeds the 1914 grade authorized for the fuseplug levee at head of said floodway by Public Law No.678, 74th Congress, approved June 15, 1936, and also whenever the water surface in the Atchafalaya River shall rise above the top of the levee along the west bank of the Atchafalaya River as said levee now stands or it may in the future be reconstructed or repaired by or with the approval of the United States….".

Since the West Atchafalaya River Levee is included in the foregoing, the question of freeboard, in the sense being considered in this report, does not arise. It is believed that in order to achieve the full intended use of the West Floodway, it will be necessary for portions of the West Atchafalaya River Levee to be overtopped or breached. The changing condition of the Atchafalaya River will necessitate review of the grades along the river levee but is not properly a matter for consideration here. The levee and areas protected by it, however, will be described as matters of general interest and in order to make this report more complete.

The West Atchafalaya River Levee is 67.6 miles long exclusive of the back levees at Simmesport, Melville, and Krotz Springs and includes the Teche-Vermillion Pump Station located in St. Landry Parish 1 mile upstream of Krotz Springs, Louisiana, on the west batture of the Atchafalaya River. The pump station conveys water across the West Atchafalaya Basin Floodway to a gated structure in the West Atchafalaya Basin Protection Levee to pass the water for distribution downstream to provide supplementary fresh water to the surrounding areas. The fuseplug levee was intended to be overtopped for the Project Flood. The river levee from Simmesport, Louisiana, to the head of Whiskey Bay Pilot Channel is authorized to have no freeboard above the Project Flood except at the Simmesport, Melville and Krotz Springs ring levees. Because of uncertainty as to the exact division of water that would pass into the areas east of the Atchafalaya River, the Atchafalaya River channel, and west of the Atchafalaya River, the project prescribed that the Atchafalaya River levees should remain at their existing heights. The extension of the river levee below the head of Whiskey Bay Pilot Channel to below Butte La Rose, Louisiana, is authorized to have a grade to confine a flow of 1,000,000 cfs supplied by the river and Morganza Floodway. The Simmesport and Melville ring and river levees are authorized to have three feet of freeboard above the Project Flood. The Krotz Springs river levee

is authorized to have three feet freeboard over the Project Flood; the back levee is to have two feet freeboard over 600,000 cfs through the West Floodway, with project flow in the basin. The approved cross section for the fuseplug is the 1947 code section with 1V on 4H landside slopes and 1V on 4H floodside slopes; for the Atchafalaya River Levee, it is 1V on 4H landside, 1V on 3H riverside, and 10-foot crown; for the Butte La Rose extension levee, it is 1V on 4H both sides, and a 10-foot crown.

7.4. MVN System #20-Simmesport Ring Area

This is New Orleans District LSER System #20 Simmesport Ring Area. The Simmesport Ring Levee consists of 3.46 miles of earthen levee (1.6 miles from the Simmesport Ring and the remainder from Bayou Des Glaises) and the Brushy Bayou Drainage Structure located in Simmesport, Louisiana. The levees typically range from 15 to 20 feet tall with 1V on 4H landside slopes and 1V on 3H floodside slopes.

Brushy Bayou Drainage Structure is located in the ring levee which surrounds the Town of Simmesport, Avoyelles Parish, Louisiana, at the junction of Bayou des Glaises and the Atchafalaya River. The gate structure is designed to give protection against floodwaters while providing for the flow of Brushy Bayou through the levee during low water periods. This structure provides Simmesport with a controlled drainage outlet through the ring levee that protects it from floodwaters during the operation of the West Atchafalaya Floodway.

7.5. MVN System #21-Melville Ring Area

This is New Orleans District LSER System #21 Melville Ring Area. The Melville Ring Levee consists of 5.7 miles of earthen levee (4 miles from the Melville Ring and the remainder from the West Atchafalaya River Levee), two interior drainage structures (each with one sluice gate) known as Melville Drainage Structure (South) and Melville Drainage Structure (North) and 72 feet of I-wall located in Melville, Louisiana. The system segment surrounds Melville, Simmesport, in St. Landry Parish, Louisiana, which is located at the intersection of LA-10 and LA-105. The eastern portion of the system segment runs between the west bank of the Atchafalaya River and LA-105. The Melville Ring Levee contains earthen levees that typically range from 15 to 20 feet tall with 1V on 4H landside slopes and 1V on 4H floodside slopes (Melville Ring Levee Enlargement, Geotechnical Report June 2002).

Melville Ring Drainage Structures. The interior area inside of the Melville Ring Levee is drained by the two Melville Ring Drainage Structures, which are situated along the reach of the Melville Ring Levee that is exposed to West Atchafalaya Floodway stages. The gates of these structures remain open except during the operation of the West Atchafalaya Basin Floodway and during occurrence of a 1% rainfall event within the West Atchafalaya Floodway.

7.6. MVN System #22-Krotz Springs Ring Area

This is New Orleans District LSER System #22 Krotz Springs Ring Area. The Krotz Springs Ring Levee is approximately 2.7 miles long, has no floodwall, and includes one drainage structure located in Krotz Springs, Louisiana. The system segment surrounds Krotz Springs, Louisiana and begins at the Missouri Pacific Railroad, west of Krotz Springs. The system segment runs north from the railroad, crosses US-190, continues northeast to the Atchafalaya

River, then runs southeast between the river and LA-105 until it ends at the Missouri Pacific Railroad, east of Krotz Springs.

Krotz Springs Drainage Structure. The interior area inside of the Krotz Springs Ring Levee is drained by the Krotz Springs Drainage Structure, which is situated along the reach of the Krotz Springs Ring Levee that is exposed to West Atchafalaya Floodway stages. The gate of that structure remains open during occurrence of a 1% rainfall event within the West Atchafalaya Floodway but will be closed during an operation of the West Atchafalaya Basin Floodway. The levees vary in height from 4 to 18 feet. The West Atchafalaya River Levee protects the lands in the West Atchafalaya Floodway from the Bayou des Glaises fuseplug levee down to near Krotz Springs. In the event the Project Flood should occur, the fuseplug levee from Simmesport to Hamburg would be overtopped or breached in order to pass a part of the flood through the West Floodway. The area aggregates about 235 square miles with the only towns being Melville, Simmesport, and Krotz Springs, Louisiana. Levees around these towns tie in to the Atchafalaya River levee for protection in the event the floodway is placed in use. The Federal Government holds flowage rights on all of these lands, except within the levee enclosing Simmesport and Melville.

7.7. MVN Systems #17-Wax Lake West Area, #18 Bayou Sale Area, and part of #16 West Atchafalaya Basin

This is New Orleans District LSER Systems #17 Wax Lake West Area, #18 Bayou Sale Area, and part of #16 West Atchafalaya Basin. This levee extends from the Mansura Hills to Hamburg, thence to the Wax Lake Outlet, and thence to a point below Berwick, Louisiana. The length of the levee is 149.1 miles and includes less than 1 mile of floodwall, Teche-Vermilion Conveyance Channel Control Structure, Bayou D'Arbonne Drainage Structure, Bayou Courtableau Control Structure, and Henderson Lake Control Structure. The West Atchafalaya Basin is part of the Atchafalaya Basin Floodway System and is authorized by the Flood Control Act approved 15 May 1928.

The Flood Control Acts authorized construction of a floodway through the Atchafalaya River Basin for excess floodwaters diverted from the Mississippi River at the latitude of Old River and through the Morganza Floodway to pass to the Gulf of Mexico. Above Krotz Springs the authorized grade is sufficiently high to confine a flow of 600,000 cfs through the West Floodway. The levee below the latitude of Krotz Springs was to provide a 2-foot freeboard over the Project Flood of 1,500,000 cfs through the basin. Essentially the entire system has been constructed to the original project grade, which is no longer adequate in the middle and lower reaches because of deterioration in the flow carrying capacity of the floodway.

From below Berwick the levee extends westward along the north bank of the Intracoastal Waterway to Wax Lake Outlet thence to Bayou Sale Ridge a distance of 19 miles, and is designed to protect against the combined effect of storm tides and Project Flood. A 2-foot freeboard is provided for this levee. Discontinuous and secondary levee systems for the same purpose along Bayou Sale and Teche Ridge, aggregating, 41.5 miles, are designed with a 1-foot freeboard.

The major drainage structures located in this levee, described as follows:

The Bordelonville Floodgate is located in the Bayou des Glaises loop south of Bordelonville. This structure was built by the State of Louisiana. The gates are closed during high stages in the Red River backwater area. The structure is a reinforced concrete floodgate approximately 150 feet long with two steel lift gates over 30-foot by 11-foot openings. Gates are counterbalanced and lifted mechanically.

The Bayou Darbonne Structure is a reinforced concrete box culvert 10-foot by 10-foot by 265 feet long, with a manually controlled gate, located where the West Atchafalaya Basin Protection Levee crosses Bayou Darbonne. With the gate open, it permits no real flow from the West Atchafalaya Floodway to reach Bayou Teche through Bayou Courtableau and thereby provides water frequently needed for irrigation purposes. With the gate closed, it protects lands west of the protection levee from floodwaters.

The Courtableau Drainage Structure is located approximately two miles southeast of the village of Courtableau in the West Atchafalaya Basin Protection Levee. The structure is a 335-foot long reinforced concrete structure having five 10-foot by 15-foot openings with steel gates operated by manual or motorized lifts. The structure is designed to divert a portion of the excess intercepted drainage flow through the West Protection Levee into the West Floodway.

The Charenton Floodgate, located in the West Atchafalaya Basin Protection Levee, about one mile north of Charenton, Louisiana, is a reinforced concrete structure 175 feet long with a clear width of 45 feet, a bottom elevation of 10.0 feet below mean sea level, with steel sector gates. It provides a navigation connection between Grand Lake and the West Atchafalaya Basin Protection Levee borrow pit and Charenton drainage canal. It is also used to regulate flood flows between Bayou Teche and the Atchafalaya Basin Floodway. A removable bridge across the structure has a low steel elevation of 20.7 feet mean sea level.

The East and West Calumet Floodgates are located in the east and west Wax Lake Outlet guide levees where the levees cross Bayou Teche. Each floodgate is a reinforced concrete structure 161 feet long with a 45-feet clear width and a sill elevation of 9.8 feet below mean sea level and is equipped with steel sector gates. The floodgates will provide for navigation in Bayou Teche, and to some extent, will regulate flood flows.

The Teche-Vermilion Conveyance Channel Control Structure is approximately 1 mile north of Bayou Darbonne Drainage Structure. The structure consists of two 10-foot x 10-foot reinforced concrete box culverts 310 feet long, including one monolith with an operating tower and vertical list gate. The control structure is operated and maintained by the Teche-Vermilion Fresh Water District.

The Bayou Darbonne Drainage Structure is a reinforced concrete box culvert 10-foot x 10-foot x 265 feet long, with a manually controlled gate, located where the West Atchafalaya Basic Protection Levee crosses Bayou Darbonne. With the gate open, it permits no real flow from the West Atchafalaya Floodway to reach Bayou Teche through Bayou Courtableau and thereby provides water frequently needed for irrigation purposes. With the gate closed, it protects lands west of the protection levees from floodwaters.

The Bayou Courtableau Control Structure is located approximately 2 miles southeast of the village of Courtableau in the West Atchafalaya Basin Protection Levee. The structure is a 335 feet long reinforced concrete structure having five 10-foot x 15-foot openings with steel gates operated by manual or motorized lifts. The structure is designed to divert a portion of the excess intercepted drainage flow through the West Protection Levee into the West Floodway.

I-walls—there are five locations shown in Table 7-1 of approximately 2,500 feet of I-walls identified in the system alignment.

Table 7-1
Floodwall Locations

Structure	Identifier
Bordelonville Floodgate Cutoff Structure	*
Missouri Pacific Floodwall	1165+59 to 1166+20
I-10 Floodwall	2747+98 to 2752+16
W68 Floodwall	3594+95 to 3610+31
W74 Floodwall	3940+84 to 3941+86

*The channel has been completely filled-in and there is approximately 400 linear feet of 4-feet high wall across the former channel location.

The subject levee protects the alluvial lands west of the West Atchafalaya Basin Protection Levee, in all or parts of Rapides, Avoyelles, Evangeline, St. Landry, Lafayette, St. Martin, Iberia, and St. Mary Parishes, Louisiana, from the south bank of Red River at a point about 10 miles below Alexandria to the Gulf Intracoastal Waterway. The area is bounded on the west by the hills west of LeCompte and by a line continuing in a southerly direction slightly east of Opelousas, Lafayette, New Iberia, and Jeanerette and then in a southerly direction to West Cote Blanche Bay. The area aggregates 1,619 square miles. Franklin, Bunkie, and St. Martinville, Louisiana, are the largest towns with 15 smaller towns in the area. Improvements include seven railroads, three Federal highways, numerous state and parish roads, and the Gulf Intracoastal Waterway. There are numerous oil and gas fields, pipelines and associated installations. A sugar refinery is located at Franklin, Louisiana, and sugar mills are located along Bayou Teche. A break in the upper end of the levee would overflow a major portion of the area. A break at any point downstream would overflow a lesser area and would result in less damage.

The levee height varies from 7 to 25 feet with 1V on 4H landside slopes and 1V on 4H floodside slopes. The levee could be increased in height without difficulty between Hamburg and Palmetto. Below Palmetto, however, an increase in height would cause undue expense due to foundation difficulties. In addition, it is considered that an increase in the height of this levee should be accompanied by an increase of cross section.

Drainage of the areas on the protected side of this levee system is provided by a network of streams, as well as by borrow pits and other intercepted drainage channels that were constructed when this levee system was constructed. All of these streams and channels carry drainage flows parallel to, or away from, this levee system. The exception to these drainage patterns consists of drainage through the Courtableau and Darbonne Drainage Structures near US Highway 190, which can convey drainage from the protected side of this levee system to the floodside by gravity only when the tailwater stages (within the West Atchafalaya Floodway) are lower than the headwater stages on the protected side of these structures.

7.8. MVN System #51-Morganza Floodway (East Atchafalaya River Levee below Morganza Floodway Upper Guide Levee)

This is New Orleans District LSER System #51 Morganza Floodway. This levee begins at the intersection with the Morganza Floodway Upper Guide Levee near the Point Coupee Pumping Station and ends at Atchafalaya River Mile 52.5. It is 26.2 miles long. During no real high river stages, i.e., floods not large enough to require the operation of Morganza Floodway, the levee protects from high stages on the Atchafalaya River. The authorized freeboard is three feet above the 1986 refined flowline without the Avoca Island Extension Levee. The MR&T authorized design levee section is a 1V on 3H riverside slope, a 10-foot wide crown, and a 1V on 4H landside slope. The height of the levee varies between 9 and 22 feet. Foundation subsidence has not been a major cause of difficulty.

This levee protects the alluvial lands within the Morganza Floodway between it and the East Atchafalaya Basin Protection levee. The area aggregates about 103 square miles, with no towns. The Federal Government holds flowage rights over all of these lands.

7.9. MVN System #55-Terrebonne Basin and part of #25-Mississippi River West Bank-Below Morganza (East Atchafalaya Basin Protection Levee (EABPL))

This is New Orleans District LSER Systems #55 Terrebonne Basin and part of #25 Mississippi River West Bank – Below Morganza. This levee begins at Morganza Structure embankment and ends at Cutoff Bayou (below Morgan City, Louisiana.); it is 107.5 miles long. The approved levee section is 1V on 3.5H floodway side, 1V on 4H landside, with 20-foot crown width. The levees were designed and built following USACE criteria. The riverside slopes were designed at a 1V on 4H. The landside slopes were designed at a 1V on 4H, with many sections having landside berms designed at 1V on 15H. There are sections of the project that contain sheet pile I-wall and T-wall. The original authorization for freeboard contemplated that the East Guide levee would have one-foot superiority over the river levees. The present authorized freeboard is two feet above the Project Flood of 600,000 cfs in the Morganza Floodway as a component of 1,500,000 cfs in the basin. Levee construction has been designed with a net grade of two feet above the 1986 Project Flood flowline without the Avoca Island Extension Levee. Essentially the entire system has been constructed to the original project grade which is no longer adequate in the middle reach because of deterioration of flow conditions.

The East Atchafalaya Basin Protection Levee functions together with the East Atchafalaya River Levee and the West Atchafalaya Basin Protection Levee. These levees form a basin between them that directs water south toward the Gulf of Mexico during a major flood event. At the

north end of the basin is the Morganza Control Structure. When opened, the structure passes water from the Mississippi River into the basin between the EABPL and the East Atchafalaya River Levee, where the water continues to flow to the south. The northern end of the EABPL generally is not touched by water from the Atchafalaya River. The East Atchafalaya River Levee, which is to the west of the protection levee, prevents water from the Atchafalaya River from reaching the EABPL. The East Atchafalaya River Levee tapers out and ends at the town of Sherburne, Louisiana, south of Highway 190. At that point, backwater from the Atchafalaya River can come into the basin between the East Atchafalaya River Levee and the EABPL and it may flow south along the EABPL beginning around the town of Maringouin, Louisiana. In this way, the Morganza Floodway and the Atchafalaya Basin can relieve stage flooding from the Mississippi River and reduce flooding downstream in New Orleans, Louisiana. The last major flood event occurred in 1973. Since that time, floodwaters had not impacted the EABPL, until the high water event of May 2011 with the opening of the Morganza Spillway. The levee has been enlarged through various contracts, mostly during the 1980s, after the 1973 flood. The Morganza Floodway had not been used since the 1973 flood event, until the high water event of May 2011.
The levee height varies between 12 and 28 feet. Maintaining the authorized freeboard is difficult in this reach. To increase the freeboard would require an increase in base width, the construction of berms, and in some places borrow pit refill or possibly relocation of the levee.
The Atchafalaya Basin Levee District's portion of the EABPL in the Terrebonne Basin is roughly 24.8 miles in length and is located in Iberia and St Martin Parishes. This portion of the system is composed of approximately 17.2 miles (2.3 miles in Iberia Parish and 14.9 miles in St. Martin Parish) of sheet pile driven though the top of an earthen levee in order to achieve needed height. There are approximately 7.6 miles of earthen levee (3.5 miles in Iberia Parish and 4.1 miles in St Martin Parish) and no structures other than the occasional gate in the sheet pile for access to the floodside. It is maintained by the Atchafalaya Basin Levee District.

St. Mary Parish's portion of the EABPL segment in the Terrebonne Basin is approximately 7.3 miles in length and is located on the Avoca Island Levee in St Mary Parish. This portion of the system is primarily composed of sheetpile driven though the top of a small earthen levee in order to achieve needed height with 2 miles being just earthen levee. There are no structures in this portion of the system. This section of the system is officially the responsibility of St. Mary Parish government but maintenance responsibility has been delegated to the new St. Mary Levee District.

The City of Morgan City's stretch of the system is composed of two noncontiguous sections, both within St. Mary Parish near Morgan City. The northern segment is approximately 1.65 miles long and is composed entirely of sheet pile driven though the top of an earthen levee in order to achieve needed height. It runs from the St. Mary/St. Martin Parish line on the EABPL to a point on the EABPL adjacent to the local Morgan City Ring Levee. There are no structures other than the occasional gate through the sheet pile. .The southern segment runs from the intersection of the EABPL and the railroad track to the Bayou Bouef Lock. This segment is approximately 2.4 miles long and is composed of 2 miles of floodwall and sheet pile driven though the top of a small earthen levee and 0.4 miles of earthen levee. The only structure is the Bayou Bouef Lock located on the eastern most end of this segment. It is maintained by Morgan City.

Terrebonne Levee District's section of the system is approximately 6.8 miles in length and is located on the Avoca Island Levee in Terrebonne Parish. This portion of the system is primarily earthen levee, however, about 4.2 miles of this portion of the system is composed of sheet pile driven though the top of a small earthen levee in order to achieve needed height. There are no other structures in this portion of the system.

The EABPL protects the alluvial lands in parts or all of the parishes of Pointe Coupee, West Baton Rouge, Iberville, Assumption, Ascension, Lafourche, St. Mary, and Terrebonne Parishes, Louisiana. In addition, it protects between this levee and the West Mississippi River levee from Morganza to Donaldsonville and thence between the EABPL and the ridges of Bayous Lafourche, Terrebonne, La Carpe, and Grand Caillou on down to the Gulf of Mexico. The area aggregates about 1,719 square miles. This same area is leveed by the West Bank Mississippi River Levee from Morganza to Donaldsonville, Louisiana. Houma and Morgan City are the two largest cities with 17 smaller towns or communities in the area.

7.10. MVN Systems #26-Mississippi River West Bank-Lafourche Basin, #52-Westwego/Harvey/Algiers Polder, #10-Belle Chasse Polder, #11-Oakville to City Price Polder, #12-St. Jude to Venice Polder and part of #25-Mississippi River West Bank – Below Morganza (West Bank Mississippi River Levee between Morganza Floodway and the Gulf of Mexico)

This is New Orleans District LSER Systems #26 Mississippi River West Bank – Lafourche Basin, #52 Westwego/Harvey/Algiers Polder, #10 Belle Chasse Polder, #11 Oakville to City Price Polder, #12 St. Jude to Venice Polder and part of #25 Mississippi River West Bank – Below Morganza. The portion of this levee, 172.4 miles long, between Morganza, Louisiana, and New Orleans, will be discussed first. In this distance the authorized freeboard is three feet above the Project Flood between Morganza and Plaquemine, Louisiana, increasing to four feet at River Mile 157; increasing to 4.9 feet at River Mile 128; increasing to 5.7 feet River Mile 104; remaining at 5.7 feet to River Mile 95.5; decreasing to 5.0 feet at River Mile 95.9; decreasing to 4.7 feet at River Mile 91.5; decreasing to 4.0 feet at River Mile 82.5 and remaining at 4.0 feet to River Mile 46.3 where the New Orleans to Venice Hurricane Protection (NOVHP) System takes over from St. Jude to Venice.

West Bank Mississippi River Levees were designed and built following USACE guidelines to a greater protection level than the present 1% annual chance exceedance flood. The height of the levee varies between 12 and 33 feet above the base with 1V on 5.5H landside slopes and 1V on 4H riverside slopes.

Major structures include:

Port Allen Lock. This is a navigation lock located at the Mississippi River that connects the Mississippi River to the Gulf Intracoastal Waterway (GIWW) in Louisiana, located at River Mile 228.5 Above Head of Passes (AHP).

Davis Pond Freshwater Diversion Structure. This is a diversion structure located at River Mile 118.5 AHP.

Harvey Lock. This is a feature of the GIWW. The lock is located at the junction of the Harvey Canal and the Mississippi River, approximately 98 miles AHP. The lock serves as a flood control structure during periods of high water in the Mississippi.

Algiers Lock. This is a feature of the Algiers Canal. The lock is located at the junction of the Algiers Canal and the Mississippi River, approximately 88 miles AHP. The lock serves as a flood control structure during periods of high water in the Mississippi.

Empire Lock.

Floodwalls include:

Table 7.2
Floodwall Locations

Structure	Identifier
Waggaman & Bridge City FW	WB 105-107
Algiers FW	WB RIVER MILE 95.5
Algiers FW	WB RIVER MILE 94.7
Westwego FW	WB RIVER MILE 102-102.4
Westwego FW	WB RIVER MILE 101.6-102
Waggaman FW	WB RIVER MILE 108-109
Avondale Lv	WB RIVER MILE 107-108
Gretna Lv	WB RIVER MILE 99-100
Gretna Lv	WB RIVER MILE 98.1-99
Gretna Lv	WB RIVER MILE 97-98.1
Gretna Lv	WB RIVER MILE 96-97
Gretna Lv	WB RIVER MILE 95.5-96

When the Mississippi River reaches a stage of 11.0 feet on the Carrollton gage (New Orleans) and is rising, flood fight procedures must be activated. When the river stage at Carrollton reaches 15.0 feet and further increases are forecast, the Corps of Engineers will enter Phase II Mobilization. Conditions on the southern reach of the Mississippi River during the 2011 flood event within the New Orleans District were controlled by two structures, the Bonnet Carré Spillway and the Morganza Floodway. The Morganza Floodway controls water levels from just north of Baton Rouge down to New Orleans, while the Bonnet Carré controls the water from New Orleans to the mouth of the river. A portion of the Mississippi River flood flows are diverted to the Atchafalaya Basin at the Old River Control Complex and at the Morganza Control Structure. Governed by a 3,900-foot long and a 125-bay intake structure, the Morganza

Floodway is designed to divert 600,000 cfs from the Mississippi River during the PDF. The Morganza Floodway is operated when the Mississippi River flows below Morganza are projected to exceed 1,500,000 cfs; thereby assuring that flows between Morganza and Bonnet Carré remain at or below 1,500,000 cfs. During the 2011 flood, sites on the Atchafalaya River and Basin within the New Orleans District experienced high water stages that required emergency response flood fight activities. The Morganza Floodway was opened on 14 May 2011 and by 18 May 2011 had seventeen (17) gates open. The crest at Red River Landing reached 63.4 feet on 18 May 2011 and was sustained until 20 May 2011. The Morganza Floodway was completely closed by 7 July 2011. The Bonnet Carre Spillway was opened on 9 May 2011 when the crest at the Carrollton gage reached 16.8 feet. 330 bays out of 350 bays were opened. By 20 June 2011 the Bonnet Carre Spillway was closed.

The portion of the levee within Orleans Parish is 13.6 miles long. The authorized freeboard is five feet at the upstream end and four feet at the downstream end. About nine miles are at or above authorized grade. Built by local interest, the typical existing levee section is 1V on 3H riverside slope, 10-foot crown, and 1V on 4H landside slope. This levee was incorporated into the MR&T Project by the Flood Control Act of 17 May 1950. The levee heights vary between 10 and 20 feet. Foundation subsidence has not been a major cause of difficulty but has occurred locally, requiring a second lift after several years; foundation conditions will not be discussed further because it is not anticipated that it will be found desirable to increase the freeboard in this reach.

The portion of the levee from the Orleans-Plaquemine Parish line downstream to the end near Venice, Louisiana, is 71.9 miles in length. The authorized freeboard above the Project Flood is four feet. The typical existing section is 1V on 3H riverside slope, 10-foot crown, and 1V on 4H landside slope. The levee heights vary from 6 to 15 feet. The subsurface soils are a complex deltaic deposit consisting predominantly of silts inter-bedded with a considerable amount of very soft highly organic clay and with local zones and layers of sand and silty sand. In some places, highly organic very soft clays are encountered within 5 to 15 feet of the surface and are underlain by sand and silts. The highly organic soils have low shear strength and are very compressible. Foundation subsidence has been a major cause of difficulty.

The MRL portion of the MR&T Project East Bank levee alignments between River Mile 70 (Eastern Tie-In) – 119 (Western Tie-In at Davis Pond Diversion Structure) on the West Bank are coincident with the Hurricane Storm Damage Risk Reduction System (HSDRRS) and consist of an integral component of the system perimeter. The MR&T Project was authorized by Congress and designed to reduce the risk of flood damage from high river flows. Recent hydraulic modeling revealed that the HSDRRS authorized grade exceeds that of the MR&T Project between River Mile 70-85.5 on the west bank of the MRL. River Mile 85.5 on the MRL west bank is commonly referred to as the MRL "crossover" point. Therefore, the MRL between River Mile 70-85.5 is now operating under the dual authority of West Bank and Vicinity (WBV) and MR&T. River Mile 70-85.5 MRL West Bank alignment is commonly referred to as "MRL co-located" and used MR&T and WBV funding to construct the required 1% hurricane grade (and section) as part of the HSDRRS construction effort. The remaining MRL coincident reaches (within HSDRRS limits, i.e. River Mile 85.5-119 west bank) operate under traditional MR&T authorization and the associated major maintenance aspect of that program. Furthermore, as the

MRL hurricane "crossover" point migrates upriver due to regional subsidence and sea level rise trends that have been documented over the past 50 years, the amount of MRL alignment with dual authority will increase over time. The current crossover point where HSDRRS and MR&T governing authorities meet is River Mile 85.5 on the West Bank MRL.

The West Bank MRL (WBMRL) from River Mile 47.1 south to River Mile 10.0 is also part of the St. Jude to Venice ring levee located in Plaquemines Parish. The ring levee system has two major components that connect to each other at the north and south end of the system encircling the leveed area. The first is WBMRL, and the second is the Back/Hurricane Levee on the western populated edge of Plaquemines Parish along the Gulf of Mexico. The WBMRL was raised to hurricane grades starting in 1987 after the "New Orleans to Venice, Louisiana, West Bank Mississippi River Levee City Price to Venice, Louisiana, General Design Memorandum No. 1, Supplement No. 6" was approved by the Lower Mississippi River Division on 23 October 1987. This reach of the MRL serves the dual purpose of providing risk reduction from both riverine flooding and hurricane surge flooding.
The afore-described levees, extending from Morganza to Venice, Louisiana, protect the alluvial lands on the right bank of the Mississippi River in all or part of Pointe Coupee, West Baton Rouge, Iberville, Assumption, St. Mary, Terrebonne, Ascension, St. James, St. John the Baptist, Lafourche, St. Charles, Jefferson, Orleans, and Plaquemine Parishes, Louisiana, from Morganza to Venice, south of the Mississippi River levee and east of the East Atchafalaya Basin Protection Levee down to the marsh fringe on the Gulf of Mexico. The area aggregates about 4,125 square miles, cities are Algiers (New Orleans west bank), Gretna, Houma, and Morgan City. There are 25 smaller towns and communities within the area.

Improvements include five railroads, three Federal highways, numerous state and parish roads, seven Mississippi River Bridges and two railroad bridges crossing the river (Baton Rouge and Jefferson Parish), and the GIWW, and alternate waterway to Plaquemine and Port Allen. Extensive industrial and residential developments are concentrated from near Westwego to Algiers. Industry is also located at Port Allen, Luling, Ama, Avondale, Belle Chasse, and Port Sulphur. Numerous sugar mills are located along the Mississippi River and along Bayou Lafourche. There are over fifty oil and gas fields, numerous petrochemical plants, chemical plants, the Waterford Three nuclear power plant, other power plants, grain elevators, pipe lines and associated equipment scattered throughout the area.

The raising of the Mississippi River levees since the 1973 flood has caused an accelerated development of industry along the banks of the river. Permit applications for the construction of new industries have more than doubled. The agriculture of the region is extensively developed and it is anticipated that industrial development will be extensive in the future along the levee from Baton Rouge to and below New Orleans.

A break in this levee at any point from Morganza to Donaldsonville would overflow the area between the Mississippi River and the East Atchafalaya Basin Protection Levee and would be mostly confined on the east by the high alluvial ridges of Bayou Lafourche, Bayou Terrebonne, Bayou La Carpe, and Bayou Grand Caillou on down to the Gulf of Mexico. A break at the upper end near Morganza would result in more overflow and greater damage than at any point further downstream. A break in the levee at any point below Donaldsonville would overflow all or part

of the right bank area to the east of the ridges of Bayous Lafourche, Terrebonne, La Carpe, and Grand Caillou. There would be less area of overflow from a break at any point downstream than there would be from a break near Donaldsonville. A break in the area from Killona (River Mile 130) to Oakville(River Mile 70) would probably result in greater damage than at any other location because of the complex of industrial, residential and military development in this reach of river.

7.11. MVN System #1-Mississippi River East Bank (Baton Rouge to Bonnet Carré Spillway)

This is New Orleans District LSER System #1 Mississippi River East Bank. The Mississippi River East Bank, New Orleans to Baton Rouge Levee System, is located in East Baton Rouge, Iberville, Ascension, St. James, Saint John the Baptist, and a portion of St. Charles Parishes, Louisiana, and provides flood risk reduction on the east bank of the Lower Mississippi River. It consists of the Bonne Carré Spillway, the northern guide levee and the mainline MRL from the Bonne Carré Spillway to Baton Rouge, Louisiana. The guide levee extends approximately 5.8 miles eastward from the northern end of the Bonne Carré Spillway to Lake Pontchartrain. The portion of this system that forms the mainline MRL extends from the northern end of the Bonne Carré Spillway approximately 100 miles northward to Baton Rouge, Louisiana, where it terminates into high ground.

The leveed area for flood control, MRL East Bank, is bounded along the east bank of the Mississippi River by the Metro Council of Baton Rouge Levee, Pontchartrain Levee District Levee and the Bonnet Carré Upper Guide Levee.

The MR&T Project levee system follows its own unique design, which is included in the Code for Utilization of Soils Data for Levees, Mississippi River Commission, Vicksburg, Mississippi, dated April 1947. The design levee section required in this document consists of a 10-foot crown width, a riverside slope of 1V on 4H and a landside slope of 1V on 5.5H with semi-compacted levee embankments less than 25 feet in height. The levees in this system adhere to the design parameters presented in this design document except in relatively short reaches where existing development dictated slightly steeper slopes.

Since relatively impervious materials were utilized for levee embankment construction, only the after construction case is applicable for slope stability analysis in the subject system where the approved design section was followed. The levees were found to be stable for the after construction case. In areas where levee embankment slopes are steeper than the design section due to development constraints, the levee embankments were also analyzed for the steady seepage case and found to be stable.

The area aggregates about 951 square miles, with the largest city being Baton Rouge. It is estimated that roughly 20 percent of Baton Rouge would be subject to flooding without the MRL. Major towns are Reserve, LaPlace, Lutcher, Garyville, Gonzales, Convent, Gramercy, and Remy. Improvements include three railroads, two Federal highways, numerous state and parish roads, numerous important industrial developments which include petroleum, chemical and aluminum plants between Baton Rouge and Laplace; electrical power generating stations at

St. Gabriel and Montz; oil refineries in Burnside and Reserve; a new steel mill under construction in Convent; sugar refineries at Lutcher, Gramercy, and Reserve; and Louisiana State University in Baton Rouge. There are oil and/or gas fields and numerous pipelines within the area. Recent developments (permit applications) show a substantial acceleration of industrial development along the river with the present protection. The abundance of fresh water, deep-water navigation, rail service, and natural resources make the area attractive to industry. These advantages have worked toward overcoming reluctance to locate behind levees.

The East Bank Mississippi River Levee, Baton Rouge to Bonnet Carré Spillway has experienced multiple high water events since 1928. High water events in 1937, 1973, and in 2011 approximated the 1% event. During high water events, conditions on the Mississippi River within the New Orleans District are controlled by five Structures, the Overbank Structure, the Old River Low Sill Structure, the Old River Auxiliary Structure, known as the Old River Complex; the Morganza Floodway, and the Bonnet Carré Spillway. The Old River Complex and the Morganza Floodway controls water levels from north of Baton Rouge down to the Bonnet Carré Spillway, while the Bonnet Carré Spillway controls water levels from New Orleans to the mouth of the river. A portion of the Mississippi River flood flows are diverted to the Atchafalaya Basin at the Old River Control Structure and at the Morganza Control Structure. During the 2011 event all available spillways and backwater areas except the West Atchafalaya Floodway were activated. Bonnet Carré Spillway was opened on 9 May 2011 and by 15 May 2011 330 bays were opened. The crest at Carrollton Gauge Reached 17 feet (gauge height) on the 11 May 2011 and was sustained until 27 May 2011, with a maximum crest elevation of 17.4 feet on 19 May 2011.

There has not been a breach of a mainline MR&T Levee since the flood of 1927. A written history of that flood indicates that a breach within this system would probably widen quickly with floodwaters entering the protected area at a fast pace. However, the Mississippi River is a large river system and major rises in stages can be forecast days in advance. In addition, this levee system is patrolled by the levee owners and the Corps of Engineers during high water events. It is very likely that a levee failure or overtopping would be predicted early and emergency construction/repairs could be made and evacuations could be started.

For any levee failure there will be an impacts on floodplain residents, businesses, transportation systems, and other critical infrastructure systems. The East Bank Mississippi River Levee, Baton Rouge to Bonnet Carré Spillway system provides flood protection for approximately 584 square miles of primarily urban, suburban, and industrial land. The MRL provides flood protection from a PDF for residents and structures in East Baton Rouge, Iberville, Ascension, St. James, St. John the Baptist and St. Charles Parishes. The largest city located within the leveed area is Baton Rouge, the state capital.

7.12. MVN System #56-New Orleans East Bank

This is part of New Orleans District LSER System #56 along the east bank of the Mississippi River from the Bonnet Carre' Spillway to the Orleans Parish line in the St. Charles/Jefferson/Orleans Metro Polder. This levee is 23.9 miles long. The authorized freeboard is 4.9 feet above the Project Flood at the Bonnet Carré Spillway, increasing to 5.7 feet

at New Orleans. The typical existing section is 1V on 4H riverside slope, 10-foot crown width, and a 1V on 5H landside slope. The levee varies in height from 11 to 22 feet.

The MR&T Project MRL alignments between River Mile 81-127 on the East Bank is coincident with the HSDRRS and consists of an integral component of the system perimeter. The reach of this levee along the Lake Pontchartrain and Vicinity has a higher profile for the river flooding than is required for hurricane surges.

Notably, there are implications with regard to funding of future levee system evaluations for HSDRRS, which would have to be determined based on system components that fall within major maintenance (MRL) and those that do not (LPV, WBV, SELA). Furthermore, as the MRL hurricane "crossover" point migrates upriver due to regional subsidence and sea level rise trends that have been documented over the past 50 years, the amount of MRL alignment with dual authority will increase over time and may eventually include portions of the east bank MRL that is currently coincident with the HSDRRS. The current crossover point where HSDRRS and MR&T governing authorities meet is River Mile 77.3 on the East Bank MRL.
This levee protects all the lands along the left descending bank of the Mississippi River, within St. Charles and Jefferson Parishes, Louisiana, from the lower Bonnet Carré Spillway levee to the Orleans Parish line out to the south shore of Lake Pontchartrain. The area aggregates about 61 square miles most of which is urban. Towns and unincorporated settlements include Norco, Goodhope, Kenner, Destrehan, St. Rose, Jefferson Heights, Harahan, River Ridge, and Metairie.

Improvements include two Federal highways, two bridges crossing the Mississippi River, the approach road to the Lake Pontchartrain Causeway, the Louie Armstrong International Airport, two oil refineries and chemical plant at Norco, oil refineries or tank farms at Destrehan and St. Rose, miscellaneous industrial establishments from Kenner on down to the Orleans Parish line and the large residential and commercial sections which include Metairie, Destrehan, St. Rose, Norco, Kenner, River Ridge, Harahan, and Jefferson Heights.

A break anywhere in this levee would cause flooding of a major portion of the area due to the confining influence of railroads, highways, and the St. Charles Parish hurricane protection levee, north of Airline Highway. A break anywhere in the levee would cause serious damage since it is highly developed.

Localities where foreshore is narrow require, and generally have, wavewash protection. The floodside slope of the river levee is protected from wavewash erosion by concrete slope pavement. The slope pavement is contiguous except for small reaches in Jefferson Parish where the batture is wide and high enough to prevent wind and ship driven waves from damaging the levee during high river stages.

This is part of New Orleans District LSER System #56 within the St. Charles/Jefferson/Orleans Metro Polder and St. Bernard Polder. This levee protects, from Mississippi River floods, the City of New Orleans. The authorized freeboard is 5.7 feet at the Jefferson/Orleans Parish line and 4.7 feet at the Orleans/St. Bernard Parish line. The earthen levee section extends from the Jefferson/Orleans Parish line (River Mile 104) to just upstream of the Nashville Avenue wharf, approximate River Mile 101. From there to the Inner Harbor Navigation Channel (IHNC) west

forebay levee, the flood protection consists of an unbroken line of floodwalls (I-Type and T-Type) with floodgate openings for vehicular, rail and pedestrian traffic. The earthen levee picks up again at the IHNC westside forebay levee and ties into the riverside gates of the IHNC Lock. The earthen levee picks up again along the IHNC eastside forebay levee and continues to the floodwall at the Alabo Street wharf, approximate River Mile 92. The earthen levee picks up again at the downstream end of the Alabo Street Floodwall, approximate River Mile 91.9 and continues to the Orleans/St. Bernard Parish line, River Mile 91.5. The earthen section consists of a 1V on 3H floodside slope, a 10-foot crown width and a 1V on 4H landside slope. The first floodwall, the Dumaine Street Floodwall, was constructed in 1951. The remaining floodwalls were constructed between 1975 and 1985.

This is part of New Orleans District LSER System #56 along the east bank of the Mississippi River below New Orleans in the St. Bernard Polder. The east bank levee below New Orleans is composed of two levee districts. The Lake Borgne Levee District extends from the Orleans-St. Bernard Parish line, approximate River Mile 91.5, to the St. Bernard/Plaquemines Parish approximate River Mile 81.6. The Grand Prairie Levee District extends from the St. Bernard/Plaquemines Parish line to Bohemia, Louisiana (River Mile 44).

The Lake Borgne Levee District. The authorized freeboard above the 1973 Refined Project Flowline in the Lake Borgne Levee District is 4.7 feet at River Mile 91.5 to 4 feet at River Mile 81.6. The authorized freeboard in the Grand Prairie Levee District is 4 feet. The typical net levee cross section is riverside slope, 1V on 3H, a 10-foot crown width, and 1V on 4H landside slope. The levee is 8 to 16 feet high.

This levee protects the lands on the left descending bank of the Mississippi River in parts of St. Bernard and Plaquemine Parishes, Louisiana, out to the shore of Lake Borgne to Shell Beach and then on a southerly line down to Bohemia. The area aggregates about 322 square miles. There are no incorporated towns. The communities of Chalmette and Arabi just below the Orleans Parish line are the largest. Other small communities are Violet, Poydras, St. Bernard, and Point-a-la-Hache. Improvements include the large aluminum works, three oil refineries, other industrial works, and river port facilities in and around Chalmette and Arabi. The major portion of the improved farm lands below Chalmette are devoted to truck crop production and considerable acreage in orange groves. Both sport and commercial fishing and other seafood development exist in the marsh streams and bordering waters. Numerous oil and gas fields and pipelines are located within the area. The upper portion of this area has experienced a considerable expansion of industry and residential developments. It has the same general natural advantages of the area in St. Charles and Jefferson Parishes above New Orleans and would be expected to develop at an accelerated rate with the present high degree of protection. A break in the levee at the upper end of this area would cause much greater damage than at any point downstream because the upper area is much more highly developed. The back levees situated about a mile back of the mainline levee in the reaches from the Orleans Parish Line to Poydras and from Point-a-la-Hache to a point about 13 miles upstream would tend to impound water to considerable depth if the mainline levee was to break within these reaches. In the reach between those two, there are no back levees and floodwaters from a break would run off into the marsh and would not overflow an extensive area of improved land. A levee break in the upper section described above would cause much more damage than one in the lower section.

7.13. MVN System #6-Caernarvon to Phoenix Polder

This is New Orleans District LSER System #6 Caernarvon to Phoenix. The Caernarvon to Phoenix Levee System was authorized by the MR&T Project. The Caernarvon to Phoenix Levee System consists of approximately 22 miles of earthen levee along the Mississippi River and the Caernarvon Freshwater Diversion Structure at Braithwaite, Louisiana. The system does not have any floodwalls along the alignment, except tie-in floodwalls at the freshwater diversion structure.

The Caernarvon Freshwater Diversion Structure is located south of New Orleans, Louisiana, along the east bank of the Mississippi River at Braithwaite, Louisiana, approximate River Mile 87.5 AHP. The purpose of the project is to divert freshwater from the Mississippi River to combat saltwater intrusion and to introduce nutrients and a small amount of sediments to the marsh areas. The diversion structure consists of five types of concrete monoliths: six inflow monoliths, one sluice gated monolith, eight box culvert monoliths, one downstream bulkhead monolith, and four outflow wing walls. Flow through the structure is regulated by five positive seating sluice gates. An approximate 255 linear foot inflow channel conveys water to the structure and an approximate 7,690 linear foot outflow channel convey water to the ponding area. The Caernarvon Freshwater Diversion Structure was operable by 1991. The Louisiana Department of Natural Resources (LDNR) is the sole responsible agency for operation and maintenance. The Office of Coastal Protection and Restoration (OCPR) is a part of LDNR. The interior area of the Caernarvon to Phoenix System is drained by three pumping stations and a drainage control structure. The drainage control structure at Braithwaite was built to provide drainage during non-flood events. The related pumping stations are required to maintain pre-project conditions within the protected areas.

7.14. MVN System #7-Phoenix to Bohemia Polder

This is New Orleans District LSER System #7 Phoenix to Bohemia. The Phoenix to Bohemia Levee System was authorized by the MR&T Project. The system was also authorized by the New Orleans to Venice (NOV) Project. The NOV Project was authorized in the Flood Control Act of 1962 (Public Law 87-874) as the Mississippi River Delta and below New Orleans, Louisiana, Flood Control Project. The project subsequently became known as the NOV Hurricane Protection Project. The reach of NOV levee between Phoenix and Bohemia is known as NOV Reach C. This includes approximately 16 miles of existing, Federal back levees on the east bank from Phoenix to Bohemia for hurricane risk reduction purposes. The project is authorized to provide a 50-year (2%) level of risk reduction (LORR).

The Phoenix to Bohemia Levee System consists of two levees, the MRL from approximate River Mile 44 to River Mile 59, which is part of MR&T Project, and the HSDRRS Levee (Back Levee or Reach C) from Station 0+00.00 to Station 834+68.40. Additionally, the system includes two pump stations, one at Bellevue (Station 241+77) and the other at East Pointe a la Hache (Station 551+38). Approximately 31 miles of levee enclose an area of nearly 4,500 acres from Phoenix to Bohemia in Plaquemines Parish, Louisiana. The area is largely rural with a few industrial facilities that have operational lines that cross over, under, or through the levee. The MRL and back levee have different configurations and purposes. The MRL is designed with the constraint

that it could have high water for an extended period on an annual basis whereas the NOV back levee is designed for high water from short duration tropical events.

The Bellevue and the East Point a la Hache pumping stations include provisions for protection from design hurricane tides. A continuous protective system is provided by the floodwalls between the discharge basins and the adjacent levees; the discharge basin sidewalls; and the backwalls of the discharge basins. The critical structure loadings resulting from design hurricane-induced stage differentials are transmitted from the discharge basin backwalls through longitudinal shear walls and ultimately distributed to all the structural components of the pumping stations. Therefore, essentially the entire pumping station is used to resist these loads.

The interior area of the Phoenix to Bohemia System is drained by various drains, two pumping stations and a drainage control structure. The drainage structures were built to provide drainage during non-flood events. The related pumping stations are required to maintain pre-project conditions within the protected areas.

8. Major Tributary Features

Numerous tributary levees were authorized under the MR&T Project and required evaluation for FEMA certification. A brief description is provided below of the larger tributary systems in the MR&T Project.

8.1. St. Francis River Levees

The St. Francis Floodway Levee System was constructed as part of the St. Francis Basin Project, which is a portion of the MR&T Project. The Flood Control Act (FCA) of 15 May 1928 as amended by the Acts of 15 June 1936, 18 August 1941, 24 July 1946, 17 May 1950, 27 October 1965, and 13 August 1968 provide for the construction, enlargement, and strengthening of the levees of the St. Francis Basin Project in order to safely pass the floodwaters of the St. Francis River and its tributaries into the Mississippi River.

The West Bank St. Francis Floodway Levee System is 118 miles long and extends from the Union Pacific Railroad immediately south of town of St. Francis, Arkansas to the confluence of Straight Slough Ditch near Wynne, Arkansas. West bank drainage in the basin enters the floodway through a series of sleeve levees. Sleeve levees are essentially parallel to the mainline levees and are designed to contain high water events by allowing floodway water to back up between the levees without causing damages. The parallel sleeve levees have openings for interior drainage to enter the floodway but are extended far enough upstream to protect adjacent lands. Primarily agricultural lands between Crowley's Ridge and the levee system are afforded protection from St. Francis Floodways highwater conditions.

The East Bank St. Francis Floodway Levee System, which ties into the Big Lake Floodway West Levee System, is more extensive than the West Bank St. Francis Floodway System. The East Bank St. Francis Floodway levees provide flood risk reduction from the waters of the St. Francis River. The Big Lake Floodway West levees provide flood risk reduction from the waters of the

Little River as they flow through the Big Lake Floodway. Together, this 111.5-mile system is called the East Bank St. Francis Floodway to Big lake Floodway West Levee System.

The East Bank St. Francis Floodway Levees make up 77.5 miles of the system and extend from high ground in the vicinity of St. Francis, Missouri, to the vicinity of Rivervale, Arkansas, where they join with the Big Lake Floodway West Levees. The Big Lake Floodway West Levees make up approximately 34 miles of the system and extend from high ground at Hornersville, Missouri, to the vicinity of Rivervale, Arkansas.

Another levee system provides flood risk reduction to a single area located east of the Big Lake Floodway and the St. Francis River Floodway in northeastern Arkansas. The Big Lake and St. Francis River East Levee System contains approximately 120 miles of levee. This system begins as a sleeve levee near Blytheville, Arkansas, and extends to the confluence of the St. Francis River with the Mississippi River in Lee County, Arkansas. The northern portion of this system provides flood risk reduction from the waters of the Little River as they pass through the Big Lake Floodway. The southern portion provides flood risk reduction from the waters of the St. Francis River and from backwater flooding from the Mississippi River and ties into the St. Francis River Backwater Levee. Parts of Mississippi, Craighead, Crittenden, Cross, St. Francis and Lee Counties in Arkansas, are protected from this levee system.

Levees in the lower St. Francis Floodway are designed to accommodate levee design flows, with are estimated to be equivalent to the 1% annual chance exceedance flood based on the recent statistical analysis. As mentioned previously, at the lower end of this floodway system, a fuseplug allows Mississippi River backwater to inundate the area. This inundated area can be evacuated by use of the Huxtable Pump Station, when deemed appropriate. The total population and homes protected by this is approximately 29,787 and the 16,187, respectively. An estimated property damage total of $2.4 million could occur if the area was inundated.

8.2. North Bank Arkansas River Levee

This levee extends from the vicinity of Tucker, Arkansas, to near Gillette, Arkansas. This is a length of 54.9 miles, of which 49.6 miles have been completed to grade and section. An additional 5.3 miles were authorized, but there are no plans to construct the remaining section of levee. Levee grades on the north bank are based on those of the opposite south bank. They were obtained by projection from the south bank grade and are three feet lower. The effect was to provide a one-foot freeboard over the design flow of 813,000 cfs (1927 flood in the Arkansas River) meeting a 1927 confined flood in the Mississippi River.

The typical approved net levee section is landside slope 1V on 4H, a 10-foot crown width, and riverside slope 1V on 5.5H. The average height of levee is 13.5 feet. Major drainage structures in the levee are the Flat Bayou Drainage Structure (Station 640+38), consisting of three 8-foot by 8-foot concrete culverts with manually operated gates; the Little Bayou Meto Floodgate, consisting of two 12-foot by 32-foot concrete culverts with manually operated gates; and the Big Bayou Meto Floodgate, consisting of three 24-foot by 32-foot concrete culverts with power operated gates. This levee furnishes protection against the project flood to approximately 371 square miles of highly productive farmlands, communities, a railroad, pipelines, highways, and

other improvements. The leveed area protects approximately 3,000 persons, based on the NLD. There are no major cities or towns within the protected area.

8.3. South Bank Red River Levees

The project levees along the south bank of Red River begin at Hot Wells, Louisiana, and end at Moncla. This is a length of 60 miles. The levee has been completed to grade and, except for minor deficiencies, to code cross section. Several areas along the southern portion of the levee have reported seepage during high water events and plans and specifications are being prepared for seepage berms and relief wells. From Hot Wells to Alexandria, the authorized freeboard is 4 feet, and below Alexandria is 3 feet. The levee height varies from nine to 23 feet. The cross section has a landside slope, 1V on 5.5H, 10-foot crown width, and riverside slope of 1V on 4H.

The levee contains the Bayou Rapides Pumping Plant and Drainage Structure. It is located at the outlet of Bayou Rapides, adjacent to Rapides Regional Hospital, on the southwest bank of the Red River in Rapides Parish within the City of Alexandria, Louisiana. The Pumping Plant consists of an approach channel, gated structure, conventional wet-pit sump intakes for each of the two vertical axial-flow pumps, and over-the-levee discharge piping which includes vacuum breaker valves. Each pump has a capacity of 111 cfs at 5.5 feet of static head per pump. The station has a total capacity of 222 cfs. Each of the pumps is driven by a vertical shaft electric motor rated at 350 HP at 507 RPM. The pump motors are located outdoors adjacent to the drainage channel. The controls and electrical switchgear are housed in the pump station's masonry control house. The Drainage Structure consists of four electrically operated 10-foot x 12-foot sluice gates. Red River, Atchafalaya, and Bayou Boeuf Levee District is responsible for operating the sluice gates.

This levee protects the alluvial lands south of Red River and west of the West Atchafalaya Basin Protection Levee, in all or parts of Rapides, Avoyelles, Evangeline, St. Landry, Lafayette, St. Martin, Iberia, and St. Mary Parishes, Louisiana, from Hot Wells, Louisiana, to the GIWW. The area is bounded on the west by the hills from Hot Wells to near Opelousas and by the alluvial ridge along Bayou Teche. The total area probably would not be flooded by a great flood if the levee were to fail; however, flooding of the lower areas would be extensive and the entire area would sustain either direct or indirect damages. The area aggregates approximately 1,739 square miles. Towns with populations greater than 4,000 are Alexandria, Franklin, Bunkie, and St. Martinville. There are fifteen other towns ranging in population from 277 to 2,500. Improvements include two railroad stations, four Federal highways, numerous state and parish roads, the GIWW, and three military bases. There are 188 oil and gas facilities 1,320 oil and gas pipelines and associated installations. A sugar refinery is located at Franklin and sugar mills are located along Bayou Teche. No acceleration of development in this area would be anticipated because of providing a higher degree of protection. The presently approved levee freeboards of 4 feet above and 3 feet below Alexandria are believed to be adequate.

8.4. Tributary Summary

Table 8-1 shows all the tributaries authorized in the MR&T Project that were analyzed in a LSER.

Table 8-1
Tributary Levee Systems

System #	District	System Name	River	Levee Miles
14	Memphis	Elk Chute Levee System	St. Francis River	22.8
11	Memphis	St. Francis East to Big Lake West	St. Francis River	112.9
12	Memphis	Big Lake and St. Francis River East System	St. Francis River	119.4
10	Memphis	West Bank St. Francis River**	St. Francis River	117.9
58	New Orleans	Butte La Rose Floodway	Atchafalaya/Mississippi	11.4
17	New Orleans	Wax Lake West Area	Atchafalaya/Surge	62
18	New Orleans	Bayou Sale	Atchafalaya/Surge	17.4
59	New Orleans	Morgan City Ring Area	Atchafalaya	14.5*
24	New Orleans	Wax Lake East	Atchafalaya	30.8
55	New Orleans	Terrebonne Basin	Atchafalaya	43.7
16	New Orleans	West of Atchafalaya Basin	Atchafalaya	160.73
20	New Orleans	Simmesport Ring	Atchafalaya	3.46
21	New Orleans	Melville	Atchafalaya	5.67
22	New Orleans	Krotz Springs	Atchafalaya	4.34
50	New Orleans	West of Atchafalaya Floodway	Atchafalaya	63.79
24	Vicksburg	Whittington Aux South MS	Yazoo River	28
31	Vicksburg	Rocky Bayou Area	O'Neal Ck	4
50	Vicksburg	Hillside Floodway South MS	Fannegusha CK	3
49	Vicksburg	Hillside Floodway North MS	Fannegusha CK	11
45	Vicksburg	Ascalmore-Tippo North MS	Ascalmore Ck	6
44	Vicksburg	Ascalmore-Tippo South MS	Ascalmore Ck	6
46	Vicksburg	Teoc Creek North	Teoc Ck	3
7 & 11	Vicksburg	Coldwater River	Coldwater River	25
23	Vicksburg	Jonesville to Larto Lake	Black River	70
516	Vicksburg	Lower Red River South Bank Alexandria, LA	Red River	59
22	Vicksburg	Red River Backwater	Black River	93
19	Vicksburg	Yazoo Levees LB South MS	Yazoo River	11
29	Vicksburg	Yazoo Levees LB Central MS	Yazoo River	17
20	Vicksburg	Sataria Area	Yazoo River	20
40	Vicksburg	Pelucia Creek South	Pelucia Ck	11
48	Vicksburg	Greenwood MS East	Yazoo River	28
12	Vicksburg	Greenwood MS West	Yazoo River	7
32	Vicksburg	Vicksburg Protection Works	Yazoo River	2
17	Vicksburg	Ouachita River – East Bank	Ouachita River	96
47	Vicksburg	Big Sand, Yalobusha, Teoc Creek	Yalobusha River	16
33	Vicksburg	West Monroe – Ouachita River	Ouachita River	7
57	Vicksburg	Jonesville Protection Works	Black River	5

43	Vicksburg	Panola-Quitment MS	Panola-Quitman Floodway	25
41	Vicksburg	Yazoo Backwater –Yazoo River RB	Yazoo River	93

9. Field Inspection Process

9.1. Routine Inspections

A major component of the NFIP levee system evaluation is determining if the system O&M is adequate enough to ensure that the overall integrity and functionality of the levee system is maintained during the base flood event or 1% annual chance exceedance flood. As stated earlier, the Corps of Engineers has major maintenance responsibility on the MR&T Project levees and structures. Public sponsors are responsible for minor maintenance on the MR&T Project and the inspections are conducted to ensure this occurs. The Corps remains aware of activities along this levee system through technical review of permits as well as through our annual inspections. These inspections are executed under the Inspection of Completed Works (ICW) program for the Corps of Engineers.

The MR&T Levees are operated, maintained and inspected in accordance with the "*Levee Owner's Manual (LOM) for Non-Federal Flood Control Works*", March 2006. Annual O&M inspections are performed by each respective MVD district within their geographical boundaries and presented in an Annual Levee Inspection Report.

As stated above, each sponsor for the MR&T Levee system has officially adopted the LOM detailing specific actions and procedures. The manual includes information such as frequency of O&M activities, provisions for routine inspections (with no more than one year between inspections), and assignments of responsibility for the activities. The intent of the document is to provide the public sponsor of a flood control system, with some clear and comprehensive guidance on the O&M of levees, floodwalls, and other flood risk management structures. Another purpose of this manual is to clearly explain the minimum requirements that the Corps has established in an effort to ensure the system will perform satisfactory during a flood event; not just the 1% annual chance exceedance flood. USACE will verify that the basic requirements are met through routine inspections. Properly maintained systems will remain active in the Rehabilitation and Inspection Program (RIP) and remain eligible for rehabilitation assistance after a flood. These inspections are not intended to be a burden but to help identify potential problems and properly maintain the levee system.

9.2. Periodic Inspections

In 2008, Periodic Inspections were mandated by the USACE Levee Safety Program for all the levees. The purpose of a Periodic Inspection is to verify proper O&M; evaluate operational adequacy and structural stability; identify features to monitor over time; and improve the ability to communicate the overall condition. The inspection team should be comprised of multi-disciplinary personnel familiar with the safety and engineering aspects of levee performance. Inspections will be performed on federally operated and maintained levee

systems and federally authorized, non-federally operated and maintained levee systems on a 5-year interval.

9.3. NFIP Levee System Evaluation Field Inspection

An NFIP levee system evaluation field inspection will be an on-the-ground field visit to be conducted by an appropriately staffed and equipped team prior to the technical analysis based on EC 1110-2-6067. The inspection team should be comprised of the full range of disciplines. Previous routine inspection reports may not be substituted for a NFIP levee system evaluation field inspection but certainly could guide the focus or areas of concern. Periodic Inspections reports may be used to fulfill the inspection requirement if planned in advanced or if the Periodic Inspection has been conducted no more than twelve months prior to the start of the NFIP levee system evaluation. If a previous Periodic Inspection report is to be used, then a site-visit will be conducted and documented to ensure no changes in field conditions have occurred since the inspection was conducted. Part of the field inspection could confirm deficiencies or reveal repairs that have been completed on required maintenance items. However, the main purpose of the inspection is to collect pertinent information to support the NFIP levee system evaluation or identify the areas that need further analysis. The NFIP field inspection is very similar to a Periodic Inspection except that additional data is collected and a technical analysis is conducted using that data.

The field inspection should consider all aspects of the levee system's capability for providing reasonable assurance of excluding the 1% annual chance exceedance flood from the leveed area, including upstream watershed changes that may affect the levee system. Inspections and performance together can provide a better indicator of performance assurance as opposed to technical analysis.

10. Performance History

A very important piece of information for NFIP levee system evaluation is knowledge of how a levee segment has or will perform during the occurrence of a major event. In most cases, routine, periodic, and the NFIP inspections are not conducted when the system is under a flood load and therefore performance indicators are not available.

During the 2011 flood, the MR&T Project levees withstood an event that was estimated to exceed the 1% annual exceedance flood event throughout the system. See Table 10.1 for the observed peak river stages in 2011. Levee performance was assessed using flood fighting records, other written accounts of flood performance and from interviews with witnesses having first-hand experience during the flood event. Although sound engineering analysis is a primary element of the levee evaluation report, supplementing the technical findings with performance results provides sufficient assurance that the MR&T Project levee system will provide protection against floods equivalent to the 1% event.

Table 10.1
2011 Mississippi & Atchafalaya River Stages

Station	Flood Stage	Stage	Date	Prior Record Stage	Record Year
Cairo, IL	40.0	***61.72**	**2 May**	59.51	1937
New Madrid, MO	34.0	***48.35**	**6 May**	47.97	1937
Caruthersville, MO	32.0	***47.61**	**7 May**	46.00	1937
Memphis, TN	34.0	47.87	10 May	48.70	1937
Helena, AR	44.0	56.59	12 May	60.21	1937
Arkansas City, AR	37.0	53.14	16 May	59.20	1927
Greenville, MS	48.0	64.22	17 May	65.4	1927
Vicksburg, MS	43.0	***57.1**	**19 May**	56.20*	1937
Natchez, MS	48.0	***61.95**	**19 May**	58.04	1937
Red River Lndg, LA	48.0	***63.09**	**21 May**	61.61	1997
Baton Rouge, LA	35.0	45.01	18 May	47.28	1927
New Orleans, LA	17.0**	17.0	14 May	21.27	1922
Simmesport, LA	47.0	44.94	23 May	59.13	1927
Butte LaRose, LA	25.0	23.15	26 May	27.28	1973
Morgan City, LA	4.0	10.35	30 May	10.53	1973

*2011 new record stages are shown in bold.

11. EC 1110-2-6067 Technical Evaluations

11.1. System Evaluation

As emphasized earlier, the objective of the NFIP levee system evaluation is to verify that the levee system performs as an integrated set of features and components functioning individually and collectively to provide a reasonable assurance that the 1% annual chance exceedance flood will be excluded from the leveed area. The focus is thus upon the levee system that is associated with a given separable floodplain (or separable consequence area in an extensive floodplain). The term ‘system’ as used herein is inclusive of all components, and associated interfaces and interactions among components, that are necessary to ensure flood risk reduction of the

associated floodplain levee sections, closure structures, pumping stations, culverts, interior drainage works, any other works or components not necessarily designed/built as components of the flood system and system O&M.

As stated earlier, the MR&T Project levee system is so massive and complex, completion of the LSER's required a joint effort between Memphis, Vicksburg, and the New Orleans Districts of MVD using a multi- disciplinary analysis. In some instances, for example, the system may include components such as high ground areas, road and railroad embankments, bridge abutments, navigation walls and channels, etc., and the system analysis must ensure that these components also meet design guidelines. Note that some reaches of MR&T Project levee systems can be determined to be found in accordance with NFIP levee system evaluation requirements because the associated floodplains (or consequence areas in an extensive floodplain) are sufficiently separable as to be unaffected by performance of other reaches of the levee system. In such circumstances, several of the MR&T Project levee systems can be considered separate systems.

11.2. Hydrology and Hydraulics-Riverine and Coastal Environments Evaluation

The 1 % annual exceedance probability chance flood event is used for the hydrologic and hydraulic technical evaluation of levee performance. According to EC 1110-2-6067, probability of exceedance and uncertainty analysis of levee containment is required for NFIP levee system evaluation of all new and existing riverine, coastal/estuarine, and lake levees. The method includes a probabilistic assessment of water levels and waves as well as their uncertainty for the present conditions.

The probability of exceedance and uncertainty analysis procedure for riverine levees or floodwalls) is described in Chapters 4 and 5 of EM 1110-2-1619, *Risk- Based Analysis for Flood Damage Reduction Studies*. For riverine levees or floodwalls, the analysis will usually include the uncertainty in the discharge-probability function and in the stage-discharge function.

To meet NFIP levee system evaluation requirements, a levee must have at least a 90% assurance of excluding the 1% annual chance exceedance flood for all reaches of the system. For levees (and floodwalls), if top of levee elevation is less than the FEMA required freeboard, which is generally 3 feet, above the 1% annual chance exceedance flood stage, then the levee can only be in accordance with NFIP levee system evaluation requirements if the assurance (CNP) is 95% or greater. Top of levee elevation shall not be less than two feet above the 1% annual chance exceedance flood elevation, even if assurance is 95% or greater.

Once overtopping assurance or conditional non-exceedance probability (CNP) is determined, the levee will fall into one of three categories: 1) assurance is less than 90%: levee cannot be found in accordance with NFIP levee system evaluation requirements, 2) assurance between 90% and 95%: levee can be found in accordance with NFIP levee system evaluation requirements if it is at least the FEMA required freeboard above the 1% annual chance exceedance flood, and 3) assurance greater than 95%: levee can be in accordance with NFIP levee system evaluation requirements if it is at least 2 feet above the 1% annual chance exceedance flood.

11.2.1. Summary of Available Information

During the earlier phases of the evaluations, MVD coordinated with the Memphis, Vicksburg and New Orleans Districts to discuss the availability of existing levee data and the necessity of collecting any additional data. The last comprehensive study of the Mississippi River flows was conducted in 1962. The period of record used for this study was from 1900 to 1953. A standard for flow frequency analysis was not available at the time. In 1979, LMVD (presently MVD) decided to analyze the need to update the frequency flows and implement the use of Bulletin 17A "Guidelines for Determining Flood Frequency" which was developed by the U.S. Water Resources Council. It should be noted the 1979 analysis resulted in no change to the adopted frequency flows.

For the LSER effort, updated frequency discharge relationships were developed using Hydrologic Engineering Center-Statistical Software Package (HEC-SSP) and the Bulletin 17B option (updated Bulletin 17A). Flows were developed for the Lower Mississippi River at the Hickman, Kentucky; Memphis, Tennessee; Helena, Arkansas; Vicksburg, Mississippi; Tarbert Landing, Louisiana; Baton Rouge, Louisiana; Donaldsonville, Louisiana; and Reserve, Louisiana gages. The period of record for this analysis ranged from 1962 to 2009. This period for the update was chosen because all flood control reservoirs were considered complete by 1962 and the flows used are based on observed measurements without adjustments.

The resulting stage and discharge uncertainty relationships were input into the Hydrologic Engineering Center-Flood Damage Analysis (HEC-FDA) program to compute the 1% flood and its corresponding 90% or 95% CNP profiles (referred to as the 90% or 95% CNP throughout the rest of the report). The Monte Carlo analysis in the FDA program was used to determine levee overtopping assurance. Other computer programs used were the HEC-SSP to produce discharge frequency information and Hydrologic Engineering Center-River Analysis System (HEC-RAS) to produce frequency water surface profiles and data.

11.2.2 Interior Drainage

Drainage of storm water from floodplains behind levee systems is impeded by the presence of the levee. EC 1110-2-6067 has guidance for analyzing interior drainage for new levees, which requires a detailed analysis of interior flooding. Interior flooding is based on a coincident analysis of exterior and interior stages that includes the capacity of gravity and blocked gravity drainage features. For riverine levee systems, the interior analysis considers interior rainfall events during both low river stages (gravity conditions) and high river stages when the gravity outlets are closed (blocked conditions) and the interior flooding is a function of the performance of pumping stations, if applicable.

EC 1110-2-6067, states that if the information is 10 years old or greater for constructed levees, a cursory update is required to ensure the data and analysis is reasonably representative of current conditions. The MR&T Project areas are predominantly rural in nature and land use has not changed significantly since the levee system was constructed. Most flood risk reduction facilities, operating plans and interior ponding areas are still adequate and functioning as originally intended when addressing rainfall-runoff quantities and patterns.

If the existing levee is considered adequate in the current flood insurance study, the coincident interior flooded area should already be mapped. The majority of levees in Memphis and Vicksburg Districts fit this case; the levee system evaluation will not require a reanalysis of interior flooding and thus will not require modifications to the flood insurance maps. The New Orleans area is more populated and the need for revisions to their interior analysis would be more prevalent for their levee systems. Any additional interior analysis for the New Orleans District can be referenced in Appendix C.

11.2.3. Wave Overtopping and Wave Induced Erosion

Wave overtopping analysis for this report is based upon EC 1110-2-6067 guidance. It states that the maximum required freeboard will be the larger of the 1% annual chance flood elevation with 90% assurance or the required freeboard based upon wave analysis, added to the 1% chance flood still-water elevation. Table IX.B-1, entitled "Freeboard Requirement for Significant Wave Heights", included in EC 1110-2-6067, lists freeboard requirements for significant wave conditions that might be experienced in a river under high winds. For this wave overtopping analysis, the 2% wave run-up method was used to determine the required freeboard needed above the 1% flood. Wave heights were determined using the guidance set forth in the Shore Protection Manual, EM 1110-2-1414, Figure 5-36, Forecasting Curves for Shallow Water Waves (constant depth = 10 feet). The average wave overtopping discharge rate of 0.10 cfs/ft was selected from the table. Since the majority of MR&T Project levee system is composed of high quality clay, high quality sod cover and good maintenance activities, the 0.10 cfs/ft was considered applicable.

11.2.4. New Orleans District Wave Overtopping

Wave characteristics are different in the New Orleans District due to the fact a portion of their boundaries are located in a coastal region. This required a more detailed analysis when compared to the Memphis and Vicksburg Districts. The methodology contained in the Shore Protection Manual was still applied but the analysis was supplemented with the use of "Coastal Flood Hazard Mapping for the Pacific Coast of the US" published by FEMA 2005. The specific technical analysis conducted for each system can be seen in Appendix C.

11.2.5. Erosion Protection

As required in EC 1110-2-6067, the potential for levee erosion on the riverside was examined. Review of post flood documentation and available data indicates the occurrence of a 1% flood event on the MR&T Project would not result in significant damage. Computed Mississippi River overbank velocities are not considered erosive with respect to the existing sod cover on the levee. The potential for any levee erosion riverward would be attributed to wave wash due to the long durations of traditional Mississippi River flooding. Wave wash erosion would be mainly on the slopes and not near the levee crest because the difference between the top of the levee and 1% flood is large enough that the probability of overtopping elevations would be rare on MR&T Project levees.

11.3. Structural Evaluation

USACE policy and criteria for performing Levee System Evaluations for NFIP purposes are detailed in EC 1110-2-6067. The following steps are outlined as guidance for structural evaluations:

11.3.1. Technical Guidance for Structural Evaluation

The first and most important step is to study past performance and define the existing conditions of all levee system structural components. Data to be collected for evaluation are, the NFIP levee system inspection report and latest routine/periodic inspection reports for the levee system, condition assessment for pipes and conduits, specific flood event After Action Reports, as-built drawings, instrumentation data, previous design analysis and information verified during site visits.

Structural stability criteria should be investigated. The required factors of safety for sliding, flotation, and overturning shall be determined for each structure. Evaluation of seismic stability and barge impacts are to be considered if there is potential for impact on the structures. The structural evaluation shall establish that the structural strength requirements are greater than the factored loads due to a flood event on the structure.

According to EC 1110-2-6067, the determination of whether a levee system meets NFIP levee system evaluation requirements should be based on the results of the prescribed evaluation as well as accompanying engineering judgment whether there is a high likelihood of adequate performance of the structure or component when subjected to the 1% annual chance exceedance flood. Therefore, as an alternate for performing an analytical analysis of the structure, an evaluation can be performed to determine if the structural elements are “Fit-for-Purpose” which means although a structure was not designed in accordance with current standards nor has a fabrication defect it will still perform adequately during a flood event. All closures structures are to be evaluated based on characteristics of the flood threat, determination that the closure satisfies the current design criteria and knowledge that it is in operational condition.

11.3.2 Mississippi Valley Division Process for Structural Evaluation

The levee structure evaluations, including floodwalls, closure gates, pipes, culverts and pump stations within the MR&T Project, were based primarily on available design information, existing as-built plans/drawings, previous calculations, recent inspection results, survey information, documented performance history and on-site observations. For many of the structures, the existing data was incomplete and engineering judgment along with experience was used to determine how the structure would perform during a flood event with 1% annual chance of exceedance.

The first step taken in the evaluation process was to review all available information on the structures. As-built plans, original construction plans along with the NLD survey provided top of floodwall elevations, culvert and pipe outlet and inlet invert elevations and structural slab elevations. These elevations were compared to the 1% event water surface elevation. Current periodic and routine inspection reports were reviewed to determine existing deficiencies of the

structures. Past performance of the structures was studied by reviewing the Damage Assessment Reports (DAR) that were completed on the MR&T Project after the 2011 flood. Culvert condition assessments were also reviewed.

After the in-depth review of available information on each structure, a site visit was completed to visually assess the structural elements. These visual assessments focused on the deficiencies that were indicated by the reviews that would affect the performance of the structure during a 1% flood event. Failure modes were evaluated for each structure type; floodwalls, conduits, closures, pump stations and inlet and outlet structures. The evaluation specific to each structure type are discussed below.

11.3.2.1. Floodwalls

Evaluations of the floodwalls were based on available stability analysis and failure modes, the 1% water surface elevations in relation to the structure elevations, recent condition assessment and review of system performance during the 2011 flood. Failure modes for floodwall include overtopping, settlement, overturning, sliding, loss of structural integrity and barge impact.

Stability evaluations on the floodwalls were completed upon review of the original documented stability analysis, including sliding, overturning, and flotation. The original design analyses were reviewed and compared to the current criteria for concrete structures detailed in EM 1110-2-2100, Stability Analysis of Concrete Structures, to verify whether the structures meet current design requirements. All levee systems attempting FEMA accreditation are considered critical because they protect the public. A determination is made if the site information available is "Well Defined", "Ordinary", or "Limited," as defined in EM 1110-2-2100. The above criterion was used to determine the required factors of safety for all levee structures. If the required factors of safety were greater than the original design factors of safety, then the structure would receive a negative evaluation. If the original design analysis were not available and/or insufficient to complete the required stability analysis or the structure did not meet current standards, a positive rating may have been provided based on a review of the system performance during the 2011 flood as outlined in the DAR's. If there were no problems during the 2011 flood, then the structure would be adequate for future 1% flood events.

Settlement calculations were not available but settlement surveys were completed at specified intervals for each of the structures to monitor movement. If assessment of these surveys indicated settlement has occurred but the top of the floodwalls are more than one foot above the 1% flood event, the structure could receive a positive evaluation for settlement.

Evaluation of concrete strength requirements were performed using the criteria in EM 1110-2-2104, Strength Design for Reinforced Concrete Hydraulic Structures. Material deficiencies noted in the review process that could impair the performance of the structure were considered for strength evaluations in determining loss of structural integrity. Most of the existing structures were not designed to meet the current codes; therefore, a positive rating may have been provided based on a review of the system performance during the 2011 flood.

Calculations were not found indicating barge impacts were considered during the original design. It is assumed that the floodwalls will not sustain a barge impact during 1% flood event. There is a low chance of impact to the floodwalls due to location of tree lines providing protection for many monoliths and barge traffic was severely restricted during the 2011 flood.

11.3.2.2. Pump Stations, Inlet and Outlet Structures

Evaluations of the pump stations and inlet and outlet structures were based on available stability analysis and failure modes, the locations of the structures (riverside or landside), the 1% water surface elevations in relation to the structure elevations and PDF, recent condition assessment and review of system performance during the 2011 flood. Failure modes include loss of structural integrity, overturning, sliding, and flotation. Stability evaluations, including sliding, overturning, and flotation for the pump stations and inlet and outlet structures were completed as discussed above for floodwalls. Evaluation of concrete strength requirements were completed as discussed above for floodwalls.

11.3.2.3. Culverts (Corrugated metal pipe, concrete pipe and concrete box culverts)

Evaluations of the conduits were based on recent and/or earlier condition assessments, the 1% water surface elevations in relation to the invert elevations, and review of system performance during the 2011 flood. Failure modes for conduits include leaking joints that may lead to soil infiltration and possible settlement of levee and material deficiencies that could lead to collapse of structure and settlement of the levee.

Review of each conduit condition assessment was conducted to determine if any previous performance issues have been noted. Condition assessments included visual inspection of the entire length of culvert using video technology, sonar, or walk-thru visual by qualified personnel. If any of the conduits have been rated as unacceptable in the condition assessments, then a negative finding would be reported. If the culvert has not been video inspected within the last five years, the conduit is not past its design life, the review of inspections longer than the five year interval and a current visual internal inspection of the conduit performed from the exterior all showed none or minimal deterioration, then a positive finding may have been given. If the conduit is past its design life and no inspection was completed within the last five years, then a negative finding would be reported. High water may have limited access to conduits preventing video inspection.

11.3.2.4. Closure

Closure structures in this system include timber and aluminum stoplogs, timber needles, sluice gates and steel swing gates with flap gates on small levee conduits. Negative or positive findings of the closure structures were included with its associated structure above. Evaluation of closures required determining whether the flood forecast time is adequate for completing/installing the closure, review of the O&M manuals on the closures, verification that all necessary materials and manpower are available and verifying the local sponsor has the knowledge and capability to safely operate the closure in accordance with official O& M methods. The evaluation included review of each levee district's Emergency Action Plan, which

states gage elevations at which closures are installed. Failure modes of closures include unknowledgeable gate operators and material deficiencies.

The typical closures in the levee system do not have calculations available. Negative findings would be reported if any of the above criteria were found unacceptable. If verification was given showing the closure has been operated effectively during the periodic inspection/ routine inspections, and the closures performed without problems during the 2011 flood, then a positive rating may have been provided.

11.3.2.5. Seismic Stability

EC 1110-2-6067 states "Structural floodwalls and pump stations within levee systems that are subjected to water loading for extended periods of time every year shall be evaluated for seismic stability. The median annual water level shall be combined with the 1% annual chance exceedance earthquake (100-year return period) load for the evaluation." In addition, EM 1110-2-2100 states: "Earthquake loads are to be combined with other loads that are expected during routine operations and should not be combined with other infrequent events such as flood loads." The MR&T Project levees are loaded only for a short period of time each year and are most often not loaded on an annual basis. Based on these criteria, a seismic evaluation was not required or performed.

11.4. Geotechnical Evaluation

USACE policy and criteria for performing levee system evaluations for NFIP purposes are detailed in EC 1110-2-6067. The following steps are outlined as guidance for geotechnical evaluations:

11.4.1. Technical Guidance for Geotechnical Evaluation

The geotechnical engineer must collect and review all available pertinent information including, but not limited to regional and site specific geologic and soils information, design documents and calculations, as-built drawings, construction records, 408 permits, inspection reports, relief well or piezometer installation and testing information, performance history, and data on system repairs or improvements.

The geotechnical engineer shall perform a site visit to observe, assess, and document the condition of the levee system and the adequacy of the maintenance efforts. Special attention should be devoted towards past performance and flood fight records. EC 1110-2-6067 states that if a system has successfully withstood a 1% event in the recent past with good performance, it is likely to do well again at the same flood stage.

EC 1110-2-6067 states that if a definitive determination cannot be made concerning the capability of the levee system to withstand the 1% annual chance exceedance event based on the information review (including consideration of past performance) the site visit, and subsequent analyses, the geotechnical engineer may determine that additional data or analyses are required.

Potential failure modes should be determined and prioritized. Evaluation of the levee system for NFIP purposes should be based on the failure mode determinations. Typical failure modes that should be considered are seepage and piping, settlement, levee stability and sliding, and failure from erosion.

11.4.2. Mississippi Valley Division Process for Geotechnical Evaluation

The geotechnical evaluations performed for the MR&T Project were conducted in accordance with the guidance provided by EC 1110-2-6067. The geotechnical evaluation of MR&T Project relied upon available geotechnical data and analyses as well as documented performance history. In addition, the geotechnical levee system evaluations considered that MVD has major maintenance responsibility for the MR&T Project, ensuring the issues that present significant risk to the flood protection works can be addressed in a timely manner; as well as the fact that the MR&T Project is designed as a series of levee systems, reservoirs, backwater areas, and floodways that work together to pass the PDF to the Gulf of Mexico. The PDF is typically 2 to 4 feet higher than the 1% event.

Geotechnical data typically available for the evaluation consisted of geologic information, borings logs, inspection reports, and deterministic analyses using factors of safety against inadequate performance. In many cases geotechnical data was incomplete or inconclusive, and engineering judgment and experience were used to assess the performance of a levee system during a future 1% event based on performance observed during past events. Specifically, the geotechnical assessments consisted of the following:

The geotechnical engineer performed a thorough document search for available plans and as-built drawings, maintenance records, design calculations, inspection reports, and flood fight and performance histories. The available information was reviewed in order to become familiar with the levee system.

After the document review was completed, the USACE levee evaluation team conducted a thorough system inspection with specific focus on issues that could potentially impact levee performance during the 1% event. The team also verified the available documentation, assessed the overall condition of the levee, and evaluated the effectiveness of maintenance procedures.

Based on the available data and observations made during the site visit, the geotechnical engineer identified all potential modes of failure. Examples of potential failure modes considered during the evaluation include loss of freeboard due to settlement, piping and foundation loss due to seepage, and slope stability failure. Since system design documentation is often incomplete, past performance history during high water events was crucial in evaluating the credibility of each failure mode. Each of the typical failure modes was evaluated as discussed below.

11.4.2.1. Settlement

Typically, MR&T Project levee systems do not have settlement calculations available; however, it is apparent that settlement was evaluated in some manner during the design process since the

levees are typically overbuilt to account for possible settlement. Since formal settlement analyses were not available, settlement was evaluated by looking at the most recent survey information along the crest of the levee and comparing it to the original construction grade as well as to other surveys performed during the life of the project. Settlement was only considered a credible failure mode if the crest of the levee was below the 90% CNP or if the survey record indicated that settlement was on-going at a rate that could result in the top of the levee falling below the 90% CNP in the future. Either of these situations would indicate that overtopping was a possibility during the 1% event and could have resulted in a negative evaluation findings.

11.4.2.2. Seepage

Formal seepage analyses were generally not performed during the initial federal construction of the MR&T Project levee systems. Since initial construction, a number of in-depth seepage studies have been completed for critical sections of the MR&T Project. The priority for the in-depth seepage studies was determined based on seepage observations during high water events, such that problem areas were evaluated first. Both performance history and the seepage analyses completed since the initial federal construction of the MR&T levee systems were reviewed to address the expected performance of the MR&T Project levees during flood events up to the 90% CNP.

EC 1110-2-6067 states that in order for a levee system to meet seepage criteria, "there must be reasonable assurance that the levee/floodwall system will reduce flood risk against the base flood with "hands off" during the occurrence of an event". "Hands off" was subsequently defined as employing standard flood fight methods to maintain the system without heroic effort. For the MR&T Project levee system evaluations, a determination was made as to whether or not the District had a reasonable assurance that each System would provide adequate flood risk reduction during events up to the 1% event with "hands off" (i.e. without heroic flood fighting) based on observations during past high water events, available seepage analyses, and past seepage remediation. Either a history of significant flood fight effort being required to maintain system integrity during high water events or a seepage analysis indicating the need for significant seepage remediation that had not yet been constructed could have resulted in a negative evaluation finding. A positive finding could have been based upon a history of good performance during high water events or upon seepage analyses indicating that all problem areas had been remediated.

11.4.2.3. Stability

Typically, slope stability analyses were not available for consideration during the levee evaluation process. In some cases there is not a record of a stability analyses being performed as a part of the levee design process. However, MR&T Project levees are constructed to standard levee design sections that were developed based upon typical soil conditions in the Mississippi Valley and typical construction methods in use at the time of construction.

Positive findings were generally based upon a history of good levee stability and a record of pro-active slope stability remediation projects that stabilized areas with chronic slope failures. A

negative finding would have resulted from any area with on-going deep seated failure issues or from a loss of stability due to bank migration towards the levee.

11.4.2.4. Seismic

The levee evaluation guidelines in EC1110-2-6067 state that only levees that have water on the toe for extended periods of time every each year must be evaluated. The MR&T Project levees are typically loaded for only a short period of time each year and are often not loaded on an annual basis. Therefore, seismic evaluation was not required or performed.

11.5. Mechanical and Electrical Evaluation

The levee evaluations for mechanical and electrical system analysis include stormwater pump stations, flap gates, culverts, sluice gates, spillway gates, and stoplog closures within the MR&T Project. Findings were based primarily on available design information, existing as-built drawings, previous design analyses, recent inspection results, documentation of performance history during flood events, and on-site inspection and observations.

The first step taken in the evaluation process was to review all available documented information on the pump facilities. As-built or original construction plans provided the equipment performance data to determine the rated pump speeds, and rating of the equipment, operating floor elevations, culvert and pipe outlet and inlet invert elevations and pump sump elevations. Current periodic and routine inspection reports were reviewed to determine existing deficiencies of equipment. Past performance of the equipment was studied by reviewing the DAR's which were completed on the MR&T Project levee system after the 2011 flood. Gated structure condition assessments were also reviewed. After the in-depth review of available information on each flood control structure, a site visit was conducted to visually assess the equipment elements focusing on the deficiencies indicated by review that would impact the performance of the structure during a 1% flood event.

Failure modes were evaluated for electrical and mechanical equipment, electrical conduits, pipes, pump stations, trash racks, grease lubricators, and inlet and outlet gated structures. The evaluation specific to each structure type are discussed below.

11.5.1. Stormwater Pumping Stations

The failure modes for pump stations that are assessed include failure of the pumps, drivers, controls, or the backflow of water through the pump station to the leveed area. Other items considered in a levee system evaluation, which could lead to a pump station failure mode, are listed below:

Pumps
Motors, engines, fans, gear reducers, and back stop devices, etc
Power supply,
Megger testing on pump motors and critical power cables,
Motor control center,
Enclosures, panel, conduit, and ducts,

Circuit breakers,
Instruments,
Sumps/wet well,
Intake and discharge pipes,
Flap gates/flap valves/pinch valves (when component of pump station),
Mechanical operating trash rakes,
Non-mechanical trash racks,
Sluice/slide gates (when component of pump station), and
Fuel system for pump engines.
In addition to the criteria defined for "Power supply," the reliability of the commercial power system and presence of backup generator power are also considered. When the commercial power is unreliable, then backup power is provided in the form of an alternate commercial power source, a properly sized generator set, or provisions for connection of a properly sized generator set that is readily available in an emergency. Pump stations that are part of flood protection systems merit additional scrutiny of certain features that may contribute to station failure.

11.5.2. Gated Structures

Evaluations of the gated structures were based on available load analysis and failure modes, the 1% water surface elevations in relation to the structure elevations, recent condition assessment and review of system performance during the 2011 flood. Failure modes for gates, motors, and gate actuators include over torque motor, gate stem buckling, and loss of equipment integrity.

Evaluations of the gated structures were based on recent condition assessments, the 1% water surface elevations in relation to the invert elevations, and review of system performance during the 2011 flood. Failure modes for gates and pipes include leaking gate seals and leaking pipe joints that may lead to soil infiltration and possible settlement of levee and material deficiencies that could lead to collapse of structure and settlement of the levee. Review of each gated control structure condition assessment was conducted to determine if any previous performance issues have been noted. If the gated structure performed well during the 2011 flood, then the structure would be adequate for future 1% flood events.

Water control structures include timber and aluminum and steel stoplogs, flap gates, sluice gates, bottom hinged gates, tainter gates, and steel swing gates. Negative or positive findings of the control structures were included with the associated structure above. Evaluation of these structures included determining whether the flood forecast time is adequate for completing/installing the gates, review of the O&M manuals on the gates and gate lifts verification all necessary materials and manpower are available and the local sponsor has ability to safely operate the structure in accordance with official O& M methods.

The typical gated structures in the levee system do not have calculations available. If verification was given showing the gate closure has been operated effectively during the periodic inspection/ routine inspections and the gates performed without problems during the 2011 flood, then the structure would be adequate for future 1% flood events.

11.3.3. Mechanical and Electrical Conclusions

The gates are operated using electric gate hoists. A steel walkway bridge connects the levee crown to the outlet structure. The walkway accesses the mechanical and electrical equipment. Some of the pump stations have had numerous undocumented electrical modifications in the motor control center. An ample commercial power supply is available at most of the pump stations. The stations have back up diesel driven generators for emergency power supply. Frequency and duration of the power outage and the size and importance of the pump station are used when determining the need for alternate power provisions. These considerations are described in Chapter 13, EM 1110-2-3105, "Mechanical and Electrical Design of Pumping Stations".

12. Summary of Memphis, Vicksburg and New Orleans Districts' LSERs

As stated earlier, 57 evaluation reports were completed and 37 resulted in negative findings. The reasons for the negative findings are primarily insufficient freeboard, seepage issues, and structural deficiencies. All negative segments are shown in Table 12-1 and the following paragraphs provide a brief explanation for the finding.

Table 12-1
MVD Negative Levee System Evaluation Reports

System #	District	System	Report Finding	Mainline or Tributary	River	Levee Length (Miles)	Reason(s) for Negative Finding
3	Memphis	Hickman KY to Obion River System	Negative	Mainline	Mississippi	60.2	Seepage
1	Memphis	Cairo and Vicinity	Negative	Mainline	Mississippi	21.5	Seepage
11	Memphis	St. Francis East to Big Lake West	Negative	Tributary	St. Francis River	112.9	Seepage
14	Memphis	Elk Chute Levee System	Negative	Tributary	St. Francis River	22.8	Grade <100year
21	Vicksburg	East Bank MRL below Memphis	Negative	Mainline	Mississippi	272	Seepage
24	Vicksburg	Whittington Aux South MS	Negative	Tributary	Yazoo River	28	Grade <100year
31	Vicksburg	Rocky Bayou Area	Negative	Tributary	O'Neal Ck	4	Grade <100year
50	Vicksburg	Hillside Floodway South MS	Negative	Tributary	Fannegusha CK	3	Grade <100year
49	Vicksburg	Hillside Floodway North MS	Negative	Tributary	Fannegusha CK	11	Grade <100year
45	Vicksburg	Ascalmore-Tippo North MS	Negative	Tributary	Ascalmore Ck	6	Grade <100year
44	Vicksburg	Ascalmore-Tippo South MS	Negative	Tributary	Ascalmore Ck	6	Grade <100year
46	Vicksburg	Teoc Creek North	Negative	Tributary	Teoc Ck	3	Grade <100year
7	Vicksburg	Coldwater River	Negative	Tributary	Coldwater River	25	Structures and Levee material
11	Vicksburg	Coldwater River	Negative	Tributary	Coldwater River	25	Structures
23	Vicksburg	Jonesville to Larto Lake	Negative	Tributary	Black River	70	Levee Slide and Structure
516	Vicksburg	Lower Red River South Bank Alexandria, LA	Negative	Tributary	Red River	59	Seepage and culverts
22	Vicksburg	Red River Backwater	Negative	Tributary	Black River	93	Seepage and culverts
19	Vicksburg	Yazoo Levees LB South MS	Negative	Tributary	Yazoo River	11	Structures
29	Vicksburg	Yazoo Levees LB Central MS	Negative	Tributary	Yazoo River	17	Structures
40	Vicksburg	Pelucia Creek South	Negative	Tributary	Pelucia Ck	11	Structures
48	Vicksburg	Greenwood MS East	Negative	Tributary	Yazoo River	28	Structures
12	Vicksburg	Greenwood MS West	Negative	Tributary	Yazoo River	7	Structures
32	Vicksburg	Vicksburg Protection Works	Negative	Tributary	Yazoo River	2	Structures
17	Vicksburg	Ouachita River - East Bank	Negative	Tributary	Ouachita River	96	Bank Caving and seepage
47	Vicksburg	Big Sand, Yalobusha, Teoc Creek	Negative	Tributary	Yalobusha River	16	Structures and Levee Slide
41	Vicksburg	Yazoo Backwater -Yazoo River RB	Negative	Tributary	Yazoo River	93	Structures and Bank Caving
51	New Orleans	Morganza Floodway	Negative	Mainline	Mississippi	30.47	Flooded during 1% event
58	New Orleans	Butte La Rose Floodway	Negative	Tributary	Atchafalaya/Mississippi	11.4	Flooded during 1% event
23	New Orleans	Mississippi River West Bank Above Morganza	Negative	both	Atchafalaya/Mississippi	55.96	Grade <100year
6	New Orleans	Caernarvon to Phoenix Polder	Negative	Mainline	Mississippi	22	Grade <100year
7	New Orleans	Phoenix to Bohemia Polder	Negative	Mainline	Mississippi		Grade <100year
11	New Orleans	Oakville to City Price Polder	Negative	Mainline	Mississippi	24.2	Grade <100year
12	New Orleans	St. Jude to Venice Polder	Negative	Mainline	Mississippi	66.2L 7.29F	Grade <100year
17	New Orleans	Wax Lake West Area	Negative	Tributary	Atchafalaya/Surge	62	Grade <100year
18	New Orleans	Bayou Sale	Negative	Tributary	Atchafalaya/Surge	17.4	Grade <100year
59	New Orleans	Morgan City Ring Area	Negative	Tributary	Atchafalaya/Surge	12.1L 2.4F	Grade <100year
24	New Orleans	Wax Lake East	Negative	Tributary	Atchafalaya/Surge	30.8	Grade <100year
55	New Orleans	Terrebonne Basin	Negative	Tributary	Atchafalaya/Surge	43.7	Grade <100year

*L-Levee

*F-Floodwall

12.1. Memphis District's Negative Finding

12.1.1 MVM System #3-Hickman, Kentucky – Obion River System

System will not provide adequate flood risk reduction during events up to the 1% event because of seepage issues. These issues require flood fight activities under emergency conditions that are required in an attempt to keep the system from failing.

12.1.2. MVM System #1-Mississippi and Ohio Rivers Levee System at Cairo and Vicinity

System will not provide adequate flood risk reduction during events up to the 1% event because of seepage issues. These issues require flood fight activities under emergency conditions that are required in an attempt to keep the system from failing.

12.1.3. MVM System #11-St. Francis East to Big Lake West System

System will not provide adequate flood risk reduction during events up to the 1% event because of seepage issues. These issues require flood fight activities under emergency conditions that are required in an attempt to keep the system from failing.

12.1.4 MVM System #14-Elk Chute Levee System

System fails to satisfy the hydraulics and hydrology risk and uncertainty requirements because the top of levee is less than two feet above the 1% annual chance exceedance flowline.

12.2 Vicksburg District's Negative Findings

12.2.1 MVK System #21-Mississippi East (East Bank MRL below Memphis System)

System will not provide adequate flood risk reduction during events up to the 1% event because of seepage issues. These issues require flood fight activities under emergency conditions that are required in an attempt to keep the system from failing.

12.2.2 MVK System #24-Whittington Auxiliary South Mississippi

System fails to satisfy the hydraulics and hydrology risk and uncertainty requirements because the top of levee is less than two feet above the 1% annual chance exceedance flowline.

12.2.3. MVK System #31-Rocky Bayou Area

System fails to satisfy the hydraulics and hydrology risk and uncertainty requirements because the top of levee is less than two feet above the 1% annual chance exceedance flowline.

12.2.4. MVK System #50-Hillside Floodway South Mississippi

System fails to satisfy the hydraulics and hydrology risk and uncertainty requirements because the top of levee is less than two feet above the 1% annual chance exceedance flowline.

12.2.5. MVK System #49-Hillside Floodway North Mississippi

System fails to satisfy the hydraulics and hydrology risk and uncertainty requirements because the top of levee is less than two feet above the 1% annual chance exceedance flowline.

12.2.6. MVK System #45-Ascalmore – Tippo North Mississippi

System fails to satisfy the hydraulics and hydrology risk and uncertainty requirements because the top of levee is less than two feet above the 1% annual chance exceedance flowline.

12.2.7. MVK System #44-Ascalmore – Tippo South Mississippi

System fails to satisfy the hydraulics and hydrology risk and uncertainty requirements because the top of levee is less than two feet above the 1% annual chance exceedance flowline.

12.2.8. MVK System #46-Teoc Creek North Mississippi

System fails to satisfy the hydraulics and hydrology risk and uncertainty requirements because the top of levee is less than two feet above the 1% annual chance exceedance flowline.

12.2.9. MVK System #7-Coldwater West Mississippi

System fails to satisfy structural and geotechnical requirements. Two structures at Station 30+97 and Station 128+63 on the west bank requires replacement due to rusting and joint separation. The levee from approximately Station 445+00 to Station 710+00 was shaped from spoil material and does not meet guidelines for levee construction. Borings were drilled and more than half lost fluid circulation with no exit of fluid found. Further investigation is warranted for the levee to determine why the borings lost.

12.2.10. MVK System #11-Coldwater East Mississippi

System fails to satisfy structural requirements. A structure at Station 83+52 on the east bank does not pass structural criteria but can most likely be rehabilitated by the installation of a new liner.

12.2.11. MVK System #23-Larto – Jonesville Louisiana

System fails to satisfy structural requirements. Of the 27 structures, the two structures at Stations 518+70 (Grassy Lake) and 1205+71 were found to be unacceptable because of their deficient condition. The structure at Station 518+70 revealed minor cracking in the conduit liner sealant at the inlet structure and severe cracking in the concrete of the operation platform. The video inspection performed on the structure at Station 1205+71 revealed a damaged joint and a large indentation approximately 30-foot into the conduit from the inlet structure. Another damaged joint and indentation was noted approximately 56-foot into the conduit from the inlet structure. The conduit is punctured at this location with soil and water seeping through. The protective coating is deteriorated and there is minor surface rust with pitting on the conduit. The site inspection revealed that the protective coating inside the conduit is deteriorating. Heavy sediment build up inside the outlet structure of the conduit was present at the time of the inspection.

12.2.12. MVK System #516-West of Atchafalaya Basin (Lower Red River South Bank Alexandria, Louisiana)

The Lower Red River South Bank Levee does not satisfy geotechnical design criteria. With sandboils and sinkholes located at or very near the levee toe, the system is susceptible to failure, and therefore creates a failure concern.

12.2.13. MVK System #22-Red River Backwater Louisiana

System fails to satisfy structural, geotechnical, and mechanical and electrical requirements. The system has issues at nine culverts and the lack of a video inspection could not verify previous site inspection findings. Seven locations show unacceptable underseepage conditions that warrant further investigation. Until the investigation can be completed, the geotechnical requirements cannot be confirmed. Flap gates, a manual hoist, and the lack of gates at two structures caused the system to not meet requirements.

12.2.14. MVK System #19-Yazoo Levees Left Bank South Mississippi

System fails to satisfy structural, and geotechnical requirements. One of the five structures was unacceptable because the video inspection has not been completed. Debris blocked the progress of the inspection and severe deterioration and rust created concerns. In addition, underseepage has been observed and the extent cannot be determined. The system needs an updated subsurface investigation and subsequent seepage analysis.

12.2.15. MVK System #29-Yazoo Levees Left Bank Central Mississippi

System fails to satisfy hydraulic and hydrology, structural, and geotechnical requirements. Due to the lack of information being available for that portion of levee following Techeva Creek, and two locations where gap closure plans are not available, a complete analysis of the Yazoo Levee LB Central Levee System could not be completed. Moderate deterioration and minor surface rust at joints were considered unacceptable. Water also appeared to be seeping into the conduit. From a geotechnical standpoint, the system cannot be recommended for accreditation until the utility line beneath the base of the levee is properly abandoned to prevent seepage through the system protection.

12.2.16. MVK System #40-Pelucia Creek South

System fails to satisfy structural requirements. The lack of a video inspection at a culvert resulted in an unacceptable rating.

12.2.17. MVK System#48-Greenwood Mississippi East

System fails to satisfy structural, geotechnical, and mechanical and electrical requirements. Of the 43 drainage structures, 25 were found to be unacceptable. The utilities beneath the base of the levee need to be are properly abandoned to prevent seepage through the system protection.

12.2.18. MVK System #12-Greenwood Mississippi West

System fails to satisfy structural, geotechnical, and mechanical and electrical requirements. Of the 10 pumping stations and 27 drainage structures, 26 were found to be unacceptable. The three sinkholes need investigating to determine source of the material loss. The identified defect must be repaired and the sinkholes properly backfilled and compacted. The utilities beneath the base of the levee need to be are properly abandoned to prevent seepage through the system protection.

12.2.19. MVK System #32-Vicksburg Protection Works

System fails to satisfy structural and mechanical and electrical requirements. All eleven of the gravity structures were found to be acceptable. Two of the eleven manual sluice gages received unacceptable ratings are not expected to function during a flood event.

12.2.20. MVK System #17-Ouachita River Louisiana (East Bank Levee)

System fails to satisfy structural, geotechnical and mechanical and electrical requirements. The site inspection revealed a standing pipe at approximate Station 830+00 in which USACE has not found any documentation. The structure at Station 1912+90 contained a large amount of debris blocking the inlet of the conduit and the video inspection revealed a deformation in the pipe that occurred at approximately 72 feet from the inlet. The Calypso Street Pumping Plant at Station 1955+00 has a floor elevation below the 95% CNP. The site inspection also revealed the floor has severe cracking around the pumps. The structure at Station 2000+00 had areas of significant material seepage through the joints of the concrete pipe. The structure at Station 2083+00 contained approximately 4” of mud at the inlet of the structure and approximately 8” of mud on the outlet. The build-up in the conduit did not allow the bottom of the pipe to be accurately assessed. During the site inspection, five abandoned 12-inch gas line pipes were found and had not been capped off. A 12-inch pipe that penetrated the levee at the Davis Lake Pumping Plant at approximate Station 4579+00 does not have a gate on the outlet to prevent a back flow of water during a high water event. Additionally, the discharge channel is filling in with sediment, which is impeding flow out of the culvert. The site inspection of the 84-inch pipe at the Marquette Pumping Plant (station number unknown) is failing with obvious settlement and joint separation. There are six bank caving sites that must be repaired and subsurface investigations must be completed in order to determine the stability of 16 sites. Furthermore, cross section survey information must be gathered along the majority of the levee system to be compared with construction drawings and determine the extent of the stability issues. Additionally, subsurface investigations must be conducted at all sites of sand boils to produce adequate seepage analyses. Because of these deficiencies, the East Bank Ouachita River Levee does not meet the USACE requirements for evaluation of the 1% flood. The City of Monroe should raise Calypso Pump Station’s floor above the 95% elevation of 82.8 feet to ensure the stations operability during the 1% flood event. The city of Monroe should further investigate and determine the cause of the vibration at the Forrest Pump Station and perform the required maintenance. Tensas Basin Levee District should adjust or replace the manual sluice gate located at Station 2083+00 to prevent future leaks during high water events and ensure the structure seals properly.

12.2.21. MVK System #47-Big Sand, Yalobusha, Teoc Creek Mississippi

System fails to satisfy hydraulic and hydrology, structural, and geotechnical requirements. System fails to satisfy the hydraulics and hydrology risk and uncertainty requirements. Of the eighteen drainage structures, 13 were found to be unacceptable. Until the bank caving at station 384+00 is repaired, the system cannot be recommended for accreditation.

12.2.22. MVK System #41-Yazoo Backwater – Yazoo River Right Bank

System fails to satisfy structural and geotechnical requirements. Of the 39 structures, nine were found to be unacceptable. The system cannot be recommended for accreditation until the bank cavings are evaluated.

12.3. New Orleans District's Negative Findings

12.3.1. MVN System #51-Morganza Floodway

Morganza Control Structure will be open for the 1% event and will be non-compliant since water is allowed to pass into the protected area. In addition, the Morganza Control Structure does not meet minimum CNP requirements and will be overtopped by wave run up.

12.3.2. MVN System #50-Butte LaRose Floodway

System fails to satisfy the hydraulics and hydrology risk and uncertainty requirements due to the current levee crown elevations.

12.3.3 MVN System #23-Mississippi River West Bank – Above Morganza

System fails to satisfy the hydraulics and hydrology risk and uncertainty requirements. The crown profile does not have an elevation difference below the FEMA minimum freeboard compliance line, which is on the plan/profile drawings, which is 2 feet above the 1% flowline. There are sections along the profile that are overtopped by wave run up.

12.3.4 MVN System #6-Caermarvon to Phoenix Polder

System fails to satisfy the hydraulics and hydrology risk and uncertainty requirements. The current levee elevations are below the minimum criteria required for hurricane design elevations.

12.3.5. MVN System #7-Phoenix to Bohemia Polder

System fails to satisfy the hydraulics and hydrology risk and uncertainty requirements. The current levee elevations are below the minimum criteria required for hurricane design elevations.

12.3.6. MVN System #11-Oakville to St. Jude Polder

System fails to satisfy the hydraulics and hydrology risk and uncertainty requirements. The current levee elevations are below the minimum criteria required for hurricane design elevations.

12.3.7. MVN System #12-St. Jude to Venice Polder

System fails to satisfy the hydraulics and hydrology risk and uncertainty requirements. The current levee elevations are below the minimum criteria required for hurricane design elevations.

12.3.8. MVN System #17-Wax Lake West Area

System fails to satisfy the hydraulics and hydrology risk and uncertainty requirements. The current levee crown elevations does not meet the USACE requirements for evaluation of either the 1% hurricane design grade, or the 95% CNP and wave run-up compliance lines and the 1% riverine flood event.

12.3.9. MVN System #18-Bayou Sale

System fails to satisfy the hydraulics and hydrology risk and uncertainty requirements. The current levee crown elevations does not meet the USACE requirements for evaluation of either the 1% hurricane design grade, or the 95% CNP and wave run-up compliance lines and the 1% riverine flood event. Two events were evaluated for the Bayou Sale Levee System, a 1% riverine event and a 1% hurricane storm surge event. Areas where the alignment has not been authorized but has been built (i.e. the reach parallel to the GIWW), natural ground elevation falls below all riverine compliance lines.

12.3.10. MVN System #59-Morgan City Ring Area

System fails to satisfy the hydraulics and hydrology risk and uncertainty requirements. Results demonstrate that this system does meet requirements for evaluation of the 1% annual chance exceedance flood.

12.3.11. MVN System #24-Wax Lake East Area

System fails to satisfy the hydraulics and hydrology risk and uncertainty requirements. Results do not meet hydrologic and hydraulic requirements based on current levee crown elevations.

12.3.12. MVN System #55-Terrebonne Basin

System fails to satisfy the hydraulics and hydrology risk and uncertainty requirements. Results do not meet hydrologic and hydraulic requirements based on current levee crown elevations.

13. Residual Risk and Public Safety

Living behind a levee is a risk. The term often used for this scenario is known as the residual risk and is defined as the portion of the risk that remains after a flood risk management structure (i.e. levee) has been built. Communities should be aware that there will always be a chance that any levee system can be overtopped by an extreme event.

13.1. Emergency Response Plan

Because of the risk, EC 1110-2-6067 states that every levee system under evaluation should have an emergency response plan supported by a flood warning system. The emergency action and evacuation plans developed by the local levee owners are a good means of reducing the residual risk to public safety. Emergency response plans will address the key issues of flood threat recognition, warning dissemination, evacuation, and search and rescue. All gap closure operations for the MR&T Project should be included in the emergency response plans.

MVD districts share responsibility with the local levee owners for ensuring that the levees are properly monitored and maintained during high water events. During a high water event, the districts deploy teams that patrol and maintain the levees in accordance with district emergency guidelines. Flooding on the main stem Mississippi River can usually be forecasted in days, if not weeks in advance of the crest, which provides ample time to employ emergency procedures. Unfortunately, not all areas protected by MR&T Project are afforded slow rising floods or an available forecast to perform emergency actions, residual risks have a higher probability to affect their leveed areas, and an emergency becomes more critical.

13.2. Probability of Capacity Exceedance

The design for the majority of the MRL system is based on the PDF plus an additional 3 feet freeboard. While no frequency is assigned to the PDF, the annual chance exceedance probability of the PDF has been estimated to be in excess of the 0.5% chance event or in excess of the 200 year return period. This expected probability and the freeboard allowance shows that the majority of the MR&T Project levee system has a relatively low chance of overtopping. It should be noted, several of MR&T Project levee systems were not built to different standards/authorizations and may overtop for probabilities more frequent than the 1% annual chance exceedance event. Levee upgrades using gravel were required to several levees in the MR&T Project to prevent the possibility of overtopping during the 2011 flood.

13.3. Consequence of Failure

The majority of MR&T Project areas, north of New Orleans, Louisiana are predominantly rural in nature. The low density populated areas and the slow rising nature of the Mississippi River, typically provides ample time to reduce flood risks by evacuation operations. Additionally, the MR&T Project levee system is patrolled by both the levee districts and the Corps of Engineers during high water events. It is likely that a levee failure due to either overtopping or seepage would be predicted early and emergency construction/repairs could be made and evacuations could be executed, if necessary.

14. Communications with Partners and Stakeholders

The findings of the LSER have been relayed to the sponsors and stakeholders through a comprehensive strategic communications plan. See Strategic Communication Plan following paragraph 15. USACE has coordinated with FEMA, state and local levee and drainage districts, county and local governments, and the public at large. The main purpose is to communicate the risks associated with living and/or working behind the MR&T Project levee system. These communications are to maximize the direction for research, development, and release of flood risk communication products and maps. All communication efforts are intended to encourage

the community and motivate positive behavior. Living with levees is a shared responsibility and local community officials and communities, as a whole, should remain engaged in flood risk management activities. Public safety is the number one goal of the USACE Levee Safety Program. It is important for all to know the risk, know their role in helping to reduce that risk, and what specific actions they can take.

Both negative and positive findings are an opportunity to inform the public about the risk associated with levees. A positive LSER finding does not indicate an absence of risk. There are residual risks that the levee system could be overtopped, breached prior to or after overtopping, or have a failure of an integral component. In cases where the LSER results in a negative finding and accreditation was not recommended, other measures can be employed to reduce risk such as the purchase of flood insurance, elevating structures, maintaining a current flood warning system and evacuation plan, and wisely managing the floodplain development. If the solution to the levee deficiency is a structural alternative, the anticipated work should be prioritized and repaired as soon as funding is available. Fortunately, many of the issues that are leading to negative findings for MR&T levees are major maintenance items, and are therefore the responsibility of USACE to repair. Communication should also relate that a breach in one part of a defined but large levee system, such as the MRL, may or may not impact other areas protected by the levee. Sound engineering practices dictate that we take this system-based approach because a chain is only as strong as its weakest link.

The public should be aware that the purpose of a levee system is to protect property and individuals from flooding, not to eliminate the need for flood insurance and that the 1% event is used for mapping and is not a safety standard. The intent of flood insurance is to mitigate property damage and financial losses and the ultimate purpose of a levee is to reduce damages and the risk of harm to residents by floods. Communications with our partners and stakeholders should include FEMA's role after the findings of a USACE LSER are acknowledged. A major point to communicate is if a levee is not accredited in the NFIP, FEMA flood maps are produced as if the levee were not there and the resulting Special Flood Hazard areas should be updated to communicate the risk.

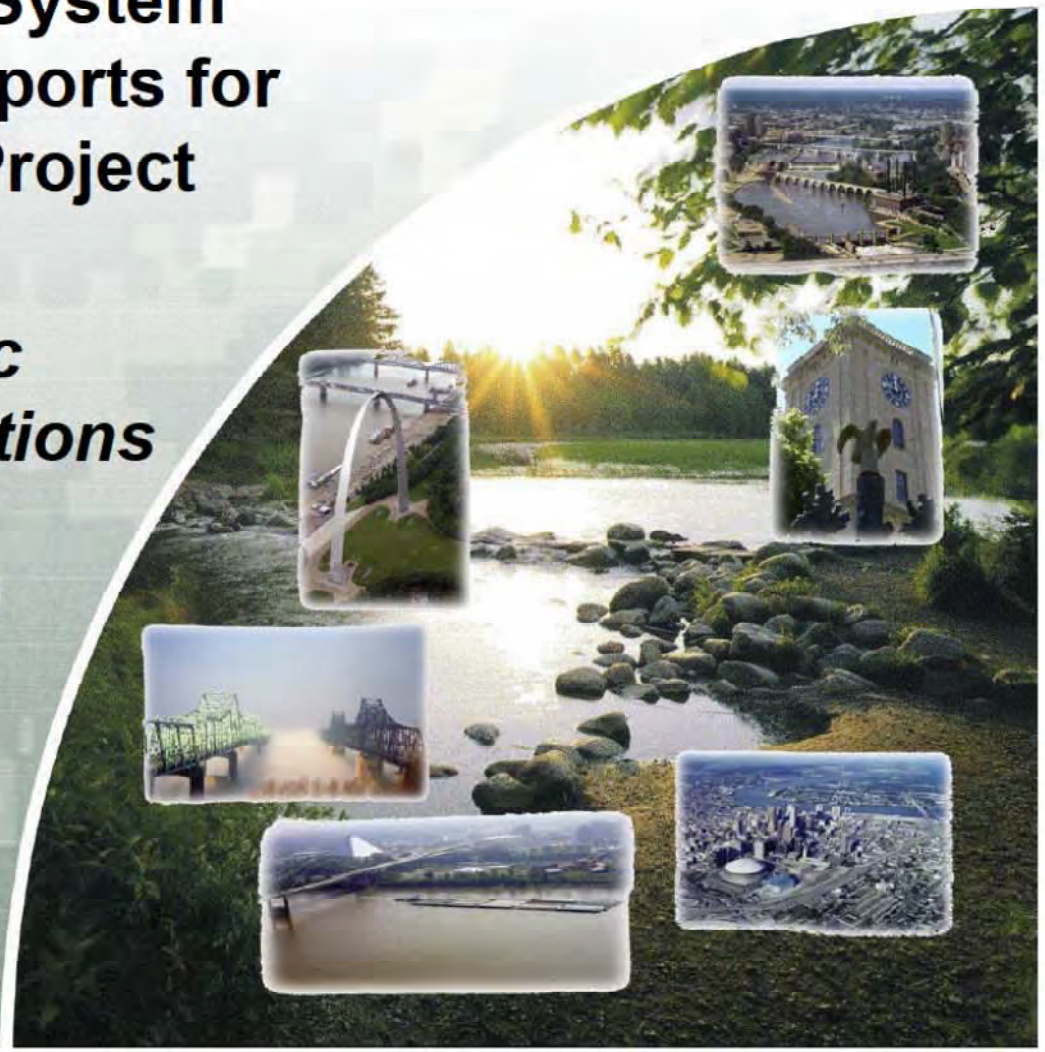
15. Validity Period

It is important to note that these levee evaluations are for a snapshot in time. External items arise that alter the conditions that a levee was evaluated such that the levee is no longer in agreement with EC 1110-2-6067 provisions. Existing USACE policy letter and other guidance documents do not specifically address the period for which NFIP levee system evaluation is to be considered valid. In the past, "levee certifications" were issued and considered valid over the life of the project. Except for routine and period inspections, revisiting the basis for the levee certifications was seldom performed. To formalize the back-checking of the evaluation viability, USACE has chosen 10 years as the agency maximum period of validity. Positive levee system evaluation findings and reports issued by USACE will include a statement that the NFIP levee system is valid for a stated period not to exceed 10 years. USACE shall notify the levee sponsor and FEMA at the 9-year mark that 10-year NFIP levee system is approaching. If USACE determines that a levee is no longer in accordance with NFIP levee system evaluation standards at any time

prior to the end of a 10-year NFIP levee system evaluation period, USACE shall inform the appropriate officials.

NFIP Levee System Evaluation Reports for the MR&T Project

Strategic Communications Plan



US Army Corps of Engineers
BUILDING STRONG®

Communication Summary for National Flood Insurance Program (NFIP) Levee System Evaluation Reports for the MR&T Project

Define Assignment or Challenge:
Communicate findings of the NFIP Levee System Evaluation Reports (NLSER) for the MR&T Project.

Key Stakeholders:
Congress; FEMA; Levee Boards/Districts; State, County and Local governments; Public at large

Communication Goal:
To communicate the risks associated with living or working behind the MR&T Project levee system to our partners and stakeholders.

Key Messages:

- Public safety is the number one goal of the USACE Levee Safety Program.
- Levee safety and communicating risks is a shared responsibility among federal, state, local and private partners, and crucial for individuals to make well informed, risk-based decisions with regard to public safety and floodplain management.
- The Corps of Engineers prepared NFIP Levee System Evaluation Reports (NLSER) for all levees in the MR&T Project for which the Corps retains major maintenance responsibility.
- Conditions that result in a negative NFIP Levee System Evaluation Report finding are prioritized and repaired as funding is made available.

Key Talking Points:

•The purpose of the NFIP Levee System Evaluation Reports (NLSER) is to determine if the levee system meets the requirements of Title 44 of the Code of Federal Regulations, Section 65.10 (44 CFR 65.10), *Mapping Areas Protected by Levee Systems* utilizing Corps of Engineers Criteria found in EC 1110-2-6067.

•Positive NLSER prepared by USACE is a technical finding that, for the floodplain in question, there is a reasonable certainty that the levee system will protect the floodplain from the base flood (1% annual chance exceedance event, aka 100 year flood). If a levee system does not meet the evaluation requirements (negative finding), the protected area within the levee system could be mapped as a Special Flood Hazard Area (SFHA) on the FEMA Flood Insurance Rate Map.

• Findings for individual systems are communicated directly with levee districts, local officials and FEMA through a deliberate process.

•57 Levee System Evaluation Reports within the MR&T Project
  • All reports complete: 19 positive, 38 negative
  • Negative reports: 9 MRL and 29 Tributary Levees

•Negative report findings: 9 due to culvert or structure issues; 6 due to uncontrolled seepage/floodfighting concerns; 3 due to bank caving/slides; 20 systems never authorized to protect to a100 year flood or within a floodway

•Deficiencies discovered during the evaluation process are prioritized and repaired as funding is made available.

•Positive NLSER finding does not eliminate risk. There are residual risks that the levee system could be overtopped, breach prior to or after overtopping, or have a failure of an integral component such as a pipe structure..

Communication Tactics:

- Keep federal, state, and local officials informed.
- Congressional and stakeholder call for critical events.

Communication Products:

- Levee System Evaluation Reports & summary papers
- Congressional and stakeholder email notifications
- Talking Points
- Questions & Answers

Communication Activities:

- Public meetings/briefings as needed
- Targeted stakeholder briefings

National Flood Insurance Program (NFIP)
Levee System Evaluation Reports for the MR&T Project
Stakeholders/Partners and their Interests

State Government	Local Government	Local Populace	Interest Groups
Governors of states encompassed in the Mississippi River watershed	Mayors and City Officials	Local residents	American Society of Dam Safety Officials (ASDO)
Legislators from states encompassed in the Mississippi River watershed	County/Parish Officials		United States Society on Dams (USSD)
EMAs from states encompassed in the Mississippi River watershed	Levee Boards/Districts		Association of State Floodplain Managers (ASFPM)
			National Association of Flood and Stormwater Management Agencies (NAFSMA)
			American Society of Civil Engineers (ASCE)
			Council of Mayors
			National Committee on Levee Safety (NCLS)

One Voice Message for Workforce:

Currently, the Federal Emergency Management Agency (FEMA) is engaged in an effort to update and modernize the nation's flood maps. The Mississippi Valley Division (MVD) has prepared NFIP Levee System Evaluation Reports (NLSER) for the MR&T Project and results are provided to FEMA for their use in map modernization efforts. A positive NLSER is a technical finding that, for the flood plain in question, there is a reasonable certainty that the levee system will protect the floodplain from the 1% annual chance exceedance flood, aka 100 year flood. NLSERs help communicate the risks associated with living or working behind the MR&T Project levee system to our partners and stakeholders with regards to public safety and floodplain management.

Appendix A

Memphis District Individual Levee System Evaluation Reports

Appendix B

Vicksburg District Individual Levee System Evaluation Reports

Appendix C

New Orleans District Individual Levee System Evaluation Reports

Appendix D

Glossary

Terms and Abbreviations

100-year flood (for NFIP levee system evaluation and FEMA mapping accreditation) - The median peak flood discharge having a 1% annual chance exceedance expressed as a return period.

Accredited levee - A levee that the Federal Emergency Management Agency (FEMA) has shown on the Flood Insurance Rate Map as providing protection from the 1% annual chance exceedance flood. This determination is based on the submittal of data and documentation as required by Section 65.10 of the National Flood Insurance Program regulations. FEMA will accredit a levee that has been determined to be found in accordance with NFIP levee system evaluation requirements by federal agencies with levee design and construction competence, such as U.S. Army Corps of Engineers (USACE), or by a registered professional engineer.

Annual chance exceedance flood - The flood that has a (stated percent- %) chance of being equaled or exceeded in any given year, such as the 1% annual chance flood.

Annual exceedance probability (AEP) - The probability that a random variable (e.g. flood discharge or stage) will occur in any given year considering the full range of annual possible flood discharges.

Assurance - The probability that a target stage will not be exceeded during the occurrence of a specified flood. For example, USACE requires that, for a levee system to be found in accordance with NFIP levee system evaluation requirements, it must have at least a 90 percent chance of not being overtopped when subjected to the estimated 1% annual chance exceedance flood. Term selected to replace 'conditional non-exceedance probability'.

Base flood (FEMA BF) - The flood that has a median estimate of 1% annual chance of being equaled or exceeded in any given year.

Base flood elevation (BFE) - The water surface elevation of the median estimate of the 1% annual chance exceedance flood.

Community - Any state or area or political subdivision thereof, or any Indian tribe or authorized tribal organization, or Alaska Native village, or authorized native organization that has the authority to adopt and enforce floodplain management regulations for the areas within its jurisdiction.

Conditional non-exceedance probability (CNP, replaced by 'assurance') -

Deterministic analysis - A technical analysis approach that is accomplished using single values for key variables as opposed to using a probability distribution of values for the key variables (which acknowledges and incorporates uncertainty).

Digital flood insurance rate map (DFIRM) - A Flood Insurance Rate Map (FIRM) that has been prepared as a digital product. Linkages are built into an associated database to allow users options to access the engineering backup material used to develop the DFIRM, such as hydrologic and hydraulic models, flood profiles, data tables, digital elevation models (DEMs), and structure-specific data, such as digital elevation certificates and digital photographs of bridges and culverts.

Federal Emergency Management Agency (FEMA) - The agency within the Emergency Preparedness and Response Directorate of the U.S. Department of Homeland Security. FEMA oversees the administration of the National Flood Insurance Program.

Flood damage reduction - The objective of flood-related projects, systems, structures, or measures. These include structural and non-structural measures taken to reduce flood damage. These may include implementation of reservoirs, detention storage, channels, diversions, levees, interior drainage systems, flood-proofing, raising, relocation, and flood warning and preparedness actions.

Flood-frequency - A graph, table, or single tabulation showing the relationship of the flood variable of interest (peak flow, peak stage, 3-hour volume, etc.) to the probability of the variable being equaled or exceeded in any given year.

Flood insurance rate map (FIRM) -The insurance and floodplain management map produced by FEMA that identifies, based on detailed or approximate analyses, the areas subject to flooding during a 1% annual chance exceedance (1 00-year) flood event in a community. Flood insurance risk zones, which are used to compute actuarial flood insurance rates, also are shown. In areas studied by detailed analyses, the FIRM shows Base Flood Elevations (BFEs) to reflect the elevations of the 1% annual chance exceedance flood. For many communities, when detailed analyses are performed, the FIRM also may show areas inundated by 0.2% annual chance exceedance (500-year) flood and regulatory floodway areas.

Flood map modernization (Map Mod) program - The multiyear program undertaken by FEMA to perform flood hazard assessments and produce new or updated DFIRMs and Flood Insurance Study (FIS) reports for flood-prone communities throughout the United States.

Freeboard - The increment of levee height added to the design flood height to increase the likelihood of the design event being contained without the levee overtopping.

Incised channels - Incised channels are flood damage reduction channels wherein the design water surface is below the natural ground levels.

NFIP levee system evaluation - The purpose of an NFIP levee system evaluation is to determine how flood hazard areas behind levees are mapped on FIRMs. The resultant maps are used to determine flood insurance rates; federal, state, and local floodplain management requirements; and other floodplain management decisions. It should be noted here that the definition of 'NFIP levee system evaluation' for the purposes of USACE application under this EC is consistent with definitions in 44 CFR 65. Once a positive finding is made in an NFIP levee system evaluation, accreditation of the levee system by FEMA is required and is the final determining factor on how areas protected by levee systems are mapped.

NFIP levee system evaluation determination - This is a technical finding by a registered professional engineer that, for the floodplain in question, there is, or is not, a reasonable certainty that the levee system will provide protection from the 1% annual chance exceedance flood. A 'there is' answer leads to a positive finding, and an 'is not' answer means a negative finding for NFIP levee system evaluation thus, accreditation is not supported.

Levee system - A levee system comprises one or more components, which collectively provide flood damage reduction to a defined area. Failure of one component within a system constitutes failure of the entire system. The levee system is inclusive of all components that are interconnected and necessary to ensure protection of the associated separable floodplain-levee and floodwall sections, closure structures, pumping stations, culverts, and interior drainage works. This diagram is an example of how levee systems are to be interpreted for the purposes of this EC.

Level-of-protection associated with NFIP levee system evaluation - The recurrence interval of flooding that with a high degree of assurance will not result in levee failure or overtopping that subsequently would inundate the protected area. As used herein, the full range of uncertainty in discharge or stage is considered but other elements of levee performance are based on deterministic analysis and criteria.

Life risk - The threat to loss of life from failure of a flood protection system or feature. Life risk is often expressed as an annual exceedance probability vs. incremental life lost function or expected value of that function (annual lives lost), sometimes referred to as 'annual statistical lives lost.'

Monte Carlo analysis - A method that produces a statistical estimate of a variable of interest by drawing many random samples from a set of variables with associated uncertainty or relationships of interest with their associated uncertainty. The method is typically used when values for variables are uncertain and best described by appropriate probability distributions.

National Flood Insurance Program (NFIP) - Federal program under which flood-prone areas are identified and flood insurance is made available to the owners of the property in participating communities.

Non-structural measures - Non-structural measures reduce flood damages without significantly altering the nature or extent of flooding. Damage reduction from non-structural measures is accomplished by changing the use made of the floodplains, or by accommodating existing uses to the flood hazard. Examples are flood proofing, relocation of

structures, flood warning and preparedness systems (including associated emergency measures), and regulation of floodplain uses.

Overtopping - A condition that occurs when the elevation of the still-water level and/or associated waves exceeds the top of the levee or system.

Probability - A measure of the likelihood, chance, or degree of belief that a particular outcome or consequence will occur. A probability provides a quantitative description of the likelihood of occurrence of a particular event. This is expressed as a value between zero and one**.**

Probabilistic analysis - The application of probability theory and statistical methods to make inferences about information, facility performance, and the associated uncertainty in inferences.

Probability function - A relationship between exceedance probability and a variable of interest. The function could be graphical, tabular, or analytical. For example, a discharge-exceedance or stage-exceedance probability relationship for a reach developed by traditional, site-specific, hydrologic engineering analysis procedures.

Public safety- Public safety involves the prevention of and protection from events that could endanger the safety of the general public from significant danger, injury/harm, or damage, such as natural and man-made disasters.

Reach - A levee reach is a portion of a levee system (usually a length of levee) that may be considered as a unit taken for analysis purposes to have uniform representative properties. A levee reach will be the unique entity having properties different from other reaches of the levee system and is used to determine the probability and uncertainty assessment of the levee system. No maximum length is associated with a reach.

Residual risk - The flood risk (probability of capacity exceedance or failure and the associated consequences) that remains after the flood damage reduction project is implemented.

Return period - Alternate term 'recurrence interval'. The average time interval, usually expressed in years, between occurrences of an event of a certain magnitude. Normally computed as the reciprocal of the annual chance exceedance.

Risk - Measure of the probability and severity of undesirable consequences.

Risk analysis - Risk analysis is a decision-making framework that comprises three tasks: risk assessment, risk management, and risk communication.

Risk and uncertainty analysis - Risk analysis that explicitly, and analytically, incorporates consideration of uncertainty of parameters and functions used in the analysis to determine the undesirable consequences.

Separable floodplain - The portion of a floodplain that may be protected by its associated levee system. See above definition for 'Levee system' and associated diagram for further clarification

Special flood hazard area (SFHA) - The area delineated on a National Flood Insurance Program map as being subject to inundation by the FEMA BF.

Stage - Water height measured as the vertical distance in feet (meters) above or below a local or national elevation datum.

Stage-discharge function (alternatively 'Rating Curve') - A tabular or graphical relationship that yields the stage for a given discharge at a specific location on a stream or river.

Stage-discharge functions with uncertainty - Relationship of the water surface stage and discharge. Uncertainty is the distribution of the errors of stage estimates about a specific discharge.

Standard deviation - A statistical measure of the spread of the values of a probability distribution about the mean.

Structural (measures) - Those water resources project measures designed to modify the flow of flood waters.

Uncertainty - A measure of the imprecision of knowledge of variables and functions used in the risk analysis. Uncertainty may be represented by a specific probability distribution with associated parameters, or sometimes expressed simply as standard deviation.

Abbreviations

ACI	American Concrete Institute
AEP	Annual Exceedance Probability
CFR	Code of Federal Regulations
CHL	Coastal and Hydraulics Laboratory
CMP	Corrugated metal pipe
CNP	Conditional non-exceedance probability
DFIRM	Digital Flood Insurance Rate Map
EC	Engineer Circular
EM	Engineer Manual
EP	Engineer Pamphlet
ER	Engineer Regulation
ERDC	Engineer Research and Development Center
EST	Empirical Simulation Technique
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
FMA	Failure Mode Analysis
FPMS	Floodplain Management Services (Program)
FRMP	Flood Risk Management Program
HEC	Hydrologic Engineering Center
HEC-FDA	Hydrologic Engineering Center- Flood Damage Reduction Analysis software program
HPS	Hurricane Protective System
ICW	Inspection of Completed Works Program
IHNC	Inner Harbor Navigation Canal
IPET	Interagency Performance Evaluation Team
ITR	Independent Technical Review
JPM	Joint Probability Method
JPM-OS	Joint Probability Method Optimal Sampling
LaCPR	Louisiana Coastal Protection and Restoration
NLSER	NFIP Levee System Evaluation Report
LF	Load factor
LIDAR	Light Detection and Ranging
LSO	Levee Safety Officer
Map Mod	FEMA Flood Map Modernization Program
MsCIP	Mississippi Coastal Improvement Project
NFIP	National Flood Insurance Program
PGA	Peak ground acceleration
QA/QC	Quality assurance/quality control
RIP	Rehabilitation and Inspection Program
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey

Appendix E

References

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