Dallas Floodway, Dallas, Texas
Final Feasibility Report

US Army Corps of Engineers

MAIN REPORT

December 2014

City of Dallas

Acronyms and Abbreviations

%	percent
AAHU	Average Annual Habitat Unit
AB	Able Basin
AEP	Annual Exceedance Probability
ALARP	As Low As Reasonably Practicable
ASA(CW)	Assistant Secretary of the Army for Civil Works
AT&SF	Atchison, Topeka and Santa Fe
BB	Baker Basin
BVP	Balanced Vision Plan
CB	Charlie Basin
CDC	Corridor Development Certificate
CEQ	Council of Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
Corps	U.S. Army Corps of Engineers
Corps HQ	Corps Headquarters
CWWTP	Central Wastewater Treatment Plant
DB	Delta Basin
DCFCD	Dallas County Flood Control District
DCLID	Dallas County Levee Improvement District
DDR	Design Documentation Report
DFE	Dallas Floodway Extension
EA	Environmental Assessment
EAD	Equivalent Annual Damages
EAP	Emergency Action Plan
EIS	Environmental Impact Statement
ELIDS	East Levee Interior Drainage System
EO	Executive Order
ER	Engineering Regulation
EWLIDS	East and West Levee Interior Drainage Systems
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FRM	Flood Risk Management
gpm	gallons per minute
HB	Hampton Basin
HEC	Hydrologic Engineering Center
HEC-FDA	Hydrologic Engineering Center – Flood Damage Reduction Analysis
HEC-FIA	Hydrologic Engineering Center – Flood Impact Analysis
HEC-RAS	Hydrologic Engineering Center – River Analysis System
HU	habitat unit
IDP	Interior Drainage Plan
IDS	Interior Drainage System
IG	Implementation Guidance
IH	Interstate Highway
K	thousand
LERRD	lands, easements, right-of-ways, and disposals
LRP	Levee Remediation Plan
MDCP	Maintenance Deficiency Correction Period
MDFP	Modified Dallas Floodway Project
MOU	Memorandum of Understanding
N/A	not applicable
NCTCOG	North Central Texas Council of Governments
NED	National Economic Development
NEPA	National Environmental Policy Act
NER	National Ecosystem Restoration
NPV	Net Present Value
NTTA	North Texas Tollway Authority
O&M	Operations and Maintenance
OMRR&R	Operations, Maintenance, Repair, Replacement, and Rehabilitation
P&S	plans and specifications
PAR	Population at Risk
PB	Pavaho Basin
PED	Pre-construction, Engineering and Design
PFM	Potential Failure Mode
PI	Periodic Inspection
PMP	Project Management Plan
POV	personal occupancy vehicle
PPA	Project Partnership Agreement
RMC	Risk Management Center
ROD	Record of Decision
SH	State Highway
SPF	Standard Project Flood
TCEQ	Texas Commission on Environmental Quality
TPWD	Texas Parks and Wildlife Department
TRC	Trinity River Corridor
TRCP	Trinity River Corridor Project
TRCCLUP	Trinity River Corridor Comprehensive Land Use Plan
TREIS	Trinity River Environmental Impact Statement
TSP	Tentatively Selected Plan
U.S.	United States
USFWS	U.S. Fish and Wildlife Service
UTRFS	Upper Trinity River Feasibility Study
UTRB PEIS	Upper Trinity River Basin Programmatic EIS
WIK	work-in-kind
WLIDS	West Levee Interior Drainage System
WRDA	Water Resources Development Act
WRRDA	Water Resources Reform and Development Act

DALLAS FLOODWAY, DALLAS, TEXAS

FINAL FEASIBILITY REPORT

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APPENDICES

DALLAS FLOODWAY, DALLAS, TEXAS
FINAL FEASIBILITY REPORT
Errata Sheet
February 2015

1) The Final Feasibility Report was updated following the final National Environmental Policy Act Review, to Fiscal Year 2015 Price levels and discount rates, per Economic Guidance Memorandum 15-01. The following tables replace Tables ES-14 and ES-15 on Pages ES–24 and ES-25 of the Final Feasibility Report, respectively.

Table ES-14. Cost Estimate Summary for the Modified Dallas Floodway Project

Total First Cost October 2015 Price Level	
FLOOD RISK MANAGEMENT	
01 Lands and Damages	$12,321,000
08 Roads, Railroads, and Bridges	$1,527,000
11 Levees and Floodwalls	$6,663,000
13 Pumping Plant	$179,035,000
30 Planning, Engineering and Design	$20,210,000
31 Construction Management	$21,901,000
Flood Risk Management Total	**$241,657,000**
ECOSYSTEM RESTORATION	
01 Lands and Damages	$17,000
02 Relocations	$42,649,000
06 Fish and Wildlife	$5,903,000
08 Roads, Railroads and Bridges	$38,931,000
09 Channels	$185,650,000
30 Planning, Engineering and Design	$30,106,000
31 Construction Management	$26,679,000
Ecosystem Restoration Total	**$329,935,000**
Total	**$571,592,000**

Table ES-15. Cost Share Summary of the Recommended Plan First Costs With Credit Consideration - October 2015 Price Level

Feature	*Federal*	*Non-Federal*	*Total*
FLOOD RISK MANAGEMENT			
Construction	$157,077,000		$157,077,000
Lands, Easements, Right-of-ways, and Disposals (LERRDs)		$12,321,000	$12,321,000
5% Cash		$12,083,000	$12,083,000
Credit		$47,740,000	$47,740,000
Additional Cash		$12,436,000	$12,436,000
Subtotal	**$157,077,000**	**$84,580,000**	**$241,657,000**
Percentage	**65%**	**35%**	
ECOSYSTEM RESTORATION			
Construction	$214,458,000		$214,458,000
LERRDs		$42,666,000	$42,666,000
Credit		$25,739,000	$25,739,000
Additional Cash		$47,072,000	$47,072,000
Subtotal	**$214,458,000**	**$115,477,000**	**$329,935,000**
Percentage	**65%**	**35%**	
Subtotal Combined Flood Risk Management/Ecosystem Restoration	**$371,535,000**	**$200,057,000**	**$571,592,000**
Combined Percentages	**65%**	**35%**	

2) The Final Feasibility Report was updated following the final National Environmental Policy Act Review, to Fiscal Year 2015 Price levels and discount rates, per Economic Guidance Memorandum 15-01. The following tables replace Table 5-2 and Table 5-4 on Pages 5-2 and 5-10 of the Final Feasibility Report, respectively.

Table 5-2. Cost Estimate Summary for the Modified Dallas Floodway Project

Total First Cost October 2014 Price Level	
FLOOD RISK MANAGEMENT	
01 Lands and Damages	$12,321,000
08 Roads, Railroads, and Bridges	$1,527,000
11 Levees and Floodwalls	$6,663,000
13 Pumping Plant	$179,035,000
30 Planning, Engineering and Design	$20,210,000
31 Construction Management	$21,901,000
Flood Risk Management Total	**$241,657,000**
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Ecosystem Restoration Total	**$329,935,000**
Total	**$571,592,000**

Table 5-4. Cost Share Summary of the Recommended Plan First Costs With Credit Consideration - October 2014 Price Level

Feature	*Federal*	*Non-Federal*	*Total*
FLOOD RISK MANAGEMENT			
Construction	$157,077,000		$157,077,000
Lands, Easements, Right-of-ways, and Disposals (LERRDs)		$12,321,000	$12,321,000
5% Cash		$12,083,000	$12,083,000
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Combined Percentages	**65%**	**35%**	

3) The Final Feasibility Report was updated following the final National Environmental Policy Act Review, to Fiscal Year 2015 Price levels and discount rates, per Economic Guidance Memorandum 15-01. The following table replaces Table ES-7 on Page ES-12 of the Final Feasibility Report based on those updates.

Table 4-2. Economic Summary of the NED Plan
(October 2014 Price Level/3.5% Federal Interest Rate)

INVESTMENT	3.375 Percent	7 Percent
Construction	$8,190,000	$8,190,000
PED	$933,000	$933,000
Construction Management	$831,000	$831,000
Estimated First Cost	$9,954,000	$9,954,000
Annual Interest Rate	3.375%	7.0%
Project Life (years)	50	50
Construction Period (months)	22	22
Interest During Construction	$310,000	$646,000
Investment Cost	$10,265,000	$10,601,000
Interest	$346,000	$742,000
Amortization	$81,000	$26,000
OMRR&R ($/year)	$31,000	$31,000
TOTAL ANNUAL CHARGES	**$459,000**	**$799,000**
Without Project EAD	$5,650,000	$5,592,000
Residual EAD	$3,913,000	$3,869,000
Flood Reduction Benefits	$1,737,000	$1,723,000
TOTAL BENEFITS	**$1,737,000**	**$1,723,000**
NET BENEFITS	**$1,278,000**	**$924,000**
BENEFIT-COST RATIO	**3.8**	**2.2**

4) The Final Feasibility Report was updated following the final National Environmental Policy Act Review, to Fiscal Year 2015 Price levels and discount rates, per Economic Guidance Memorandum 15-01. The following table replaces Table 4-2 on Page 4–4 of the Final Feasibility Report based on those updates.

Table 4-2. Economic Summary of the NED Plan
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EXECUTIVE SUMMARY

STUDY INFORMATION

This report documents the results of a feasibility study initiated in response to Section 5141 of the Water Resources Development Act (WRDA) of 2007 (Public Law 110-114), as amended by Section 4013 of the Water Resources Reform and Development Act of 2014 (Public Law 113-121). This report was developed as a cooperative effort by the United States Army Corps of Engineers (Corps) Fort Worth District and the City of Dallas, Texas (non-Federal sponsor). Further, since implementation of any plan under Section 5141 of WRDA 2007 represents a significant Federal action, an Environmental Impact Statement (EIS) in accordance with the National Environmental Policy Act (NEPA) of 1969, as amended, was required. The EIS was prepared and provided separately.

The purpose of the study was to determine whether the City of Dallas' Balanced Vision Plan (BVP) and Interior Drainage Plan (IDP) were technically sound and environmentally acceptable in accordance with the authorization of Section 5141 of WRDA 2007, as amended. It also identified which features of the BVP and IDP will modify the existing Dallas Floodway Project under Section 5141 of WRDA 2007, as amended. Once the feasibility report is approved by the Corps Headquarters (Corps HQ), a Director's Report would be processed for approval by the Assistant Secretary of the Army for Civil Works (ASA(CW)). The Director's Report would include a recommendation to the ASA(CW) for approval and signature of a Record of Decision (ROD) for the plan identified for implementation in this feasibility report. Should the feasibility report be approved by the ASA(CW), the project will not require additional authorization for construction (provided it falls within the parameters of the authorization of Section 5141 of WRDA 2007, as amended). This decision document identifies the BVP and IDP features that meet the Corps planning objectives, provides a technically sound and environmentally acceptable determination of those features, and proposes a Recommended Plan to be implemented as the Modified Dallas Floodway Project (MDFP) under Section 5141 of WRDA 2007, as amended. The authorization also allowed for a "Comprehensive Analysis" described in the subsequent paragraphs. Additional details of the evaluation and identification of the MDFP and the Comprehensive Analysis are contained in the Study Overview Section of the main report (Section 1.7).

The existing Dallas Floodway Project is located on the Elm Fork, West Fork and Trinity River in Dallas, Texas. The project includes 22.6 miles of levees: 11.7 miles on the northeast levee (usually referred to as the East Levee) and 10.9 miles along the southwest levee (usually referred to as the West Levee). The East Levee provides flood risk benefits to the Stemmons Corridor (a major transportation route through the City of Dallas), and parts of Downtown Dallas and the Central Business District from flooding on the Trinity River, while the West Levee protects a large portion of West Dallas (largely residential areas).

Subsequent to the enactment of Section 5141 of WRDA 2007, the Fort Worth District issued the Periodic Inspection (PI) Report No. 9, dated March of 2009, which documented significant deficiencies with the existing structural integrity of the Dallas Floodway Project. It became readily apparent that this study was extremely complex with various actions requiring evaluation by the Corps including the deficiencies identified in the PI Report No. 9, multiple local projects requiring Section 408 approval (including the Trinity Parkway), and the Section 5141 of WRDA 2007 authority to review the BVP and IDP. The Section 408 approval process is described in detail in Section 1.7.4 of the main report. Therefore, as part of the Implementation Guidance (IG) prepared for Section 5141 of WRDA 2007 issued December of

2009, a plan was developed to lay out a framework to evaluate all components proposed for implementation within the study area. This plan is referred to as the "Comprehensive Analysis."

In order to perform the Comprehensive Analysis, the study was conducted in phases. To comply with the IG, the first phase addressed deficiencies with the levee system and formulated the Flood Risk Management (FRM) feature of the BVP utilizing National Economic Development (NED) criteria. The FRM feature then became a component of the BVP. Next, the remaining BVP and IDP features were evaluated to determine which met the Corps objectives and whether they were technically sound and environmentally acceptable. The features of the BVP and IDP that met the Corps objectives and were technically sound and environmental acceptable were recommended to be implemented as the MDFP under Section 5141 of WRDA 2007.

Then all proposed projects and features currently being planned within the Dallas Floodway Project (BVP, IDP, local features, and the Trinity Parkway) were evaluated in the Comprehensive Analysis. This analysis ensured that all of the proposed activities, even the ones already constructed, within the Floodway were compatible with the MDFP features and will not have significant adverse effects on the functioning of the existing Dallas Floodway Project from a system-wide standpoint.

The City of Dallas' BVP and IDP are projects, which address flood risk, environmental restoration and management, and parks and recreation that are part of a long-range vision for the entire Trinity River Corridor (TRC), commonly referred to as the Trinity River Corridor Project (TRCP). Other TRCP proposals include transportation projects, and community and economic development projects. These local features require a Section 408 review by the Corps.

Local features evaluated as part of the Comprehensive Analysis were evaluated against the MDFP and the existing Dallas Floodway Project. The local features included in the Comprehensive Analysis were the Trinity Parkway, Trinity River Standing Wave, the Santa Fe Trestle Trail, the Pavaho Wetlands, the Dallas Horseshoe Project, the Sylvan Avenue Bridge, Jefferson Memorial Bridge, Dallas Water Utilities Waterlines, Continental Bridge, and the East Bank/West Bank Interceptor Line. A complete list and status of the Section 408 approval process is provided in the main body of the report in Chapter 1, Table 1-1. The local projects evaluated in the Comprehensive Analysis follow a separate Section 408 approval process by the Corps.

PROBLEMS AND OPPORTUNITIES

The population of the Dallas-Fort Worth Metroplex has mushroomed to 6.5 million people, making it one of the 10 largest in the United States. The touchstone 1908 Dallas flood, which killed five people and left 4,000 homeless, set in motion what has become a series of major water projects to respond to this dynamic growth environment. Among the major actions were a major Trinity River relocation and levee construction program in the 1920s, a Federal levee system (that strengthened the original levee) constructed in the 1950s and construction of a series of upstream flood-control reservoirs (1952-1987).

Following Trinity River flooding in 1989 and 1990, the City of Dallas (in conjunction with regional stakeholders) began looking at ways to outline a long-range vision for the entire TRC. The vision aimed to reclaim the Trinity River as a great natural resource in order to create a unique public domain and achieve a model of environmental stewardship. In 1998, Dallas voters authorized the largest bond package in city history – $246 million – to fund flood control, recreation and transportation projects in the TRC. In the subsequent years of planning and community input, the City of Dallas and stakeholders developed concepts for addressing five key issues:

- Flood Risk Management;
- Environmental Restoration and Management;
- Parks and Recreation;
- Transportation; and
- Community and Economic Development (City of Dallas 2003).

The outcome of this effort culminated in "The Balanced Vision Plan" for the TRC (December 2003, amended March 2004). The BVP aims to create an environment that brings residents and development closer to a healthier TRC without diminishing the long-term effectiveness of the existing Dallas Floodway Project.

The same levees that provide flood damage benefits to the City of Dallas from Trinity River flood events also prevent the local stormwater runoff from draining directly to the river. The City of Dallas' reports entitled, "The Interior Levee Drainage Study, East Levee – Phase I, Dallas, Texas," dated September 2006, and "The Interior Levee Drainage Study, West Levee - Phase II, Dallas, Texas," dated February 2009 (City of Dallas 2006, 2009), identify means to reduce the stormwater flood risk for structures located within the predicted flood area for the 100-year, 24-hour storm event on the protected side of the levees. Collectively, these reports are referred to as the City of Dallas' IDP.

The BVP and IDP were developed by the City of Dallas to address problems and opportunities some of which are above those normally considered for implementation by the Corps. Transportation projects, and community and economic development projects, do not align with the traditional Corps missions and are generally the responsibility of locals and other Federal agencies. However, the Corps does have an interest in FRM and ecosystem restoration and an ancillary interest in providing recreation development. Problems and opportunities were identified, and goals and objectives were developed that align with the identified Corps mission areas of FRM and ecosystem restoration. These objectives were used to measure the success of individual measures and overall plans, as well as determine which parts of the BVP and IDP are recommended under Section 5141 of WRDA 2007 to modify the existing Dallas Floodway Project. The Corps also addressed problems, opportunities, goals and objectives for items outside the traditional Corps missions in the Comprehensive Analysis. These are presented under the water-related problems and opportunities, and goals and objectives below.

Flood Risk Management

The Dallas Floodway Project is composed of the East and West Levees and the area between the levees commonly referred to as the "Floodway." The Dallas Floodway Project encompasses the East and West Levees, Floodway and interior drainage system features including drainage structures, pressure sewers, pump stations and sump areas. Levee structural integrity issues were identified in the Periodic Inspection Report Number 9 (PI Report No. 9) for the Dallas Floodway Project, when the system received an overall "unacceptable" rating by the Corps in 2009. In response to PI Report No. 9, the City of Dallas prepared a Maintenance Deficiency and Correction Period (MDCP) plan that addressed 198 items listed in the PI Report No. 9. There were 21 levee integrity issues listed in the PI Report No. 9 that could be considered beyond routine maintenance and repair and were evaluated in this feasibility study. To quantify and evaluate risks posed by the East and West Levees associated with Trinity River flooding, the Corps performed a risk assessment. The findings in the risk assessment were instrumental in determining Dallas Floodway Project risks and solutions, and provided for a risk-informed decision on the path forward for the East and West Levees.

In addition to the risks associated with the levees themselves, the City of Dallas was also experiencing frequent inundation due to interior drainage on the protected side of the levees. While interior drainage is normally a local responsibility, the current authorization allows for Corps participation in this problem. The Federal Emergency Management Agency (FEMA) was proposing to remap the floodplain behind the levees not only due to the levee issues identified in PI Report No. 9, but also because the current condition of the Interior Drainage System (IDS) does not contain the 100-year flood event. The non-Federal sponsor is seeking FEMA certification for National Flood Insurance Program purposes as their floodplain management choice. Once the IDP features are implemented and the impact area of the 100-year floodplain is modified/improved, the areas outside the 100-year flood event would not be required to pay mandatory flood insurance and no development restrictions would be enforced. Using the risk assessment to define the baseline risks with the Dallas Floodway Project and the knowledge of the conditions of the existing IDS, problem and opportunity statements, followed by the corresponding objective to address flood risk were developed as shown in Table ES-1.

Table ES-1. Flood Risk Management Problems, Opportunities and Objectives

<table>
<tr><th>Problem 1</th><th>Opportunity 1</th><th>Objective 1</th></tr>
<tr><td>There is approximately $13.7 billion (in structure and content value) in floodplain investment behind the Dallas Floodway Project that is at risk from a failure of the levee system. There is approximately $5 million in remaining equivalent annual damages with the Dallas Floodway Project in place.</td><td>Reduce the likelihood of potential flood damages behind the levees.</td><td rowspan="5">Ensure the reliability and integrity of the current infrastructure and improve the functioning to further reduce residual flood risk to property while promoting life safety for the Dallas Floodway Project over a 50-year period of analysis.</td></tr>
<tr><th>Problem 2</th><th>Opportunity 2a</th></tr>
<tr><td rowspan="2">The levee system could overtop, overtop and breach, or breach prior to overtopping and could result in flood damages and loss-of-life.</td><td>Prevent the levees from overtopping, overtopping and breaching, and/or breaching prior to overtopping.</td></tr>
<tr><th>Opportunity 2b</th></tr>
<tr><td>Improve the City of Dallas’ Emergency Action Plan to address flood warning and evacuation.</td></tr>
<tr><th>Problem 3</th><th>Opportunity 3</th></tr>
<tr><td>Desiccation cracking on the levees has led to slope failures in the past and will continue to contribute to slope failures in the future.</td><td>Reduce future Operation and Maintenance costs of the Dallas Floodway Project by increasing stability and decreasing slope failures.</td></tr>
<tr><th>Problem 4</th><th>Opportunity 4</th><th>Objective 2</th></tr>
<tr><td>Undersized pumps and sumps result in flood damages behind the Dallas Floodway Project and general flooding on the protected side of the levees.</td><td rowspan="3">Increase pump and sump capacity to be able to discharge the 100-year flow.</td><td rowspan="3">Reduce the risk of flooding due to interior drainage.</td></tr>
<tr><th>Problem 5</th></tr>
<tr><td>FEMA updates may result in remapping of 100-year flood zones behind levee system that are not protected by 100-year interior drainage projects.</td></tr>
</table>

Aquatic Ecosystem Restoration

The major Trinity River relocation and levee construction program in the 1920s channelized the Trinity River and led to a number of ecological consequences for the aquatic ecosystem. Historically, the Trinity River contained natural channel forming processes that supported the function, structure and diversity of riparian and aquatic components of the riverine ecosystem. The losses to structure and function of the riverine system resulting from channelization and maintenance include:

- Lack of diverse in-channel habitat complexity due to the current structure of the Trinity River channel;
- Steep, uniform channel bank slopes;
- Riparian vegetation along the existing channel is relatively limited in extent, density and diversity; and
- Transition from in-channel to floodplain habitat is abrupt and limits habitat quality.

The degradations listed above provide an image of the structurally and functionally homogenous and restrained riverine system that characterizes the existing and future condition of the Trinity River. The result is degraded riverine habitat, which no longer supports the historic level of organism diversity at any trophic level. The restoration of some of the historic structure, function and dynamic nature of the Trinity River, such as those listed above, will capitalize on the opportunity to provide benefits to fish and wildlife in the Dallas Metroplex. Table ES-2 summarizes the aquatic ecosystem restoration problems and opportunities into one statement, followed by the corresponding objective.

Table ES-2. Aquatic Ecosystem Problems, Opportunities and Objectives

Problem 6	*Opportunity 5*	*Objective 3*
River function and habitat has been degraded over time due to relocation of the river channel within the Dallas Floodway.	Restore a more naturally functioning river within the Dallas Floodway to benefit fish and wildlife.	Restore to the extent possible the aquatic and riparian ecosystem of the Trinity River within the boundaries of the Dallas Floodway Project over a 50-year period of analysis.

Water Related Problems and Opportunities

Other TRCP proposals address ancillary ecosystem restoration, as well as parks, recreation, transportation, and community and economic development. The community and economic development projects are embedded within the Comprehensive Analysis projects. These local features require a Section 408 review and approval by the Corps prior to construction activities. Because the local features were analyzed in the Comprehensive Analysis does not mean they will be approved through the Section 408 approval process. For the items of the BVP and IDP not recommended under Section 5141 of WRDA 2007 to modify the existing Dallas Floodway Project, the City of Dallas wishes to pursue under Section 408. The local features included in the Comprehensive Analysis with their key “primary” issue indicated in parentheses:

- Trinity Parkway (transportation);
- Trinity River Standing Wave (parks and recreation);
- Santa Fe Trestle Trail (parks and recreation);
- Pavaho Wetlands (environmental restoration and management);
- Dallas Horseshoe Project (transportation);
- Sylvan Avenue Bridge (transportation);

- Jefferson Memorial Bridge (transportation);
- Dallas Water Utilities Waterlines (water and wastewater service [community projects]);
- Continental Bridge (parks and recreation);
- East Bank/West Bank Interceptor Line (water and wastewater service [community projects]); and
- Remaining IDP and BVP features (flood risk, environmental restoration and parks and recreation).

There are limited recreational opportunities available in the Dallas Floodway, and most people do not perceive the Dallas Floodway as a desirable destination for active recreation, festivities or nature observation. There is also inadequate access to the Dallas Floodway, which hampers the public's ability to enjoy the limited existing recreational opportunities. There is a latent recreation demand for open space and water-related recreation in the downtown area. While this is not a primary mission area for the Corps, there is an opportunity to increase recreational opportunity along the vast areas of the Dallas Floodway Project. The City of Dallas and the Corps decided the major recreation features were beyond what the Corps would traditionally participate in and decided that they should not be included for cost sharing purposes and the City of Dallas should seek approval to construct those features through a separate Section 408 process. Therefore, the recreation features were eliminated from consideration from a cost share perspective.

Transportation improvements are proposed to address traffic congestion and deficiencies with the existing roadway facilities within the downtown Dallas area to address current and projected transportation needs and deficiencies in existing roadway facilities. The primary purpose of the transportation improvements is to provide safe and efficient transportation solutions to manage traffic congestion and improve safety in the area of the Dallas Central Business District.

Overall, the Corps goal in the Comprehensive Analysis was to ensure the projects would function on a system-wide basis and the combined features would not impact the functioning of the MDFP. During this process the Corps reviewed each feature to ensure that it could meet Corps engineering and safety standards. While this was not considered a Section 408 review, it will be helpful for reviewing future Section 408 packages that are submitted for review. The Corps problems, opportunities and objectives for the Comprehensive Analysis are listed in Table ES-3. The objective was developed to achieve the overall goal and allow for other local and Federal entities to submit their Section 408 submittal packages for Corps approval once the Comprehensive Analysis was complete. The Comprehensive Analysis modeled features collectively and not on an individual basis. Projects were analyzed at an individual level under the Corps Section 408 review process.

Table ES-3. Water-Related Problems, Opportunities and Objectives

Problem 7	*Opportunity 6*	*Objective 4*
There is latent recreation demand for open space and water related recreation in the downtown Dallas area.	Increase recreational opportunity along the vast areas of the Dallas Floodway Project.	Ensure local projects do not impact the functioning or integrity of the Dallas Floodway System.
Problem 8	*Opportunity 7*	
Several proposals to modify the Dallas Floodway Project have the potential to impact the functioning of the Dallas Floodway Project.	The Corps could take a bigger role in project design and implementation to ensure major project features do not impact the authorized functioning of the Dallas Floodway Project.	

GOALS, OBJECTIVES AND PLANNING CRITERIA

The City of Dallas' overall goal is to create an environment that brings residents and development closer to a healthier TRC without diminishing the long-term effectiveness of the Dallas Floodway Project. The objectives prepared during the course of developing the BVP by the City of Dallas results in diverse and potentially conflicting objectives of:

- Providing improved flood risk management for the full length of the TRC in a way that also allows for the achievement of environmental, recreational, mobility and economic goals;
- Implementing environmental responsibility, restoration and proper management initiatives in the midst of an urban setting;
- Creating a recreation and urban open space amenity that does not interfere with vehicular traffic or periodic floodwaters;
- Meeting stated regional transportation goals in a way that supports economic development and air quality improvement; and
- Creating community and economic opportunities for the neighborhoods bordering the Trinity River and thus forming the centerpiece for a major urban region (December 2003, amended March 2004).

While the City of Dallas had broad goals for the entire TRC, the Corps is somewhat limited to determining what combination of the BVP and IDP best align with Corps missions and objectives for recommending the MDFP under Section 5141 of WRDA 2007. The overarching Corps goal is to improve the existing Dallas Floodway Project and ensure the flood risk function of the project. The following are objectives to address the problems and opportunities identified in the previous section for both the Section 5141 of WRDA 2007 and Comprehensive Analysis:

- Ensure the reliability and integrity of the current infrastructure and improve the functioning to further reduce residual flood risk to property while promoting life safety for the Dallas Floodway Project over a 50-year period of analysis;
- Reduce the risk of flooding due to interior drainage;
- Restore to the extent possible the aquatic and riparian ecosystem of the Trinity River within the boundaries of the Dallas Floodway Project over a 50-year period of analysis; and
- Ensure local projects do not impact the functioning or integrity of the Dallas Floodway System.

In accordance with the IG, economic analyses and recommendation of a NED and National Ecosystem Restoration (NER) plan was not required to recommend the BVP or IDP to modify the existing Dallas Floodway Project. However, the planning objectives were developed to support the Recommended Plan for the MDFP using sound judgment and prudent analytical approaches. Features of the BVP and IDP related to flood risk were formulated using criteria as shown in Table ES-4. Even though not required, NED criteria was utilized to develop a FRM plan concentrating on river flooding in order to see if it would be economically justified.

Table ES-4. Flood Risk Management Objectives and Decision Criteria

Objective 1	*Measurement 1*	*Decision Criteria 1*
Ensure the reliability and integrity of the current infrastructure and improve the functioning to further reduce residual flood risk to property while promoting life safety for the Dallas Floodway Project over a 50-year period of analysis.	Show reduction in Estimated Annual Damages using the Hydrologic Engineering Center – Flood Damage Reduction Analysis model.	The alternative that maximizes net economic benefits was considered for modification to the Dallas Floodway Project.
	Measurement 2	*Decision Criteria 2*
	Show reduction in Annualized Loss-of-Life estimates using the Hydrologic Engineering Center – Flood Impact Analysis model.	An alternative that reduces the annualized Loss-of-Life was considered for modification to the Dallas Floodway Project.
	Measurement 3	*Decision Criteria 3*
	Estimated Cost to Save a Statistical Life Analysis.	An alternative that reduces the annualized Loss-of-Life and meets "As-Low-As-Reasonably-Practicable" criteria to address efficiency with a project proposal to reduce risk was considered for modification to the Dallas Floodway Project.
	Measurement 4	*Decision Criteria 4*
	Show reductions in Operations and Maintenance (O&M) costs using Net Present Value.	If an alternative sufficiently reduces the cost of O&M versus the present method of maintenance (fix-as-fails) it was considered for modification to the Dallas Floodway Project.
	Measurement 5	*Decision Criteria 5*
	Qualitative life safety concerns with the current conditions of the East and West Levee.	Other reasons such as the levee mowing hazards, construction cost efficiencies and achieving overall BVP goals were considered whether a modification to the Dallas Floodway Project is warranted.
Objective 2	*Measurement 6*	*Decision Criteria 6*
Reduce the risk of flooding due to interior drainage.	Show reductions in the number of structures affected by the 100-year, 24-hour storm event located on the landward side of the Dallas Floodway Project.	An alternative that reduces the number of structures affected by the 100-year, 24-hour storm event was considered for modification to the Dallas Floodway Project.
		Decision Criteria 7
		Qualitative life safety concerns with the current conditions of the East and West Levee Interior Drainage System were considered.

Features of the BVP related to aquatic ecosystem restoration were formulated using criteria presented in Table ES-5. It is important to note traditional formulation for NER including cost effectiveness and incremental cost analysis is not performed. The major environmental restoration and management features of the City of Dallas' BVP were analyzed as a whole and not evaluated in increments.

Table ES-5. Aquatic Ecosystem Objectives and Decision Criteria

Objective 3	*Measurement 7*	*Decision Criteria 8*
Restore to the extent possible the aquatic and riparian ecosystem of the Trinity River within the boundaries of the Dallas Floodway Project over a 50-year period of analysis.	Show increases in Average Annual Habitat Units over a 50-year period for the environmental restoration and management features of the BVP.	Major BVP environmental restoration and management features that align with the overall NER Objective by increasing the net quantity and/or quality of desired ecosystem resources were considered for modification to the Dallas Floodway Project.

During the Comprehensive Analysis, local features were reviewed against Corps engineer regulations and safety standards to ensure the projects would not have a significant adverse impact on the function of the MDFP. The review findings are contained in the technical appendices of this feasibility report. The findings are based on the level of design development of the individual local features at the time of the Comprehensive Analysis. Upon completion of the Comprehensive Analysis, the local interests were provided the results to use as an input into their Section 408 package. Technical analysis is contained in the individual local feature's Section 408 packages and not included in the feasibility report. The local features in the Comprehensive Analysis follow a separate Section 408 review process for approval. Features of the Comprehensive Analysis were evaluated using criteria presented in Table ES-6. It is important to note that the criteria established by the Trinity River and Tributaries Regional Environmental Impact Statement (TREIS) and ROD were only applied in the Comprehensive Analysis as a whole collection of projects. The TREIS ROD established criteria (ROD criteria) for actions that require a Corps permit to address hydrologic and hydraulic impacts for FRM purposes.

Table ES-6. Water-Related Objectives and Decision Criteria

Objective 4	*Measurement 8*	*Decision Criteria 9*
Ensure local projects do not impact the functioning or integrity of the Dallas Floodway System.	Local features were reviewed against Corps engineering and safety standards and for compatibility with the MDFP with the primary purpose of FRM.	Upon completion of the Comprehensive Analysis, local interests were provided input and allowed to submit a Section 408 package for review. However, this should not be construed as Section 408 approval under Policy and Procedural Guidance for 33 U.S. Code 408.
	Measurement 8a	
	Engineering and safety standards for the review included: • Hydraulic neutrality (ROD criteria); • Compliance with Engineer Regulations, Manuals and Technical Letters; • No increase in risk through a risk analysis; and • Completion of the EIS for the entire BVP and IDP.	

PLANS CONSIDERED FOR THE MODIFIED DALLAS FLOODWAY PROJECT

The following describes the plans considered to address the objectives for each Corps mission area for selection of the Recommended Plan for the Section 5141 of WRDA 2007, as amended. From those objectives, the Recommended Plan for the MDFP was identified. The Corps objectives for the MDFP included:

- Ensure the reliability and integrity of the current infrastructure and improve the functioning to further reduce residual flood risk to property while promoting life safety for the Dallas Floodway Project over a 50-year period of analysis;
- Reduce the risk of flooding due to interior drainage; and
- Restore to the extent possible the aquatic and riparian ecosystem of the Trinity River within the boundaries of the Dallas Floodway Project over a 50-year period of analysis.

The features that met the objectives were considered technically sound and environmentally acceptable and could be considered for the Recommended Plan for the MDFP. Other criteria for technically sound include adequate feasibility-level engineering and design, including a risk analysis. For environmental acceptability, the MDFP was analyzed as part of the larger BVP and IDP analyzed in the EIS.

Flood Risk Management – Trinity River Flood Risk

A variety of structural and nonstructural plans were developed that address the flood risk due to Trinity River flooding. The plan formulation focused on identifying a plan that maximizes NED in combination with a plan that reduces life-safety risk and maintains or improves levee resiliency. Plans that do not meet these criteria were eliminated from further consideration. The formulation process assumed the Dallas Floodway Extension Project (DFE) Project, as authorized, is fully constructed. Sixteen structural and nonstructural plans were initially considered and screened. Nine structural and nonstructural plans were carried forward for detailed evaluation due their ability to contribute to the objectives of the FRM component of the BVP including:

- Atchison, Topeka and Santa Fe Bridge (AT&SF) Modification;
- Levee Height Modification (Levee Raises);
- Levee Armoring;
- Levee Controlled Overtopping;
- Seepage Cut-Off Walls;
- Levee Side Slope Flattening;
- Improved Emergency Action Planning;
- Localized Buyouts; and
- Instrumentation.

Considering the nine plans above, a plan to maximize NED and reduced life-safety risks was identified. The NED Plan includes raising levee low spots in select locations to pass a 277,000 cubic feet per second (cfs) flow combined with the AT&SF Railroad Bridge modification because it was the plan with the most net benefits. The remaining structural plans listed above were removed from consideration from an economic standpoint. However, two additional plans were analyzed in a final array of alternatives for their ability to complement the NED Plan and further reduce life-safety risk.

The additional plans included in the final array were:

- The 277,000 cfs Levee Raise and AT&SF Railroad Bridge Modification with Controlled Overtopping; and
- The 277,000 cfs Levee Raise with AT&SF Railroad Bridge Modification with Cut-off Walls.

Additional localized nonstructural plans were evaluated to see whether remaining residual risk not captured by more comprehensive alternatives could contribute to the life-safety objective. The City of Dallas has an existing in-depth Emergency Action Plan (EAP) that identifies elderly populations over 65, special needs households, and other structures that should to be targeted for evacuation during flood events. Improvements to the existing plan will be implemented by providing floodplain inundation maps to the City of Dallas so emergency action personnel target the hardest hit areas first. Piezometers will be installed along the East and West Levee for seepage monitoring purposes, but are only required for the River Relocation. Localized buyouts were considered, but were not economically justified.

Once the NED Plan was identified utilizing economics, a risk assessment was performed to measure the changes in life-safety risk for the stand-alone alternatives (levee raises and armoring) and the final array for the overtopping and subsequent breach and internal erosion failure modes. The 277,000 cfs levee raise (including the modification to the AT&SF Railroad Bridge) on the East and West Levee reduces risk of overtopping with a subsequent breach but not below the recommended tolerable risk guideline. Levee armoring, controlled overtopping techniques and seepage cut-off walls were evaluated to see if a breach could be prevented before or following an overtopping thereby reducing life-safety risk. The analysis concluded that armoring, cut-off walls and controlled overtopping were not good methods for risk reduction because they were not cost effective and did little to reduce overall life-safety risk.

One of the City of Dallas' goals was to address FRM issues, so its BVP included raising the levees up to 2 feet above the SPF water surface profile combined with riverside side slope flattening to a 4-to-1, width-to-height ratio (4H:1V). The FRM component of the BVP was formulated per Corps NED guidance. It was determined through the formulation process (using NED analysis and loss-of-life estimates) that the 4H:1V side slopes or the systemwide 2-foot levee raise were not optimal measures for NED and life-safety risk reduction. The formulation process identified that raising levee low spots to pass the 277,000 cfs flow with 3H:1V side slopes, removal of the AT&SF Railroad Bridge modification, and EAP improvements was the NED Plan and the most efficient plan for reducing life-safety risk. Table ES-7 presents the economic summary of the NED Plan at the current interest rate and Office of Management Budget interest rate. Based on the safety hazard of mowing steep side slopes, its inclusion in the BVP, and operation and maintenance issues with levee slides, the non-Federal sponsor wishes to pursue construction of 4H:1V side slopes on the entire length of the riverward side of the East and West Levees, where the existing slopes are steeper than 4H:1V, at 100% non-Federal cost. The 4H:1V side slope flattening will be implemented as a betterment to the NED Plan.

Table ES-7. Economic Summary of the NED Plan (October 2013 Price Level)

	3.5 Percent	*7 Percent*
INVESTMENT		
Construction	$8,042,000	$8,042,000
Pre-Construction Engineering and Design	$901,000	$901,000
Construction Management	$800,000	$800,000
Estimated First Cost	$9,743,000	$9,743,000
Annual Interest Rate	3.5%	7.0%
50-year Period of Analysis (years)	50	50
Construction Period (months)	22	22
Interest During Construction	$315,000	$633,000
Investment Cost	$10,058,000	$10,376,000
Interest	$352,000	$726,000
Amortization	$77,000	$26,000
Operations, Maintenance, Repair, Replacement, and Rehabilitation ($/year)	$30,000	$30,000
TOTAL ANNUAL CHARGES	**$459,000**	**$782,000**
Without Project Equivalent Annual Damages (EAD)	$5,511,000	$5,456,000
Residual EAD	$3,817,000	$3,775,000
Flood Reduction Benefits	$1,695,000	$1,681,000
TOTAL BENEFITS	**$1,695,000**	**$1,681,000**
NET BENEFITS	**$1,236,000**	**$900,000**
BENEFIT-COST RATIO	**3.7**	**2.1**

Flood Risk Management - Interior Drainage

A variety of structural and nonstructural plans were developed that address the flood risk due to interior drainage flooding in the City of Dallas' IDP. The structural and nonstructural plans included:

- Removing structures in the floodplain;
- Increase sump storage capacity;
- Alter sump inflow hydrographs (detention);
- Increase pumping capacity;
- Construct new pressure sewers;
- Improve conveyance between sump ponds; and
- Gravity sluice improvements.

These plans were screened for their ability to contribute to flood risk reduction and consideration of their cost and hydraulic performance. In summary, the screening process resulted in a set of measures to implement within each drainage basin in the study area. Table ES-8 lists the features of the East and West Levee improvements that constitute the IDP. Implementation of the IDP would reduce predicted 100-year, 24-hour storm event, resulting in a significant reduction in the number of structures potentially affected by flooding. This risk reduction would serve to reduce potential stormwater flooding impacts to people and property in the City of Dallas. In addition, proposed improvements would modernize and extend the service life of existing facilities for at least another 50 years. When combined, the measures listed in Table ES-8 would provide an acceptable systemwide level of stormwater flooding protection to the City of Dallas for decades to come. Reductions in structures affected by the 100-year, 24-hour storm event were measured to determine whether the IDP feature met the objective for the study. The estimated reduction in number of structures affected by interior drainage flooding is 83% for the East Levee and 92% for the West Levee. Therefore, all the IDP features listed in Table ES-8 could be included in the

recommendation for the MDFP. The Able, Baker and Pavaho Pump Station features will be constructed prior to signing a Project Partnership Agreement (PPA); however, the City of Dallas has not requested credit for implementation of all those features. Additional discussion on this topic is provided in the cost sharing section of the Executive Summary, and within the main text of the report in Chapter 5.

Table ES-8. Interior Drainage Plan Features (East and West Levee)

Construct New 500,000-gpm Pump Station and Outfall Rehabilitate Existing Pump Station (New Hampton) Install Three, 60-inch Culverts beneath Empire Central Drive (Nobles Branch Sump) Demolish the Old Hampton Pump Station
Construct New 700,000-gpm Pump Station and Outfall (Baker No. 3 Pump Station) Minor Improvements to the Existing Baker Pump Station Minor Improvements to the Hampton-Oak Lawn Sump
Construct New 876,000-gpm Pump Station and Outfall (Able No. 3 Pump Station)
Construct New 250,000-gpm Pump Station in Trinity-Portland Sump Rehabilitate Existing Delta Pump Station Install One, 6-square foot Culvert between Trinity-Portland and Eagle Ford Sumps
Perform Minor Improvements to the Existing Pavaho Pump Station Construct New 381,000-gpm Pump Station at Pavaho
Demolish Existing Charlie Pump Station Construct New 225,000-gpm Pump Station

Aquatic Ecosystem Restoration

Major BVP features that have ecosystem restoration components and could be considered as Corps ecosystem restoration features include:

- River Relocation;
- Corinth Wetlands;
- Natural Lake; and
- Other various surface treatment wetlands throughout the Floodway.

The proposed River Relocation is an ecosystem restoration feature that has high potential of an uplift in function and is a feature that fits within the Corps mission of ecosystem restoration and should therefore be considered for inclusion into the plan if it meets the planning objectives.

The proposed Corinth Wetlands includes expanding an existing wetland at the downstream end of the Floodway. This wetland is currently degraded due to the current operations and maintenance activities within the Floodway. The proposal would improve the operation and maintenance and quality of the wetland to provide additional fish and wildlife habitat, especially for migratory birds. This feature is consistent with a typical Corps ecosystem restoration project and should be considered for inclusion into the plan if it meets the planning objectives.

The Natural Lake is one of the proposed primary borrow sources for the Trinity Parkway. The Trinity Parkway is being processed by the Corps under a separate 404 Permit Application as a single and complete project and it needs the borrow sites to minimize hydraulic impacts. If the Trinity Parkway is constructed, the plan would be to convert the borrow area into a lake. Even though it is called the Natural Lake, its primary purpose is to provide recreational opportunities for boating and kayaking. The edges of the lake would have soft sides and therefore emergent vegetation is proposed to provide environmental

quality features but the primary purpose would still be recreation which is above and beyond in what the Corps would normally participate. With this in mind, construction of the Natural Lake was not recommended for consideration in the MDFP.

Finally, the BVP includes several areas that would function as fringe wetlands or marshlands. These features were generally associated with recreation features such as the athletic fields. While they would provide an increase in habitat values from a structure and function perspective, the ongoing operations and maintenance, recreational activities, and lighting would generally prevent fish and wildlife from utilizing the areas without being frequently disturbed. Even though these features would serve an ecosystem function, they were not considered for inclusion in the MDFP. The Corps encourages the City of Dallas to incorporate these features into their design due to the benefits that they would serve from an environmental quality perspective, such as filtering nutrients.

Since the IG for Section 5141 of WRDA 2007 did not require that the Corps formulate for NER per normal planning guidance, no attempt was made to justify ecosystem restoration components of the MDFP using cost effectiveness and incremental cost analysis. Restoration components were generally selected on the basis of which BVP elements most closely met the intent of Corps policy guidance for ecosystem restoration projects. This was accomplished by: (1) evaluating the changes or improvements to habitat in the study area quantitatively using Habitat Evaluation Procedures; (2) qualitative discussion of the alignment with Corps policies for ecosystem restoration; and (3) qualitative discussion of the outputs of the ecosystem restoration features aligning with National and Regional Significance. Table ES-9 presents the average annualized habitat units in the study area between existing conditions, future without-project conditions, all of the MDFP features, and all of the MDFP features (plus the cumulative projects) over the 50-year period of analysis.

Table ES-9. Estimated Changes to Average Annual Habitat Units within the Study Area under the Modified Dallas Floodway Project

Habitat Type	*Average Annual Habitat Units*				
	Future Without-Project Conditions	*MDFP*	*Change*	*MDFP (Cumulative)*	*Change*
Bottomland Hardwood	273.35	278.16	4.81	275.55	2.20
Emergent Wetland	68.02	76.94	8.92	79.44	11.42
Grassland	1,559.56	1,300.47	-259.09	1,243.28	-316.28
Aquatic Riverine	235.60	360.55	124.95	356.29	120.69
Open Water	96.92	106.79	9.87	106.79	9.87
Total	2,233.45	2,122.91	-110.54	2,061.35	-171.10

The River Relocation and Corinth Wetlands have positive outputs of desired habitat types of bottomland hardwood, emergent wetland, and aquatic riverine. The River Relocation and Corinth Wetlands contribute to the planning objective developed for ecosystem restoration. Together they increase habitat quality by approximately 139 Average Annual Habitat Units (AAHU) over the future without-project condition for the desired habitat types over the 50-year period of analysis. In addition to improvements to habitat in the study area, the River Relocation and the Corinth Wetlands align with Corps policies for ecosystem restoration, and their outputs align with National and Regional Significance as described further in the main report in Chapter 3, Section 3.5.

It is important to note, the River Relocation is also required to implement several of the BVP features, and supports the recreation objective for the City of Dallas. The River Relocation presents the greatest risk to the functioning of the levee system due to the potential to increase seepage under the levees, which could

result in levee safety risk. This risk is mitigated with the installation of cut-off walls, but it still presents engineering challenges; therefore, it is recommended the design for this feature be completed by the Corps. For these reasons, combined with the contributions to the Corps objective for ecosystem restoration, the River Relocation and the Corinth Wetlands were included in the Recommended Plan for the MDFP.

Recreation and other items in the BVP

The BVP included several recreational features which were above and beyond what the Corps would generally participate. These features include the West Dallas and Urban Lakes, flex fields, and associated recreational facilities such as restrooms, parking lots, roads, trails, amphitheaters, etc. The Corps traditionally participates in more low impact (passive) recreation as part of a FRM project unless it is associated with a reservoir project. Therefore, the Corps is not including recommendations for any recreation features in the MDFP. However, these recreation features were included in the Comprehensive Analysis, along with the Natural Lake as remaining BVP features since the City of Dallas has submitted a Section 408 request to construct these features.

Plans Considered for the Modified Dallas Floodway Project Summary

Based on measuring the BVP and IDP features and their contributions to the planning objectives during the plan formulation process, the Corps identified the following features for potential inclusion for the Recommended MDFP.

- NED Plan (the 277,000 levee raise with AT&SF Railroad Bridge modification and EAP improvements);
- Levee Side Slope Flattening to 4H:1V (Betterment 100% locally funded);
- IDP Phase I (Able, Baker, and Hampton Pump Stations, and the Nobles Branch sump improvements);
- IDP Phase II (Charlie, Pavaho, Delta, and New Trinity Portland Pump Stations);
- River Relocation, and
- Corinth Wetlands.

The project features identified above are estimated to cost $713,500,000. This cost exceeds the Section 902 of WRDA 1986 cost limit for Section 5141 of WRDA 2007. Therefore, there were two options for moving forward. The Corps could recommend the project to Congress for additional authorization or formulate a project that still meets the objectives of the study and stays within the Section 902 cost limit. The Corps, in coordination with the City of Dallas, decided to identify a project that is within the Section 5141 cost limit; therefore, additional screening was required as described below.

Additional Screening for the Modified Dallas Floodway Project

Early in the study process it was found that the BVP and IDP had experienced significant cost growth since the authorization. The project was authorized in 2007 at $459,000,000 and the current cost estimate for the entire BVP and IDP (including original BVP FRM Features) is estimated at $1,400,000,000. There are multiple reasons for these cost growths. These include: (1) the project was authorized based on the City of Dallas' conceptual design prior to a feasibility report being completed so the cost estimates were not developed utilizing Corps standards; (2) inflation from 2003 to 2007 was not accounted for in the WRDA 2007 authorization; and (3) additional feasibility design confirmed major increases in most project features.

Through the formulation process of identifying the NED Plan for FRM and eliminating recreation from consideration from cost share, the cost shareable total of the BVP and IDP was brought down to $713,500,000. These cost shareable features were found technically sound and environmentally acceptable and within Corps traditional mission areas (cost shareable) as described above in this formulation section. The authorized project cost of $459,000,000 brought up to current price levels is $521,170,000. The cost estimate of $713,500,000 is well over this price for all features that are technically sound and environmentally acceptable. In accordance with guidance provided in the memorandum entitled "Civil Works Delegated Authority for Project Cost Management," dated May 29, 2013, the Corps and the City of Dallas decided to descope Corps participation in the project to fit within the existing 902 limit.

In accordance with the Section 5141 and the IG, the City of Dallas had the ability to advance features of the project prior to execution of the PPA. The City of Dallas decided to request and receive approval through the Section 408 process to construct Able, Baker and Pavaho Pump Stations to address immediate interior drainage flooding concerns. Pavaho is currently operational and Baker and Able are under construction. The City of Dallas determined it would rather stay within the Section 902 limit and not request credit for the pump stations they are currently constructing, thus removing them from the total project cost. Removing Pavaho ($32,500,000) and Able ($120,200,000) Pump Stations from the MDFP makes the total cost shareable project $560,839,000. While the revised MDFP is over $521,170,000, it is within the Section 902 limit of the project and the MDFP is still considered technically sound and environmentally acceptable.

Table ES-10 presents the revised annualized habitat units in the study area between existing conditions, future without-project conditions, and the MDFP and the MDFP (with cumulative projects) over the 50-year period of analysis to account for the removal of Pavaho and Able from the MDFP in the additional screening process. The increase in habitat quality is approximately 143 AAHUs under MDFP alone and 139 under MDFP (cumulative) conditions for the desired habitat types over the 50-year period of analysis. The River Relocation and the Corinth Wetlands still align with Corps policies for ecosystem restoration, and their outputs align with National and Regional Significance as described in Section 3.6.1.1. There was a small reduction in AAHU for the bottomland hardwood habitat type for the MDFP and MDFP cumulative with the descoped MDFP; however, there is still a positive gain in AAHU for bottomland hardwood habitat.

Table ES-10. Estimated Changes to Average Annual Habitat Units within the Study Area under the Recommended Modified Dallas Floodway Project

Habitat Type	*Average Annual Habitat Units*				
	Future Without-Project Conditions	*MDFP*	*Change*[1]	*MDFP (Cumulative)*	*Change*[1]
Bottomland Hardwood	273.35	276.54	3.19	274.89	1.54
Emergent Wetland	68.02	79.06	11.04	81.56	13.54
Grassland	1,559.56	1,299.86	-259.7	1,249.40	-310.16
Aquatic Riverine	235.61	364.55	128.94	359.82	124.21
Open Water	96.92	96.93	0.01	96.93	0.01
Total	**2,233.46**	**2,116.94**	**-116.52**	**2,062.6**	**-170.86**

Note: [1] "Change" refers to the difference between the MDFP alone and under cumulative conditions at year 50 as compared to the future without-project condition at year 50.

RECOMMENDED MODIFIED DALLAS FLOODWAY PROJECT

Following the additional screening summarized in the preceding section, the Recommended Plan for the MDFP includes:

- NED Plan (the 277,000 levee raise with AT&SF Railroad Bridge modification and EAP improvements);
- Levee Side Slope Flattening to 4H:1V;
- the IDP Phase I (Hampton and Baker Pump Stations, and the Nobles Branch sump improvements);
- the IDP Phase II (Charlie, Delta and New Trinity Portland Pump Stations);
- River Relocation; and
- Corinth Wetlands.

Table ES-11 displays how the features of the Recommended Plan contribute to the Corps planning objectives.

Table ES-11. Modified Dallas Floodway Project Recommended Plan and Alignment with Corps Planning Objectives

Objective 1	*Recommended Plan Feature*	*Contribution*
Ensure the reliability and integrity of the current infrastructure and improve the functioning to further reduce residual flood risk to property while promoting life safety for the Dallas Floodway Project over a 50-year period of analysis.	NED Plan (the 277,000 cfs levee raise with AT&SF Railroad Bridge modification and EAP improvements)	Residual risk is reduced from $5,551,000 to $3,817,000. Flood reduction benefits over a 50-year period are $1,236,000. Estimated reduction in probability and Loss-of-Life is over 50% for both the East and West Levees. Annualized life-safety risk is efficiently reduced.
	EAP Improvements (Flood Inundation Maps)	The high risk areas are areas that flood first, deepest and have residents with special needs. Emergency action personnel would target these structures first.
	Levee Side Slope Flattening to 4H:1V	The present method of maintenance is more economical; however, considering mowing hazards, and construction efficiencies, the 4H:1V side slopes are being pursued by the City of Dallas as a betterment.
Objective 2	*Recommended Plan Feature*	*Contribution*[1]
Reduce the risk of flooding due to interior drainage.	East Levee IDP Phase I	The IDP would result in an 83% reduction in potentially flooded structures behind the East Levee in the predicted 100-year, 24-hour storm event.
	West Levee IDP Phase II	The IDP would result in a 92% reduction of potentially affected structures behind the West Levee in the predicted 100-year, 24-hour storm event.

Objective 3	*Recommended Plan Feature*	*Contribution*
Restore to the extent possible the aquatic and riparian ecosystem of the Trinity River within the boundaries of the Dallas Floodway Project over a 50-year period of analysis.	River Relocation and Corinth Wetlands	The River Relocation and Corinth Wetlands increases habitat quality by approximately 143 AAHUs in the project area for the desired habitat types over the 50-year period of analysis.

Note:[1] Estimates include the entire IDP proposed by the City of Dallas; the Able and Pavaho Pumping Plants, which are not proposed in the Recommended Plan, are included in this estimate.

The BVP and IDP have several features that are not part of the Recommended Plan for implementation under Section 5141 of WRDA 2007, but can be constructed through the Section 408 permit process under the Rivers and Harbors Appropriations Act of 1899, as amended. The City of Dallas will be responsible for the construction of remaining features of the BVP and IDP and their associated cost, if approved through the Section 408 process. The City of Dallas will provide separate Section 408 approval submittals for Corps review that can reference the Comprehensive Analysis evaluation presented in this feasibility report.

TECHNICALLY SOUND AND ENVIRONMENTALLY ACCEPTABLE

The features that met the objectives were considered technically sound and could be considered for the Recommended Plan for the MDFP from an engineering perspective. Other criteria for technically sound included adequate feasibility-level engineering and design, including a risk analysis. The design completed for the MDFP during this phase was considered technically sound for the current stage of the projects and will provide a sound basis for future development of detailed design during the Pre-construction, Engineering and Design (PED) phase. This determination was also based on the fact that the MDFP meets the objectives of the study. The key objectives in this determination are Objectives 1, 2 and 3.

The first objective of the study was to ensure the reliability and integrity of the current infrastructure and to further reduce residual flood risk to property. While there would be slight increases in water surface elevations downstream, it was determined that these impacts were insignificant and the project was acceptable from a hydrologic and hydraulic perspective. Furthermore, through the risk assessment process it was determined that the MDFP did not impact the geotechnical conditions of the Floodway, but instead would have beneficial impacts by further reducing the risk of failure to the levee system from seepage. Finally, the MDFP will function with other proposed features within the Floodway footprint. Because the proposed MDFP would improve the functioning of the Floodway by further reducing flood risk and property damage when the levees are raised and the AT&SF Railroad Bridge is modified, it was considered to be technically sound under Objective 1.

The second objective of the study was to reduce the risk of flooding from interior drainage. The MDFP proposes improvements to Hampton, Baker, Delta, and Charlie Pump Stations and construction of the new Trinity Portland Pump Station to reduce the risk of flooding from interior drainage. By reducing the number of structures affected by the 1% flood event, the MDFP meets Objective 2. In addition, the IDP components do not impact the functioning of the Floodway from a hydrologic and hydraulic or geotechnical perspective and will function with other project components. Therefore, the MDFP was considered technically sound when considering Objective 2.

The third objective of the study was to restore the degraded aquatic and riparian ecosystem within the Dallas Floodway study area. The MDFP restores the aquatic and riparian ecosystems of the Trinity River and the adjacent floodplain. At the same time, due to mitigation measures such as cut-off walls, the MDFP improves the functioning of the Floodway from a geotechnical perspective. As part of the larger Comprehensive Analysis it does not affect the hydrology and hydraulics and it functions with other proposed projects within the Floodway. Therefore, the MDFP was considered technically sound when considering Objective 3.

Making feasibility-level technically sound determinations of multiple projects in various stages of design and construction carries with it some level of risk. The key risks identified in the Comprehensive Analysis were related to designs provided for the River Relocation, the BVP Lakes, BVP grading plans, bridge pier modifications, earthen berms separating the River Relocation and the BVP Lakes, the clay liner and lake drainage system associated with the BVP Lakes, River Relocation erosion control, and the Trinity Parkway Geotechnical Report. The risks were related to ensuring levee system integrity, level of design detail and integration of multiple projects across the Floodway. Risks were determined manageable at this stage given continued coordination and integration of design throughout the PED phase.

The proposed MDFP is environmentally acceptable at this point in the planning process. The final determination on environmentally acceptable will be made when the ROD is finalized.

COMPREHENSIVE ANALYSIS

Following identification of the Recommended Plan for the MDFP, the Corps performed the Comprehensive Analysis to ensure that all existing and proposed projects within the Floodway would meet Corps engineering and safety standards and the proposed projects would not have a significant adverse impact on the function of the MDFP at the feasibility-level design. The Corps objective for the Comprehensive Analysis was:

- Ensure local projects do not impact the functioning or integrity of the Dallas Floodway System.

Engineering and safety standards for the review include:

- Hydraulic neutrality (ROD criteria);
- Compliance with Engineer Regulations, Manuals and Technical Letters;
- No increase in risk through a risk analysis; and
- Completion of the EIS for the entire BVP and IDP.

The Comprehensive Analysis reviewed the entire BVP and IDP as well as the local projects against the criteria established for this phase. The conclusions of the review are summarized as follows.

Hydrology and Hydraulic Analysis

The results of the Comprehensive Analysis showed that the overall BVP and IDP did not meet the Trinity River Regional EIS ROD criteria in terms of valley storage and water surface rise. Potential negative impacts related to deviations from the ROD criteria were estimated to be insignificant and a variance to the ROD criteria can be recommended. The Recommended Plan for the Section 5141 of WRDA 2007 (the MDFP), does not require a variance to the ROD criteria. A variance would be required in the ROD for the remaining BVP and IDP features pending the Section 408 approval process.

Compliance with Engineer Regulations, Manuals and Technical Letters

The Corps reviewed the local features included in the Comprehensive Analysis and found that the local features met engineering and safety standards and were compatible with the MDFP at the feasibility-level design.

Risk Analysis

A Comprehensive Analysis phase risk assessment was performed on the major features of the BVP (BVP Lakes and the River Relocation) and the Trinity Parkway. The risk assessment noted that where the proposed river meanders move closer to the levees a seepage cut-off wall would be required as a mitigation feature. It is expected the BVP Lakes construction would not cause a seepage problem, but more robust remediation measures beyond the proposed clay liner in the lake might need to be implemented (e.g., an additional cut-off wall), pending additional analysis. The risk assessment found the Trinity Parkway embankment does no harm "geotechnically" and could have a slight favorable impact of improving consequences by delaying failure times and potential size of breach on the East Levee. Total risk was reduced for the East and West Levee based on the risk assessment conducted for the Comprehensive Analysis; however, risk remains above the recommended tolerable risk guideline because risk was dominated by Potential Failure Mode (PFM) #2 (overtopping and subsequent breach) on the East and West Levees.

Completion of the EIS for the BVP and IDP

In accordance with the NEPA of 1969, an EIS was prepared. The EIS describes the potential comprehensive environmental consequences resulting from the application of proposed FRM elements, ecosystem restoration features, recreation enhancement features, interior drainage plan improvements and other proposed projects in the Dallas Floodway Project. For the Comprehensive Analysis, the Corps and the City of Dallas developed an EIS for the entire BVP and IDP. The BVP and IDP were developed for both a with- and a without- Trinity Parkway condition. The following lists the alternatives considered in the EIS. Variations of the City of Dallas' BVP and IDP were considered and are described in greater detail in the EIS in Chapter 2.

- Alternative 1 – No-Action Alternative; and
- Alternative 2 – There are two variations in design of Alternative 2: (1) MDFP and Remaining BVP Features Design with the Trinity Parkway in the Future Condition; and (2) without the Trinity Parkway in the Future Condition.

The first design consists of the MDFP, and the City of Dallas' remaining BVP and IDP features not included in the MDFP that they are pursuing under Section 408. It also takes into consideration the Trinity Parkway. Table ES-12 summarizes the major features included in the first design. The second design is the MDFP with a slight variation of the remaining BVP features taking into consideration the Trinity Parkway is not built. Table ES-11 presents the features of the City of Dallas' BVP and IDP and the MDFP recommended under Section 5141 of WRDA 2007.

Table ES-12. BVP and IDP and the Modified Dallas Floodway Project

Category	*Description*	*WRDA*[1]	*Alternative 2*	
			MDFP	*BVP/IDP*[2]
BVP Flood Risk Management				
Levees	Raise to 277,000 cfs Flood Height	✓	✓	
AT&SF	Removal of Wood Bridge Segment	✓	✓	
	Removal of Concrete Bridge Segment	✓	✓	
	Removal of Embankment Segments	✓	✓	
Levee Flattening	Flattening the Riverside Levee Side Slopes to 4H:1V[3]	✓	✓	
Cut-off Wall	Extend Cut-off Wall along the East Levee[4]	✓	✓	
Nonstructural	Emergency Action Plan Improvements	✓	✓	
	Install piezometers in the Floodway[4]	✓	✓	
BVP Ecosystem and Recreation				
Lakes	West Dallas Lake	✓		✓
	Urban Lake	✓		✓
	Natural Lake	✓		✓
River	Realignment and Modification	✓	✓	
Wetlands	Marshlands	✓		✓
	Corinth Wetlands	✓	✓	
Athletic Facilities	Potential Flex Fields	✓		✓
	Playgrounds	✓		✓
	River Access Points	✓		✓
General Features	Parking and Public Roads	✓		✓
	Lighting	✓		✓
	Vehicular Access	✓		✓
	Pedestrian Amenities	✓		✓
	Forested Ponds	✓		✓
	Restrooms	✓		✓
Interior Drainage Outfall Extensions	Extend Pump Station Outfalls	✓	✓	
	Extend Pressure Sewer Outfalls	✓	✓	
Able Sump Ponds	Recreation and Ecosystem Enhancements	✓		✓
IDP Flood Risk Management				
East Levee	Demolish Old Hampton Pump Station	✓	✓	
	Construct New Hampton Pump Station		✓	
	Nobles Branch Sump Improvements	✓	✓	
	Construct New Baker Pump Station		✓[5]	
	Construct New Able Pump Station[6]	✓		
West Levee	Demolish Old Charlie Pump Station	✓	✓	
	Construct New Charlie Pump Station	✓	✓	
	Rehabilitate Existing Delta Pump Station	✓	✓	
	Construct New Trinity-Portland Pumping Plant	✓	✓	
	Construct New Pavaho Pump Station[6]	✓		
	Eagle Ford and Trinity-Portland Sump Improvements	✓		✓
	Pavaho and Delta Sump Improvements	✓		✓

Notes: [1] Includes Section 5141 of the WRDA 2007, as amended by WRRDA of 2014.

[2] Remaining non-Federal BVP elements to be completed by the City of Dallas under a future Section 408 submittal.

[3] Included in the MDFP, and entirely paid for by the City of Dallas as a betterment.

[4] Included in the MDFP as a risk mitigation feature of the River Relocation.

[5] The Baker Pump Station is part of the MDFP but was analyzed for NEPA compliance separately (Corps 2012).

[6] Able and Pavaho are not part of the MDFP and were processed under Section 408.

Comprehensive Analysis Conclusions

The Corps reviewed the local features included in the Comprehensive Analysis and found that the local features met engineering and safety standards and were compatible with the MDFP at the feasibility-level design. The Comprehensive Analysis review provided valuable baseline conditions for the Corps to use in current and ongoing Section 408 evaluations. Local interests may submit for approval under Policy and Procedural Guidance for 33 U.S. Code 408 the local features that meet the review criteria. The Corps will be responsible for the review of Section 408 projects. The review findings of the local features are contained in the technical appendices of this feasibility report. The findings are based on the level of design development of the individual local feature at the time of the Comprehensive Analysis. Upon completion of the Comprehensive Analysis the local interests were provided the results to use as an input into their Section 408 package. Technical analysis is contained in the individual local feature's Section 408 packages and not included in this feasibility report. If there are changes between the design analyzed here and future designs, additional analysis may be required for NEPA and regulatory compliance as well an engineering and safety design requirements. This analysis may include the potential for additional public and agency review and comment.

REMAINING SECTION 408 ACTIVITIES

Table ES-13 presents the status of the ongoing Section 408 reviews. The City of Dallas has expressed a desire to construct any BVP and IDP feature not included in the Recommended Plan for the MDFP as a Section 408 project at 100% local cost. As noted in the table, there are multiple projects proposed in the Floodway that will require close coordination between the project proponent and the Corps during the Section 408 review process. Section 5.2 of the main report contains additional detail of the construction dependencies between the MDFP, BVP, IDP and the local features. The MDFP is not dependent on any Section 408 project proposed for construction.

Table ES-13. Local Features Included in the Comprehensive Analysis

Ongoing Section 408 Project Status			
Figure F-2 Key[1]	**Project Name**	**Section 408 Approval Received**	**Section 408 Undergoing Evaluation**
7	Margaret Hunt Hill Bridge	X	
10	Pavaho Pumping Plant	X	
12	Santa Fe Trestle Trail	X	
13	Sylvan Bridge	X	
17	Trinity River Standing Wave (Dallas Wave)	X	
A	Baker Pumping Plant	X[2]	
D	Continental Pedestrian Bridge	X	
F	EF2 Wastewater Interceptor Line and Laterals (Tunnel 1)	X	
	EF2 Wastewater Interceptor Line and Laterals (Tunnel 2)	X	
G	Horseshoe Project (IH-30, IH-35)	X	
J	Jefferson-Memorial Bridge		X
O	Pavaho Wetlands	X	
R	SH-183 Bridge	X	
U	Trinity Parkway		X[2]
V	Able Pumping Plant	X	
	Remaining BVP Features		X[2]

Notes: [1] Adapted from the Environmental Impact Statement Cumulative Projects list for consistency. [2] Requires Corps HQ level of approval; the 408 for Trinity Parkway and Remaining BVP Features are currently under evaluation at the District.

PUBLIC AND AGENCY INPUT

The following summarizes the public and agency coordination for the feasibility report and the EIS. In accordance with NEPA, the Corps prepared and published a Notice of Intent in the *Federal Register* (Vol. 74, No. 195) on October 19, 2009 and hosted a public scoping meeting on November 17, 2009. The meeting provided the public and resource agencies an opportunity to learn about the project and provide input as to what components of the project are important to them, as well as what environmental resources the Corps should consider in formulation of plans and impact analysis. The Corps and the City of Dallas hosted another public meeting January 29, 2013 to provide an update to the public on the on-going feasibility study and outlined the proposed levee system improvements (NED Plan). On May 8, 2014, the Corps and the City of Dallas hosted a public meeting to solicit comments on the Dallas Floodway Project Draft EIS at Dallas City Hall, L1FN Auditorium, in Dallas, Texas. The purpose of the meeting was to solicit and facilitate input from interested parties for the Draft EIS. Approximately 180 comments were received, from about 30 commenters on the Draft Feasibility Report and EIS for the Dallas Floodway Project. Appendix A of the EIS includes the public comment response matrix for the draft reports. The public comments centered on the Trinity Parkway and concerns with the cost and design of the River Relocation component of the MDFP.

Since the initiation of the study effort in 2009, the Corps coordination and collaboration efforts include the NEPA public meetings; six joint City of Dallas and Corps PowerPoint presentations (three to public town halls, and three to stakeholder groups); four Dallas City Council or Council Committee project briefings; five days of Corps project information booths at Earth Day Events; and five days of Corps project information booths at other events, primarily located on event grounds between the two Dallas Floodway levees (two were held with the local Audubon Society).

The Corps coordinated with the U.S. Fish and Wildlife Service, Texas Parks and Wildlife Department and other Federal agencies throughout the study process. The Corps has also conducted resource-specific coordination with the State Historic Preservation Office. The Federal Highway Administration was a cooperating agency for the EIS. A resource agency meeting was held May 2, 2013, to discuss the development of the proposed project and to invite resource agencies to share any concerns or questions they might have regarding the project so that the project team could proactively address their input in the Draft EIS prior to initiating the public review. The Corps addressed concerns raised by the U.S. Environmental Protection Agency and the Federal Aviation Administration in their review of the Draft EIS regarding environmental justice and air traffic adjacent to the study area. Their concerns were resolved in the Final EIS.

COSTS

The costs associated with the final Recommended Plan for the MDFP are presented in Table ES-14. The plan is estimated to cost approximately $560,839,000 at October 2013 price levels. The fully funded cost estimate is $673,066,000. The fully funded cost estimate remains under the authorized cost limit for the project provided by Section 902 of $717,260,000. The project can proceed to design and construction without additional authorization from Congress. The project authorization allows the City of Dallas to receive credit for implementing project features in advance of signing a PPA. See Section 5.4.2 of the main report for a description of the features included in the total project cost.

Table ES-14. Cost Estimate Summary for the Modified Dallas Floodway Project

Total First Cost October 2013 Price Level	
FLOOD RISK MANAGEMENT	
01 Lands and Damages	$12,145,000
08 Roads, Railroads, and Bridges	$1,499,000
11 Levees and Floodwalls	$6,543,000
13 Pumping Plant	$176,490,000
30 Planning, Engineering and Design	$19,607,000
31 Construction Management	$21,364,000
Flood Risk Management Total	**$237,648,000**
ECOSYSTEM RESTORATION	
01 Lands and Damages	$16,000
02 Relocations	$44,881,000
06 Fish and Wildlife	$5,796,000
08 Roads, Railroads and Bridges	$38,229,000
09 Channels	$182,483,000
30 Planning, Engineering and Design	$29,046,000
31 Construction Management	$25,740,000
Ecosystem Restoration Total	**$323,191,000**
Total	**$560,839,000**

COST SHARING

Table ES-14 displays the cost sharing with the work-in-kind (WIK) credit available for the project. The Recommended Plan is estimated to cost $560,839,000 that would be cost shared 65% Federal at $364,545,000 and 35% non-Federal at $196,294,000. The project authorization allows the City of Dallas to receive credit for implementing project features in advance of signing the PPA. Post PPA work is excluded. By the time a PPA is executed, the City of Dallas is expected to have potential WIK credit. Table ES-15 displays the cost sharing taking into consideration how much credit the City of Dallas might be eligible for. Table ES-15 is only an estimate and the actual amount of credit would be finalized at the end of the project.

Table ES-15. Cost Share Summary of the Recommended Plan First Costs With Credit Consideration - October 2013 Price Level

Feature	*Federal*	*Non-Federal*	*Total*
FLOOD RISK MANAGEMENT			
Construction	$154,471,000		$154,471,000
Lands, Easements, Right-of-ways, and Disposals (LERRDs)		$12,145,000	$12,145,000
5% Cash		$11,882,000	$11,882,000
Credit		$47,740,000	$47,740,000
Additional Cash		$11,410,000	$11,410,000
Subtotal	**$154,471,000**	**$83,177,000**	**$237,648,000**
Percentage	**65%**	**35%**	
ECOSYSTEM RESTORATION			
Construction	$210,074,000		$210,074,000
LERRDs		$41,897,000	$41,897,000
Credit		$25,739,000	$25,739,000
Additional Cash		$45,481,000	$45,481,000
Subtotal	**$210,074,000**	**$113,117,000**	**$323,191,000**
Percentage	**65%**	**35%**	
Subtotal Combined Flood Risk Management/Ecosystem Restoration	**$364,545,000**	**$196,294,000**	**$560,839,000**
Combined Percentages	**65%**	**35%**	

TIMELINE

Public Review of the Draft Dallas Floodway Feasibility Report and EIS took place April 18, 2014 through June 17, 2014, and a Public Meeting was held May 8, 2014. The Final Independent External Peer Review Report was received June 17, 2014. A Civil Works Review Board was not required; however, a Senior Leadership Meeting took place November 7, 2014. A Director's Report is anticipated in January 2015. The ROD for the MDFP is scheduled to be signed in March of 2015.

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CHAPTER 1
STUDY INFORMATION

1.1 OVERVIEW

This report documents the results of a feasibility study initiated in response to Section 5141 of the Water Resources Development Act (WRDA) of 2007 (Public Law 110-114) as amended by Section 4013 of the Water Resources Reform and Development Act (WRRDA) of 2014 (Public Law 113-121). This report was developed as a cooperative effort by the United States Army Corps of Engineers (Corps) Fort Worth District and the City of Dallas, Texas (non-Federal sponsor). Further, since implementation of any plan under Section 5141 of WRDA 2007 represents a significant Federal action, an Environmental Impact Statement (EIS) in accordance with the National Environmental Policy Act (NEPA) of 1969, as amended, was prepared and provided separately.

1.2 STUDY AUTHORITY

The study was authorized by Section 5141 of WRDA 2007, which reads as follows:

> *(a) IN GENERAL.— The project for flood control, Trinity River and tributaries, Texas, authorized by Section 2 of the Act entitled, ''An Act authorizing the construction, repair, and preservation of certain public works on rivers and harbors, and for other purposes'', approved March 2, 1945 (59 Stat. 18), is modified to—*
>
> *(1) direct the Secretary to review the Balanced Vision Plan for the Trinity River Corridor, Dallas, Texas, dated December 2003 and amended in March 2004, prepared by the non-Federal interest for the project;*
>
> *(2) direct the Secretary to review the Interior Levee Drainage Study Phase-I report, Dallas, Texas, dated September 2006, prepared by the non-Federal interest; and*
>
> *(3) if the Secretary determines that the project is technically sound and environmentally acceptable, authorize the Secretary to construct the project at a total cost of $459,000,000, with an estimated Federal cost of $298,000,000 and an estimated non-Federal cost of $161,000,000.*
>
> *(b) CREDIT.—*
>
> *(1) IN-KIND CONTRIBUTIONS.—The Secretary shall credit, in accordance with section 221 of the Flood Control Act of 1970 (42 U.S. Code [U.S.C.] 1962d–5b), toward the non-Federal share of the cost of the project the cost of planning, design, and construction work carried out by the non-Federal interest for the project before the date of the partnership agreement for the project.*
>
> *(2) CASH CONTRIBUTIONS.—The Secretary shall accept funds provided by the non-Federal interest for use in carrying out planning, engineering, and design for the project. The Federal share of such planning, engineering, and design carried out with non-Federal contributions shall be credited against the non-Federal share of the cost of the project."*

The study was modified by Section 4013 of the WRRDA of 2014, which reads as follows:

> *SEC. 4013 Technical Corrections.*
>
> *(d) Trinity River and Tributaries. Section 5141(a)(2) of the Water Resources Development Act of 2007 (121 Stat. 1253 is amended by inserting "and the Interior Levee Drainage Study Phase-II report, Dallas, Texas dated January 2009," after "September 2006,".*

Once the feasibility report is approved by the Corps Headquarters (Corps HQ), a Director's Report would be processed for approval by the Assistant Secretary of the Army for Civil Works (ASA(CW)). The Director's Report would include a recommendation to the ASA(CW) for approval and signature of a Record of Decision (ROD) for the plan identified for implementation in this feasibility report. Should the feasibility report be approved by the ASA(CW), the project will not require additional authorization for construction (provided it falls within the parameters of the authorization of Section 5141 of WRDA 2007, as amended). The feasibility report will be a full response to Section 5141 of WRDA 2007.

1.3 STUDY PURPOSE AND SCOPE

The purpose of the study was to determine whether the City of Dallas' Balanced Vision Plan (BVP) and Interior Drainage Plan (IDP) were technically sound and environmentally acceptable in accordance with the authorization of Section 5141 of WRDA 2007, as amended. It also identified which features of the BVP and IDP will modify the existing Dallas Floodway Project under Section 5141 of WRDA 2007, as amended. The BVP and IDP address flood risk, environmental restoration and management, parks and recreation that are part of a long-range vision for the entire Trinity River Corridor (TRC), commonly referred to as the Trinity River Corridor Project (TRCP). Other TRCP proposals include transportation projects, and community and economic development projects. These other proposals were evaluated by the Corps in a comprehensive, system-wide assessment of the overall plan for implementing elements of the TRCP, to ensure the integrity of the Dallas Floodway Project. Collectively, these actions result in the development of a "Comprehensive Analysis" as defined in the Implementation Guidance (IG) for Section 5141 of WRDA 2007 and described in greater detail in Section 1.7. The IG for Section 5141 of WRDA 2007 and Section 4013 of WRRDA 2014 are included in Appendix K (Supplemental Documentation).

1.4 STUDY AREA

1.4.1 Upper Trinity River Watershed

The study area is situated within the Upper Trinity River Watershed (Figure 1-1, box inset), along the Trinity River near Dallas, Texas. The Upper Trinity River watershed is defined as the area from its headwaters to approximately Interstate Highway (IH) 20 Bridge (near Five Mile Creek) in south Dallas and covers about 6,275 square miles. It includes the majority of the Dallas-Fort Worth Metroplex. The headwaters of the three branches included in the Upper Trinity River Watershed (West, Elm, and Clear Forks) are generally north of the Dallas-Fort Worth Metroplex. Terrain in the Upper Trinity River watershed varies in elevation from about 1,200 feet at the headwaters of the West Fork of the Trinity River just northeast of Olney, Texas, to about 380 feet at the confluence with Five Mile Creek. Five Corps flood control reservoirs exist in the Upper Trinity watershed including: Lakes Benbrook, Lewisville, Grapevine, Joe Pool and Ray Roberts. Additional major Corps flood control projects in the Upper Trinity watershed include the Fort Worth Floodway, the existing Dallas Floodway Project, and the Dallas Floodway Extension (DFE) Project.

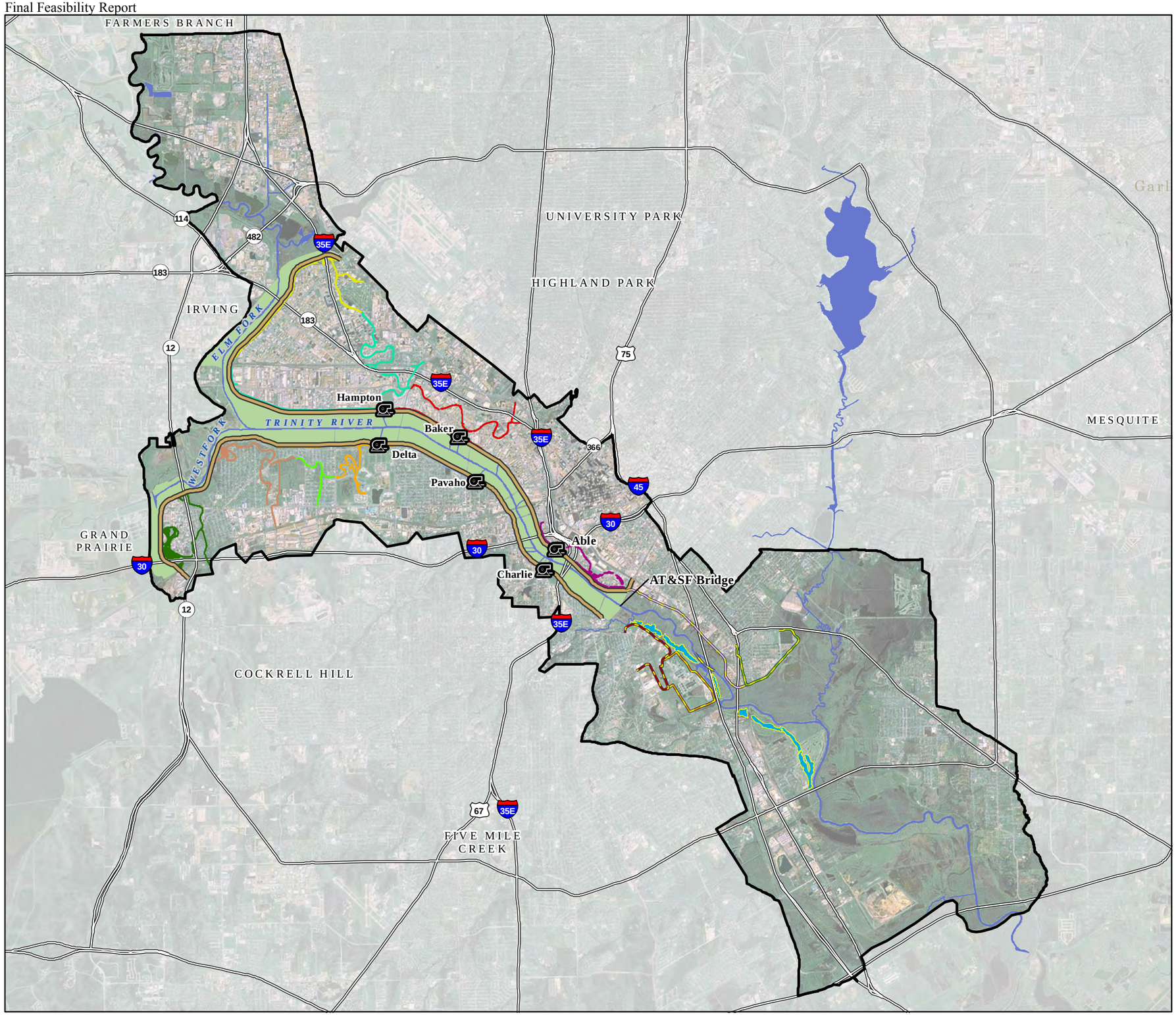


Figure 1-1
Dallas Floodway Study Area

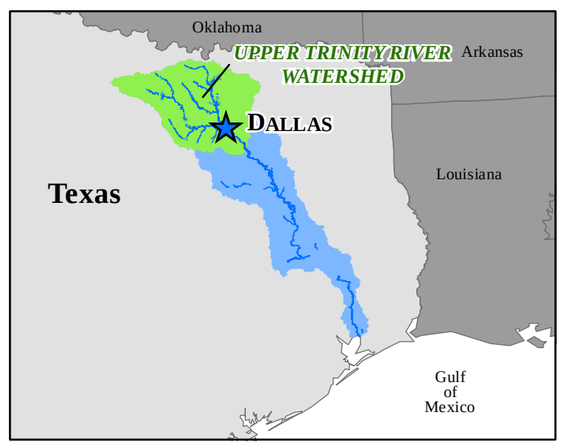
LEGEND

Study Area Features
- Pumping Plant
- Dallas Floodway Levee System Levee
- Freeway
- Study Area
- Dallas Floodway
- Surface Water

DFE Features
- Lamar Street Levee
- Cadillac Heights Levee
- Rochester Park Levee
- Central Wastewater Treatment Plant Levee Upgrade
- Trinity River Realignment

East Levee Sumps
- Able
- Hampton - Oak Lawn
- Nobles Branch
- Record Crossing

West Levee Sumps
- Charlie
- Eagle Ford
- Frances Street
- Pavaho
- Trinity - Portland
- Westmoreland - Hampton



0 0.5 1 2 Kilometers
0 0.5 1 2 Miles

Sources: City of Dallas 2008a, NCTCOG 2008

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The study area presented in Figure 1-1 was developed during the study process and corresponds to the resources analyzed in the accompanying NEPA document. The study area displayed here covers 48,263 acres, or approximately 19% of the land area of the City of Dallas.

The topographic data within the study area used for the study was based partially on a topographic mapping of the Trinity River floodplain compiled in 1991 and this data was based on the NGVD 29 vertical datum. However, the data used for the hydraulic modeling for most of the study area including the levee crest data was updated with more recent survey data from 2003 and was based on the NAVD 88 vertical datum. Therefore, the vertical datum of the model data was essentially a combination of NGVD 29 and NAVD 88 with the most of the Dallas Floodway reach and including some reaches downstream of the Dallas Floodway based on NAVD 88. Upstream of the confluence of the West Fork and the Elm Fork and downstream of the DFE project reach, the HEC-RAS model data were not converted to the later NAVD 88 because within the study area, the difference between NGVD 29 and NAVD 88 was less than one inch. Therefore, for the purposes of this feasibility study, the difference was regarded as insignificant. A more detailed discussion of the survey data used for the study is provided in Appendix A, Section 6.2.1.

1.4.2 Existing Dallas Floodway Project

The focal point in the study area (project area) is the existing Federally constructed Dallas Floodway Project, comprised of the East and West Levees and the area between the levees commonly referred to as the "Floodway." The Dallas Floodway Project encompasses the East and West Levees, Floodway, and interior drainage system features including drainage structures, pressure sewers, pump stations and sump areas. The East and West Levees extend along the Trinity River upstream from approximately the Atchison, Topeka and Santa Fe (AT&SF) Railroad Bridge at Trinity River Mile 497.37, to the confluence of the West and Elm Forks at River Mile 505.50, thence upstream along the West Fork for approximately 2.2 miles and upstream along the Elm Fork approximately 4 miles. Of the 22.6 miles of levees within this reach, the East Levee is 11.7 miles in length and the West Levee is 10.9 miles in length, which includes a 1.5-mile segment along Mountain Creek. The Federally authorized DFE Project area is directly downstream of the East and West Levee (approximately downstream of the AT&SF Railroad Bridge). The distance between the levees vary between approximately 2,500 feet to 3,000 feet and extends for nearly eight river miles on the main stem of the Trinity River. The levees are approximately 30 feet high with slopes that vary. Through the Floodway, the existing river channel is approximately 30 feet deep and 200 to 250 feet wide at its banks. The existing Dallas Floodway Project features are displayed in Figure 1-1. The East Levee provides flood risk benefits from Trinity River flooding to the "Stemmons Corridor," a major transportation corridor route through the City of Dallas and the Central Business District, while the West Levee provides flood risk benefits to a large portion of West Dallas that is largely residential areas.

The same levees that provide flood damage reduction benefits to the City of Dallas from Trinity River flood events also prevent the local stormwater runoff from draining directly to the river. A system of sump areas, pressure sewers and pump stations was constructed to accommodate the interior drainage. The stormwater runoff collects in low-lying areas on the land side of the levees (typically a remnant of the historic river channel) until it can be pumped into the river, drain through pressure sewers, or drain through gravity sluices. There are six pumping plants and sumps, seven pressure sewers and gravity sluices associated with the Interior Drainage System (IDS). The location of the pump stations and sumps are shown in Figure 1-1.

The Operation and Maintenance Manual for the Dallas Floodway Project (O&M Manual) contains the existing Dallas Floodway Project facilities. The Corps was authorized to improve and/or provide

additions to existing facilities in the River and Harbor Acts of 1945 and 1950. The following are the improvements and/or additions provided by the Corps in the 1950s listed in the O&M Manual. The list is not comprehensive, and is centered on the facilities subject to modifications proposed in the BVP and IDP.

- Clearing of the Floodway on the Trinity River from river miles 504.0 to river mile 489.0;
- Channel improvement from mile 503.0 to mile 497.5;
- Strengthening East Levee and West Levee;
- New pumping plants at A (Able), Pavaho, and Hampton Road and improvements and/or alterations to pumping plants A (Able), B (Baker), C (Charlie) and D (Delta); and
- Construction of Turtle Creek and Lake Cliff Pressure conduits, diversion of Coombs Creek, improvements and/or additions to Dallas Branch and Belleview pressure sewers.

1.5 STUDY PARTICIPANTS

The Fort Worth District and the City of Dallas prepared this feasibility report and an EIS in accordance with the study purpose. The Federal Highway Administration (FHWA) was a cooperating agency for the EIS. The study area lies within the jurisdiction of the 30th, 32nd, and 33rd Congressional Districts of Texas, and the representatives are Eddie Bernice Johnson, Pete Sessions, and Marc Veasey, respectively. Current U.S. Senators from Texas are John Cornyn and Ted Cruz. The TRCP organization is an entity within the City of Dallas whose mission is to facilitate the implementation (with regional stakeholders) of the BVP and the Trinity River Corridor Comprehensive Land Use Plan (TRCCLUP) (City of Dallas 2005). The TRCP has several on-going studies/projects, including the DFE Project, Trinity Corridor Transportation Improvements (e.g., the proposed Trinity Parkway), the Trinity Bridges, the Trinity Trails, and the Great Trinity Forest. The on-going studies related to the TRCP involve coordination with multiple Federal (e.g., Corps, FHWA, and the Federal Emergency Management Agency), State (e.g., the Texas Department of Transportation, Texas Historical Commission) and local agencies.

1.6 PRIOR STUDIES, REPORTS AND EXISTING WATER PROJECTS

The water resource studies, reports and water projects (generally presented in chronological order) related to the Dallas Floodway Project prepared by the Corps and non-Federal entities including the City of Dallas are described below.

1.6.1 Historic Dallas Floodway Development

A catastrophic flood in 1908 led the City of Dallas to seek protection from Trinity River flooding. Between 1928 and 1932, the Dallas County Levee Improvement District (DCLID) constructed earthen levees to provide flood risk benefits to the City of Dallas from Trinity River flooding. The DCLID relocated the confluence of the West and Elm Forks, rerouted the Trinity River by constructing a channel within the leveed Floodway, and filled or set aside the original channel for sump storage. These original levees had a total length of 22.6 miles, an average crest width of six feet, an average height of 26 feet, and a maximum height of 37 feet (Corps 1955).

1.6.2 U. S. Army Corps of Engineers

Trinity River and Tributaries, Texas; House Document Numbered 403, 77th Congress (Corps 1941) and the Rivers and Harbors Act of 1945; and Trinity River at Dallas and Fort Worth, Texas; House Document Numbered 242, 81st Congress (Corps 1949) and the Rivers and Harbors Act of 1950.

To reduce the riverine flood risk within the City of Dallas, Congress authorized the flood control project (commonly referred to as the Dallas Floodway, Dallas, Texas project, or the Dallas Floodway Project) in 1945, and again in 1950. From August 1952 to June 1955, the Corps produced six reports for design of the Dallas Floodway improvements to the original DCLID levees and interior drainage facilities.

U.S. Army Engineer District, Fort Worth, Corps of Engineers, Operation and Maintenance Manual, Dallas Floodway, West Fork, Elm Fork, Trinity River, Texas (Corps 1960).

In May 1960, the non-Federal sponsor for the Dallas Floodway Project, the Dallas County Flood Control District (DCFCD) formally accepted the Corps Operation and Maintenance (O&M) Manual for the Dallas Floodway Project (Corps 1960). The purpose of the O&M Manual was to furnish detailed information regarding the Dallas Floodway Project and its essential features, and to aid local interests in carrying out their obligation under the regulations governing acceptance of a completed project constructed by the Corps. The DCFCD formally transferred O&M responsibilities to the City of Dallas in 1968.

Trinity River and Tributaries Regional Environmental Impact Statement and Record of Decision.

The Trinity River and Tributaries Regional Environmental Impact Statement (TREIS) was prepared by the Fort Worth District to address the proposed increases in floodplain development occurring in the Upper Trinity River Basin during the Dallas-Fort Worth Metroplex development boom in the mid-1980s (Corps 1988a). Individually or cumulatively, future projects were expected to have the potential to increase the flood risk to development already in the floodplain.

The ROD prepared for the TREIS specified criteria that the Corps would use to evaluate future Section 404 permit applications in the Trinity River basin; specifically, projects located within the Standard Project Flood (SPF) floodplain of the Elm Fork Trinity River, the West Fork Trinity River and the main stem of the Trinity River. The TREIS ROD established criteria for actions that require a Corps permit to address hydrologic and hydraulic impacts and mitigation of habitat losses (Corps 1988a). The findings in the TREIS provided the impetus for follow-on studies under the 1988 Upper Trinity River Study Authority (Corps 1988b).

Regional Trinity River Corridor Development Certificate Process.

In response to the TREIS and ROD, cities and counties in the Trinity River watershed formed the Trinity River Steering Committee (Steering Committee), facilitated by the North Central Texas Council of Governments (NCTCOG). The Steering Committee adopted a Draft Statement of Principles for Common Permit Criteria (in February 1988), a Resolution for a Joint Trinity River Corridor Development Certificate (CDC) Process (in December 1988), and a Regional Policy Position on the TRC (in February 1989).

The CDC and the 1988 ROD hydrologic and hydraulic criteria are used to ensure that projects are designed in such a way that there are no flood rises in the water surface profile and that there are no valley storage losses for the 100-year (or 1% Annual Exceedance Probability) flood and less than 5% valley storage loss for the SPF event. The process requires that a permit applicant prepare a Hydrologic Engineering Center – River Analysis System (HEC-RAS) model for the proposed project using the current CDC HEC-RAS model as a base condition. The CDC HEC-RAS model is maintained and usually

distributed by the Corps to be used for evaluation of any and all projects that require a Section 404 Permit or a CDC Permit.

Upper Trinity River Feasibility Study Activities (1990 - 2007).

The Corps initiated the Upper Trinity River Feasibility Study (UTRFS) in response to the authority contained in the U.S. Committee on Environment and Public Works Resolution dated April 22, 1988 and the findings of the 1990 Upper Trinity River Basin Reconnaissance Report. The UTRFS identified approximately 90 potential projects addressing flood risk management (FRM), ecosystem restoration and recreation within the Upper Trinity River Basin (Corps 1988b). Of these 90 projects, three Corps projects were identified that had local sponsorship and were viewed as reasonably foreseeable, including modifications to the Dallas Floodway Project.

Upper Trinity River Basin Programmatic Environmental Impact Statement (Corps 2000).

Initiated in 1996, the Upper Trinity River Basin Programmatic EIS (UTRB PEIS) focused on various potential Corps projects that were identified and investigated as part of the UTRFS. The Corps initiated the study under the 1988 authority. Potential Corps projects that were addressed in the UTRB PEIS included the DFE Project, Johnson Creek Project, Stemmons North Industrial Project, Dallas Floodway Project, and the West Fork-Clear Fork Project. Potential projects by other entities that were also addressed in the Programmatic EIS include the Trinity Parkway.

General Reevaluation Report and Integrated Environmental Impact Statement for the Dallas Floodway Extension, Trinity River Basin, Texas (Corps 1999, 2003).

The DFE Project, authorized by the Flood Control Act of 1965, was initiated in December 2001 to construct the Chain of Wetlands, the Cadillac Heights Levee and Lamar Levee, and recreation features immediately downstream of the existing Dallas Floodway Project (Corps 2003). Construction of this project is on-going.

Periodic Inspection, Dallas Floodway Project, Trinity River, Dallas, Dallas County, Texas, Report No. 9 (Corps 2009).

The Corps performed Period Inspection Report Number 9 (PI Report No. 9) using a new inspection template on December 3-5, 2007 (Corps 2009). This inspection was the 9th PI for the East Levee and West Levee, and the first PI for both the Rochester Park Levee and the Central Wastewater Treatment Plant (CWWTP) Levee systems which are components of the DFE Project. All eight prior PIs resulted in an acceptable rating for the Dallas Floodway Project. Very specific language and rating criteria described in the new inspection template resulted in an "unacceptable rating" for the Dallas Floodway Project in the 9th Periodic Inspection.

1.6.3 City of Dallas

Rochester Park and Central Wastewater Treatment Plant Levees.

The approximate 2.8-mile Rochester Park Levee was constructed by the City of Dallas in 1991. The City of Dallas has since maintained the levee as part of its overall project operation and maintenance program. The Rochester Levee protects residential and commercial interests in East Dallas. The approximate 2.6-mile CWWTP Levee was constructed by the City of Dallas in the 1940s and the levee was raised and improved by the City of Dallas in 1994. The CWWTP Levee protects critical utility infrastructure in South Dallas. At the direction of Congress, these two levee systems were added to the DFE Project in 1996.

Dallas Floodway Phase I Construction.

Beginning in the late 1990s and continuing through 2000, the City of Dallas has made improvements to the Trinity River channel, levees and IDS. These improvements included widening portions of the existing river channel and increasing the height of some portions of the levees to 2 feet above the 1950s design elevation.

Balanced Vision Plan (City of Dallas 2003, 2004).

The BVP contains the flood risk management, environmental restoration and recreation features defined in the report prepared by the City of Dallas entitled, "The Balanced Vision Plan for the Trinity River Corridor, Dallas, Texas," dated December 2003, and amended in March 2004. This study served as the foundation for the project authorization.

Trinity River Corridor Comprehensive Land Use Plan (City of Dallas 2005).

The City of Dallas uses the TRCCLUP as a tool for guiding development and investment decisions in the TRC. In this way, the TRCCLUP guides zoning decisions relating to potential future private development towards land uses that complement identified public BVP elements.

Levee Interior Drainage Study – East Levee Phase I Report, Dallas, Texas; and West Levee Phase II Report (City of Dallas 2006 and 2009a).

Recent stormwater flood events have demonstrated that improvements are needed to the East and West Levee Interior Drainage Systems (EWLIDS) to reduce the risk of interior flooding. In March 2006, the need for improving the EWLIDS was demonstrated when a significant local storm caused widespread stormwater flooding in the City of Dallas, resulting in one fatality and significant property damage. These reports outline the City of Dallas plans for improving the EWLIDS, commonly referred to as the IDP, IDP Phase I on the East Levee and IDP Phase II for the West Levee. These studies also served as the foundation for the project authorization.

Draft Problem Identification Report (City of Dallas 2009b).

As a follow-up to PI Report No. 9, the City of Dallas conducted a preliminary analysis and design check of the Dallas Floodway Project for the 100-year riverine flood event and the current SPF event. The report, *Preliminary Analysis and Design Check of the Levee Systems for the 100-Year Flood Event and Current Standard Project Flood Level*, is commonly referred to as the Problem Identification Report (City of Dallas 2009b).

Maintenance Deficiency Correction Period (MDCP) Plan.

The MDCP Plan was prepared in response to PI Report No. 9 (Corps 2009) in accordance with Corps policy guidance. As of February 2012, the City of Dallas has completed all of the 198 deficiency maintenance O&M items identified in the MDCP Plan.

Federal Emergency Management Agency /Flood Insurance Rate Maps (on-going).

The Dallas Floodway Project was examined by the Corps in the PI Report No. 9. Based on this review, the Corps withdrew its letter of support for certification provided to the Federal Emergency Management Agency (FEMA). Because the non-Federal sponsor has not provided appropriate documentation to support certifying the levee, FEMA, as managed by 44 Code of Federal Regulations (CFR) 65.10, has indicated that the Dallas Floodway Project will be de-accredited. FEMA has announced a nationwide revision in their policy of considering no flood protection for de-accredited levees. FEMA has not started the remapping efforts for the Dallas Floodway at this point. The City of Dallas plans to have

improvements that would restore/provide sump capacity to provide flood risk reduction up to the 100-year event for interior drainage as well as improvements to the levee system for the 100-year (1% Annual Exceedance Probability [AEP]) in place before the re-mapping of the Dallas Floodway Project occurs. The non-Federal sponsor is seeking FEMA certification for National Flood Insurance Program purposes as their floodplain management choice. Once the IDP features are implemented and the impact area of the 100-year floodplain is modified/improved, the areas outside the 100-year flood event would not be required to pay mandatory flood insurance and no development restrictions would be enforced.

Interim 100-year Levee Improvements Section 408 Package.

The City of Dallas pursued necessary corrective measures and documentation required by FEMA for certification of the Dallas Floodway Project for the 1% AEP flood event on the Trinity River. The City of Dallas prepared a Section 408 package analyzing the potential impacts from implementing the interim levee improvements to the Dallas Floodway Project (City of Dallas 2012). The Corps approved the Section 408 package and a Finding of No Significant Impact was signed in February 2012 and construction was completed in calendar year 2012. The improvements included building about 3.5 miles of soil bentonite cut-off walls to prevent under seepage. The City of Dallas' cut-off wall runs along the East Levee from station 285+00 to 442+00 for a total of 15,700 feet or approximately 2.97 miles and along the West Levee from levee station 3+00 to 29+00 for a total of 2,600 feet or 0.49 miles.

1.7 STUDY OVERVIEW

Subsequent to the enactment of Section 5141 of WRDA 2007, the Fort Worth District issued the PI Report No. 9, dated March of 2009, which documented significant deficiencies with the existing structural integrity of the Dallas Floodway Project. It became readily apparent that this study was extremely complex with various actions requiring evaluation by the Corps including the deficiencies identified in the PI Report No. 9, multiple local projects requiring "Section 408" approval (including the Trinity Parkway), and the authority to review the BVP and IDP. Therefore, as part of the IG prepared for Section 5141 of WRDA 2007 issued December of 2009, a plan was developed to lay out a framework to evaluate all components proposed for implementation within the study area. This plan is referred to as the "Comprehensive Analysis."

In order to perform the Comprehensive Analysis, the study was conducted in phases. To comply with the IG, the first phase addressed deficiencies with the levee system and formulated the FRM feature of the BVP utilizing National Economic Development (NED) criteria. The FRM feature then became a component of the BVP. Next, the remaining BVP and IDP features were evaluated to determine which met the Corps objectives and whether they were technically sound and environmentally acceptable. The features of the BVP and IDP that met the Corps objectives and were technically sound and environmental acceptable were considered to be implemented as the MDFP under Section 5141 of WRDA 2007.

Then all proposed projects and features currently planned within the Dallas Floodway Project (BVP, IDP, local features, and the Trinity Parkway) were evaluated in the Comprehensive Analysis. This analysis ensured that all of the proposed activities, even the ones already constructed, within the Floodway were compatible with the MDFP features and would not have significant adverse effects on the functioning of the existing Dallas Floodway Project from a system-wide standpoint. The hydraulic impacts of the MDFP as a stand-alone plan were not presented in the EIS or the feasibility report. The MDFP was included in the analysis for the entire BVP and IDP. Specific evaluation criteria for each component of the study

follow. Appendix L contains figures of the general features of the BVP and IDP (Figures L-1 through L-4).

1.7.1 Levee Structural Integrity

A Levee Remediation Plan (LRP) was developed to address the levee structural integrity concerns and O&M deficiencies (which are the responsibility of the City of Dallas) documented in PI Report No. 9. The LRP was also intended to address potential design and construction deficiencies for the existing Dallas Floodway Project as defined in the original 1945 project authorization. The City of Dallas submitted a MDCP Plan and has corrected 198 listed items. The Corps determined there were no design and construction deficiencies with the original project. The 21 remaining items from the PI Report No. 9 were deferred to the feasibility study since they could be considered beyond routine maintenance and repair. The path forward of the 21 remaining items is discussed in Chapter 3. The LRP was assumed complete for formulation of the NED analysis for the FRM component of the BVP.

1.7.2 Balanced Vision Plan

The City of Dallas' report, "The Balanced Vision Plan for the Trinity River Corridor, Dallas, Texas" (December 2003, amended March 2004), identifies the plan to implement flood risk management, environmental restoration and management, and recreation within the Dallas Floodway Project area. Section 5141 of WRDA 2007 directs the Secretary (ASA(CW)) to construct if the BVP is "technically sound" and "environmentally acceptable." Per the IG, the Corps was to perform the analysis and make a recommendation with its findings to the ASA(CW). The BVP included language for increasing the height of the existing levees by as much as 2 feet above the SPF flood event water surface profile and flatten the riverside slope of the levee to reduce the likelihood of slope failures. Further discussion of the SPF is provided in the next Chapter, Section 2.1.4.3. Current IG required the FRM component (see Section 1.7.2.1) of the BVP to be evaluated for economic justification. The guidance also stated the BVP recreation and environmental features did not require formulation utilizing NED or National Ecosystem Restoration (NER) criteria but would be formulated using sound judgment, prudent analytical approaches and Corps engineering standards. The Corps developed goals and objectives for the formulation of the FRM and ecosystem restoration components of the BVP to determine features to recommend for implementation under Section 5141 of WRDA 2007. The goals, objectives and planning criteria are described in detail in Chapter 3.

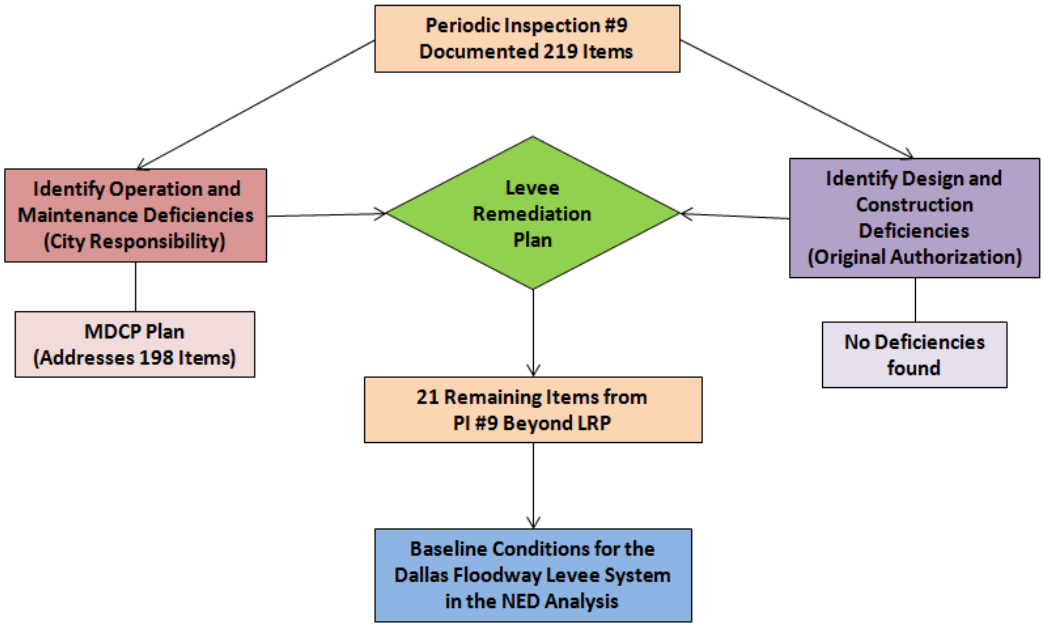
1.7.2.1 NED Analysis on the FRM Component of BVP – Trinity River Flooding

After all the PI No. 9 items were confirmed as O&M items or design and construction deficiencies in the LRP, the levee system was evaluated to see if economic and life-safety risk could be reduced. All PI No. 9 items had to be confirmed as beyond normal O&M or design and construction deficiency before they could be considered as problems to be addressed in this feasibility study for NED. The analysis followed the "Principals and Guidelines for Water and Related Land Resources," dated March 1983, including evaluation of contributions to NED and reducing potential life-safety risk. As stated above, the NED analysis was only performed on the levee system, not as a multipurpose project (combined with ecosystem restoration or recreation). Figure 1-2 presents the relationship between the LRP and the FRM component of the BVP.

The Dallas Floodway Project was evaluated to determine whether "Reconstruction" of the system was warranted. Reconstruction addresses major performance issues with an existing project beyond normal O&M (City of Dallas responsibility) or a deficiency with the original project design and construction (addressed under the original authorization). It is noted here because the IG required the Fort Worth

District to determine whether Reconstruction of the system was warranted. At the beginning of the study Reconstruction was considered for the levee system; however, a Reconstruction authorization was not pursued for reasons described later in the report, in Section 5.5.2.

Figure 1-2 Relationship Between the Levee Remediation Plan and the NED Analysis for the Dallas Floodway Project



1.7.3 Interior Drainage Plan

Section 5141 of WRDA 2007 authorized the Corps to review and evaluate the Interior Levee Drainage Study Phase I report (September 2006) and make a recommendation to the ASA(CW) on a determination of whether the plan was "technically sound" and "environmentally acceptable." The IDP Phase I report proposes improvements to existing and construction of new pumping stations and their associated gravity and pressure storm sewers (including the Able, Baker and Hampton Pump Stations) associated with the East Levee. These improvements would restore/provide sump capacity to provide flood risk reduction up to the 100-year flood event for interior drainage. The 100-year event is also referred to as the 1% (AEP). For the IDP discussion in this report, the 100-year terminology is used. Per the IG, the IDP did not have to be formulated utilizing NED criteria. The IDP was formulated solely on its ability to contribute to the goals and objectives of this study. Section 4013 of the WRRDA of 2014 (Public Law 113-121), provided a technical correction to Section 5141(a)(2) of the WRDA 2007. Section 5141 was amended by inserting "and the Interior Levee Drainage Study Phase-II report, Dallas, Texas, dated January 2009," after "September 2006." Thus, the WRRDA authorization adds the West Levee IDP to the Section 5141 of WRDA 2007 authorization.

1.7.4 Local Features

Local features were projects which were not part of the Recommended Plan, but their implementation represented a modification to an existing Federal project. These features either have or are required to undergo a "Section 408" review by the Corps. The local features were evaluated in the Comprehensive

Analysis as a collection of projects; however, they are also required to follow a separate Section 408 review process for approval and are evaluated on an individual basis. Under 33 U.S. Code 408 (commonly referred to as Section 408 in the remainder of the report) the Secretary of the Army, on the recommendation of the Chief of Engineers, may grant permission for the alteration of a Corps civil works project if it is determined that the alteration will not be injurious to the public interest and will not impair the usefulness of the project. The local features were reviewed in the Comprehensive Analysis in accordance with the review criteria outlined in 3.2.2, Table 3-6. The Comprehensive Analysis does not provide Section 408 approval.

The local features were evaluated as a part of the Comprehensive Analysis along with the BVP and IDP to ensure they collectively meet Corps engineering and safety standards and do not impact the functioning or integrity of the system. The local features in the Comprehensive Analysis included the Trinity Parkway, Trinity River Standing Wave, the Santa Fe Trestle Trail, the Pavaho Wetlands, the Dallas Horseshoe Project, the Sylvan Avenue Bridge, Jefferson Memorial Bridge, Dallas Water Utilities Waterlines, Continental Bridge, the East Bank/West Bank Interceptor Line, and IDP features that were built while the study was underway. The authorization allowed for the City of Dallas to construct features of the IDP prior to the signing of a Project Partnership Agreement (PPA) and receive in-kind credit. In-kind credit shall comply with the requirements contained in the Section 5141 of WRDA 2007 authorization and the ASA(CW) Memorandum of Understanding (MOU) dated June 10, 2009. The MOU is contained in Appendix K (Supplemental Documentation).

Some projects (excluding the Trinity Parkway) have received "approval" under Section 408 and are in various stages of design and construction. Table 1-1 presents the status of the ongoing Section 408 reviews. They were also considered existing or future without-project conditions in accordance with the stage of project design or construction. The City of Dallas has expressed a desire to construct any BVP and IDP feature not included in the Recommended Plan as a Section 408 project at 100% local cost.

Table 1-1. Local Features Included in the Comprehensive Analysis

Ongoing Section 408 Project Status			
Figure F-2 Key[1]	**Project Name**	**Section 408 Approval Received**	**Section 408 Undergoing Evaluation**
7	Margaret Hunt Hill Bridge	X	
10	Pavaho Pumping Plant	X	
12	Santa Fe Trestle Trail	X	
13	Sylvan Bridge	X	
17	Trinity River Standing Wave (Dallas Wave)	X	
A	Baker Pumping Plant	X[2]	
D	Continental Pedestrian Bridge	X	
F	EF2 Wastewater Interceptor Line and Laterals (Tunnel 1)	X	
	EF2 Wastewater Interceptor Line and Laterals (Tunnel 2)	X	
G	Horseshoe Project (IH-30, IH-35)	X	
J	Jefferson-Memorial Bridge		X
O	Pavaho Wetlands	X	
R	SH-183 Bridge	X	
U	Trinity Parkway		X[2]
V	Able Pumping Plant	X	
	Remaining BVP Features		X[2]

Notes:[1] Adapted from the Environmental Impact Statement Cumulative Projects list for consistency. [2] Requires Corps HQ level of approval; the 408 for Trinity Parkway and Remaining BVP Features are currently under evaluation at the District.

1.7.5 Planning Considerations

The study was prepared in accordance with the applicable Engineering Regulations (ER) including but not limited to:

- Corps ER 1105-2-100, *Planning Guidance Notebook;*
- Corps ER 1110-2-1150, *Engineering and Design for Civil Works Projects;*
- Corps ER 405-1-12, *Real Estate Handbook, Chapter 12*;
- Corps ER 1110-2-1302, *Civil Works Cost Engineering;*
- 33 CFR Section 230, Procedures for Implementing NEPA (ER 200-2-2). This regulation establishes Corps procedures for implementing NEPA and the Council on Environmental Quality (CEQ) regulations;
- Other pertinent regulations including Executive Order (EO) 11988, *Floodplain Management* (1977). Corps ER 1165-2-26 contains Corps' policy and guidance for implementing EO 11988; and
- A risk assessment was conducted by the Risk Management Center (RMC) on the Dallas Floodway Project as part of the Levee Safety Portfolio Risk Management Process. The purpose of the risk assessment was to quantify and evaluate risks posed by the East and West Levees associated with Trinity River flooding. The findings in the risk assessment were instrumental in determining Dallas Floodway Project risks and solutions as part of this study.

1.8 REPORT OUTLINE

Chapter 1 provides general study information, and the remaining chapters provide the results of the Corps evaluation of the BVP and IDP and the Comprehensive Analysis. Chapter 2 presents the existing and future without-project conditions for key resources that drive the NED analysis performed on the FRM component of the BVP. It also focuses on key areas that support the inclusion of BVP and IDP features in the Recommended Plan for the MDFP. Chapter 3 defines the problems, opportunities, goals and objectives derived for the BVP and IDP developed by the City of Dallas, and evaluation of the existing and future without-project conditions. Chapter 3 continues with the plan formulation, evaluation and selection results of the NED analysis, and the selection of the BVP and IDP for the MDFP. Chapter 4 contains a detailed description of the Recommended Plan for the MDFP. Lastly, Chapter 5 provides implementation requirements for the Recommended Plan.

CHAPTER 2
EXISTING AND FUTURE WITHOUT-PROJECT CONDITIONS

Conditions described here focus on summarizing technical evaluations of the resources that drive the National Economic Development (NED) analysis for the Flood Risk Management (FRM) component of the Balanced Vision Plan (BVP), the Interior Drainage Plan (IDP) and the ecosystem restoration component of the BVP. Additional detailed descriptions of the resources in the project area are provided in the accompanying EIS and the technical appendices of this report.

2.1 FLOOD RISK

A risk assessment was conducted on the Dallas Floodway Project to quantify risk of the perceived vulnerabilities of the Dallas Floodway Project and its components. The risk assessment specifically covers the East and West Levee flood risk and flood risk due to interior drainage was not addressed in this risk assessment. In an initial screening process, the risk assessment identified a number of Potential Failure Modes (PFM) with the Dallas Floodway Project. The risk assessment took into consideration the issues identified in the PI Report No. 9. A total of 14 credible failure modes were identified and summarized as follows:

- PFM #1 – Scour around a bridge pier leading to slope instability;
- PFM #2 – Overtopping and breach of a levee;
- PFM #3 – Failure of a floodwall;
- PFM #4 – Failure of the closure structures;
- PFM #5 – Scour through desiccation cracking in the crest;
- PFM #6 – Internal erosion through the levee;
- PFM #7 – Internal erosion through the foundation;
- PFM #8 – Heave leading to internal erosion through the foundation;
- PFM #9 – Internal erosion following rupture of a pressurized conduit;
- PFM #10 – Internal erosion along a penetration through the embankment or foundation;
- PFM #11 – Global instability following leaks from a pressurized conduit;
- PFM #12 – Instability at the interface between 1930s and 1950s levees;
- PFM #13 – Global slope stability; and
- PFM #14 – Failure Modes Not Developed.

The risk assessment was performed in two major phases: (1) Identification and Screening of the PFMs; and (2) Detailed Risk Evaluation. A PFM is a way a failure of the levee system can occur. It is described in terms of the means by which component failures must occur to cause loss of sub-system or system function. The risk assessment was performed by a panel made up of personnel from the United States Army Corps of Engineers (Corps) Risk Management Center (RMC), Fort Worth District, Engineering Research and Development Center, the City of Dallas, and their consultants. Each panel member brought subject matter expertise, or specific knowledge of the Dallas Floodway Levee System.

2.1.1 Methodology

Risk is composed of three components: (1) the probability of load, (2) the probability of failure at that load, and (3) the consequences should failure occur. For levees, the likelihood is highly dependent on

hydraulic load conditions and the resulting structural response (or performance of the levee). Consequences are defined in terms of Loss-of-Life and damages to structures on the protected side of the levees. Risks were estimated for the risk assessment using the Best Practices in Dam Safety Risk Analysis, which is a joint methodology developed by the Corps of Engineers and the Bureau of Reclamation. The risk estimation process relies on engineering techniques whose applications differ little in principle from traditional deterministic safety assessments. The difference between risk analysis and traditional engineering is quantifying the uncertainties in all of their various forms. Probabilistic methods in risk analysis address these uncertainties.

2.1.1.1 Identification and Screening of Potential Failure Modes

In the initial step of this phase, panel members reviewed reports and drawings and conducted a site visit to get familiar with the project. Following the familiarization process, the potential failure modes were "brainstormed" based on the group's understanding of the vulnerabilities of the levee system. All PFMs were captured and documented, then screened and eliminated if the panel found them highly unlikely.

The PFMs not eliminated from consideration as highly unlikely were evaluated and discussed in greater detail among the panel members. The evaluation/discussion consists of a full description of the potential failure from initiation through progression, to breach and flooding of the protected side of the levee. Factors that made failures more or less likely to occur were also documented. Following this evaluation, the panel screened the PFMs through discussion and expert elicitation to determine which PFMs should be carried forward to evaluate risks further. Discussions resulted in a range of estimates of upper and lower bounds for probability, consequences, and the confidence of each estimate. These discussions resulted in a potential failure descriptor and a consequence descriptor. Following categorization, the panel decided which risk categories and associated PFMs were carried forward for detailed risk evaluation.

2.1.1.2 Detailed Risk Evaluation

Before the PFMs were evaluated in detail, the panel defined the hydrologic and hydraulic, and geotechnical engineering parameters for the analysis. The locations of cross sections used to evaluate seepage, internal erosion, heave and stability were also defined.

Once the PFMs were selected, more detailed evaluation was conducted as described here. The detailed evaluation involved quantification of the likelihood and consequences of the PFMs. The initial step in the detailed evaluation phase was to develop the event tree and the hydraulic load ranges (river stages). The event tree represents the sequence of events (i.e. branches) for failure to occur given the selected load ranges. For each individual branch the panel discussed the factors that influence likelihood of an event to occur with input from the engineering analysis as appropriate. Cross sections throughout the system were analyzed to identify the most critical areas of the levee system. The consequences (life loss and single event damages) were quantified based on the load ranges for each PFM. The likelihood and consequences of each branch were developed through expert elicitation and a total probability of failure was determined for each PFM using the @Risk program. The total probability for each PFM, in an annualized value, was presented in an "f-N" Chart.

The f-N Chart plots the annualized probability of failure and the annualized consequences (Loss-of-Life) to define the risk. Each PFM has a designated point on the chart with a box that represents the Monte Carlo simulation uncertainty "clouds." A Tolerable Risk Guideline for Dams as detailed in ER 1110-2-1156 was plotted on the f-N Chart, and was used as a guide to establish whether a PFM had tolerable risk or did not fall within a tolerable level of risk in terms of life safety. If the PFM fell above or near the guideline it was recommended that further evaluation and potential action be pursued.

2.1.2 Results

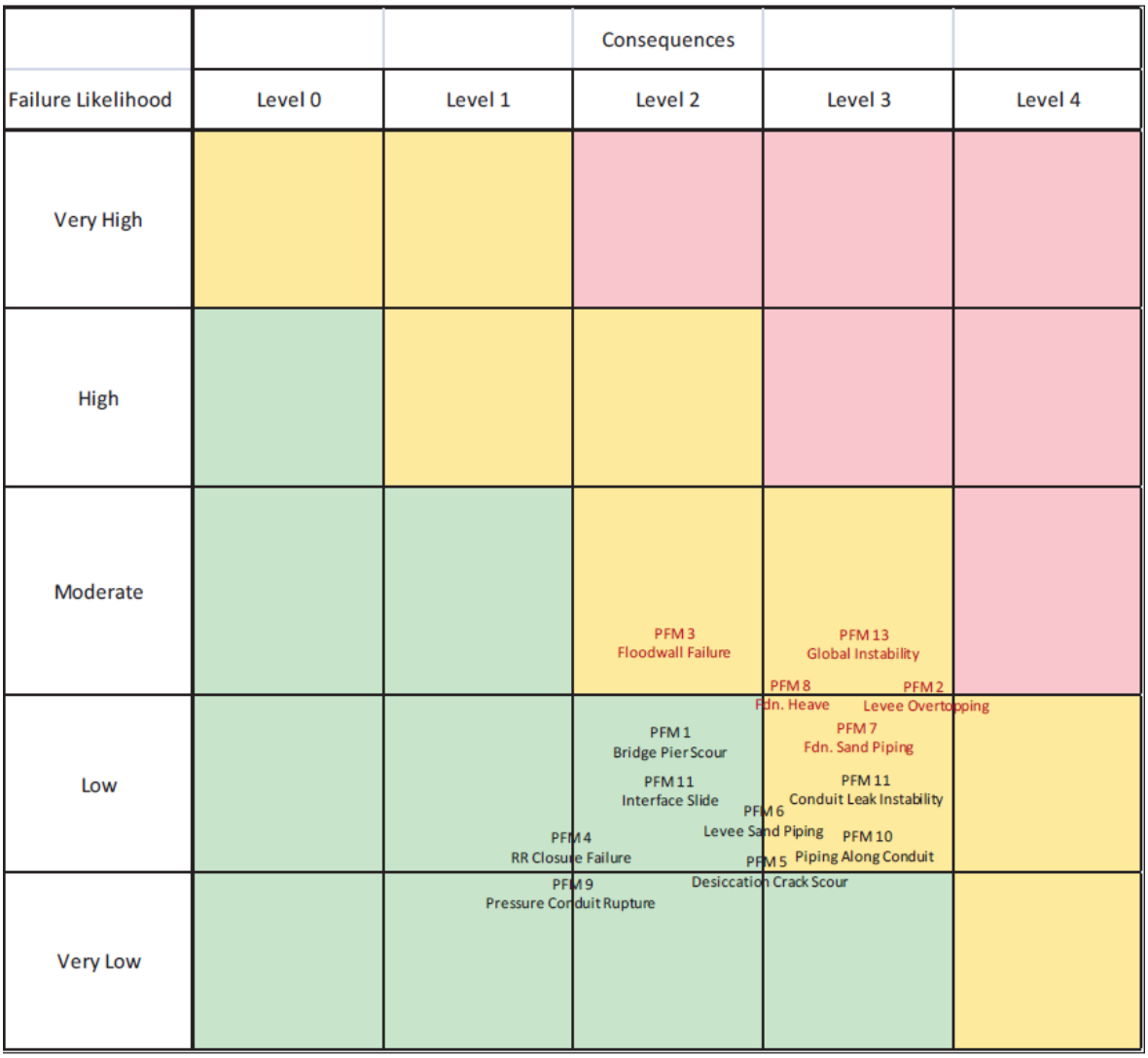
The following presents a summary of the results of the risk assessment conducted for the Dallas Floodway East and West Levees.

2.1.2.1 Identification and Initial Screening of Potential Failure Modes

The results of the identification and initial screening phase are shown in Figure 2-1. Fourteen PFMs were identified and plotted within the Screening Matrix for Failure Modes table.

The decision was made to carry forward the PFMs that plotted in the Moderate or Low to Moderate likelihood categories at Level 2 or Level 3 Consequences since they posed the highest risk (those in red text in Figure 2-1). The remaining PFMs were not estimated to be high enough risk to evaluate in detail for proposed risk reduction measures.

Figure 2-1 Results of Potential Failure Mode Analysis



In addition, PFM #7, backward erosion piping along a continuous foundation sand layer, could be evaluated as part of PFM #8, foundation heave, since it is a necessary part (predecessor) of that potential failure mode. That being the case, one might question why the team categorized PFM #7 as lower risk

than PFM #8. The reasoning was as follows. If there was an open unconfined sand conduit that caused seepage or other problems, they should have been observed in previous flood events. On the other hand, a blanket may have been sufficient to obscure seepage and keep the materials intact for lower flood elevations experienced to date, and only masked the potential heave problems that could be manifested at a higher flood stages. However, it was noted that when quantitative estimates were made, the relative ranking (displayed at the end of the detailed analysis) of these two potential failure modes could reverse. Also, it is important to note that a progressive slope instability potential failure mode (PFM 13b), not necessarily tied to the interface between the old and new levee embankments, was also evaluated quantitatively after additional discussions during the risk assessment.

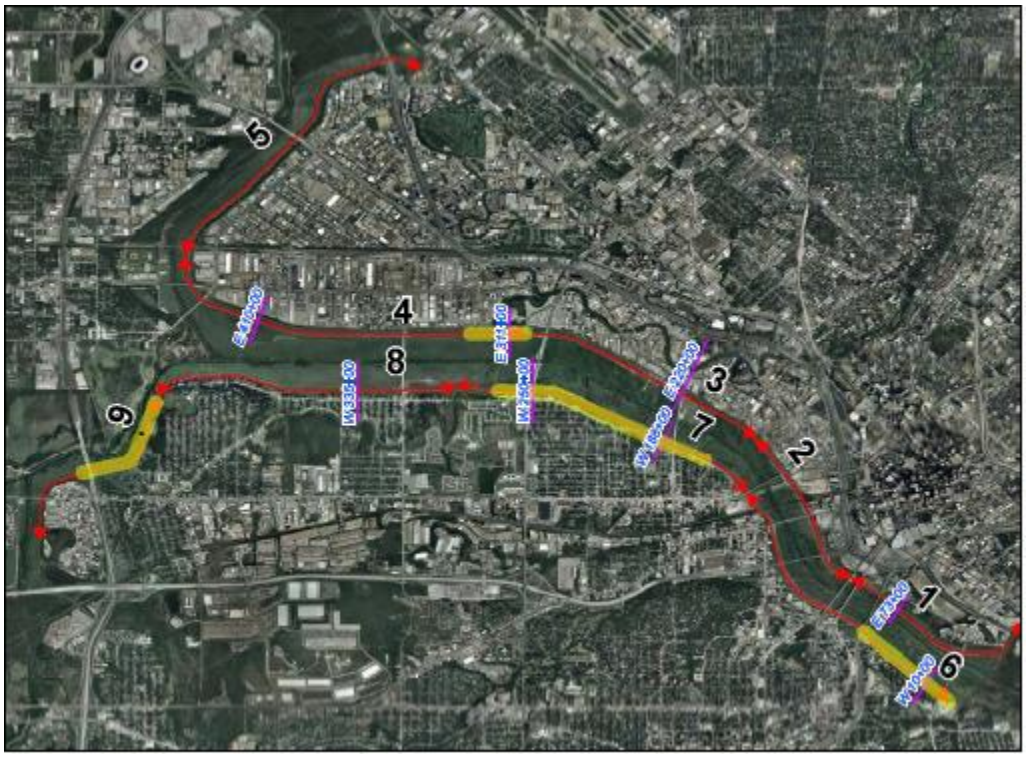
2.1.2.2 Detailed Risk Evaluation

The detailed evaluation involves quantification of the likelihood and consequences of the PFMs. Development of the event trees and the load ranges (river stages) are described in detail in Appendix C. The consequences (life loss and single event damages) are also presented in greater detail in Appendix C. The Hydrologic Engineering Center-Flood Impact Analysis (HEC-FIA) model was used to quantify the life loss and single event damages based on the load ranges for each PFM. Results of the risk assessment summarized here are focused on the likelihood and life safety consequences of the PFMs. Following the risk assessment, additional economic analysis was performed on the PFMs to estimate economic damages using the approved Hydrologic Engineering Center-Flood Damage Reduction Analysis (HEC-FDA) model. The following lists the PFMs included in the detailed risk evaluation in the risk assessment:

- PFM #2: Overtopping and breach of the levee
- PFM #3: Failure of a floodwall
- PFM #7: Internal erosion through the foundation
- PFM #8: Heave leading to internal erosion through the foundation
- PFM #13: Global instability

A total of nine reaches with eight levee cross sections were selected for the detailed risk evaluation. The cross sections were selected to be representative of the most critical conditions (worse case) for the PFMs on the levee system using the information available. Uncertainties were factored into the analysis for parameters that displayed varying results during the field and laboratory testing. Gaps were typically bridged with conservative assumptions. Stationing corresponding to the cross sections is shown in Figure 2-2. Each cross section was analyzed in the risk assessment, but the cross section with the most critical conditions for the PFM was used to the present the total risk for that PFM.

Figure 2-2 Risk Assessment Cross Sections



Note: Near Surface sands indicated in yellow.

Engineering Parameters and Analysis

Results of the engineering parameter determination and analysis are presented in detail in the risk assessment report (Appendix C, Part I). The follow section summarizes the key points of the Geotechnical and Hydrology and Hydraulics analysis for the risk assessment. The following engineering analyses were used to estimate probabilities of occurrence for individual branches of the event trees for each PFM and consequence estimates.

Geotechnical Parameters

The geotechnical conditions of the existing levee system (e.g., desiccation cracking, seepage through the foundation of the levee system, and other PFMs) were a concern for levee failure in the risk assessment for the East and West Levees. The levee system originally built by the Dallas County Levee Improvement District (DCLID) and strengthened by Corps in the late 1950s is comprised of highly plastic clays derived from the Eagle Ford, Austin and Taylor Formations. Highly plastic clays are problematic soils because they expand and contract with the application of moisture. This physical characteristic is known to induce slides on the levees. More than 300 shallow slides have been recorded since the Corps completed construction in the late 1950s. Although they are referred to as shallow, the slides are generally deeper than what is considered "normal" for shallow slides, with some slides as deep as 15 feet (Corps 2009). The City of Dallas currently fixes the slides as they happen to maintain the performance of the levee system.

Analysis of boring data shows significant quantities of sand within the subsurface of the project area including under the levee footprint. The locations of shallow sand in the project area represent areas of possible concern regarding levee performance. The near-surface sand deposits in contact with river water

can quickly become saturated and serve as seepage pathways. This is of particular concern where a shallow sand lens laterally transects a levee, creating a seepage pathway from an area exposed to river water to the near surface substrate on the protected side of the levee (e.g. exposed on the landward side in the sump areas).

Feasibility-level seepage and stability analyses were performed and conducted in accordance with Corps policy, as well as policy under development for risk assessments. Soil permeability and strength parameters were developed using the data available for the various layers that exist in the foundation and embankment of the Floodway. Transient seepage analysis was used for the seepage and stability analyses performed for the risk assessment. Routine Corps practice in the past was to use steady state seepage analysis. The Corps used transient seepage analysis due to the relatively low permeability of the levee soils and the relatively short duration of flood loading for the Dallas Floodway. The use of unsteady (transient) flow used in the risk assessment in both seepage and stability analyses resulted, in most cases, in an increase in safety factors which met or exceeded Corps requirements for the critical cross sections analyzed. Use of transient versus steady state seepage analyses was a major change from previous geotechnical analyses used in the study. The transient flow changed the levee system from not meeting Corps design standards to meeting them in most cases. It was also highly influential in defining baseline risk for the levee system in the risk assessment.

Hydrology and Hydraulics

The hydrology and hydraulics analysis provided estimates of flood duration, volume-frequency, discharge-frequency, and unsteady flow modeling for estimating consequences. The Upper Trinity River watershed contributes to the hydrology of the project area. Through the Dallas Floodway Project, the existing channel of the Trinity River is approximately 30 feet deep and 200 to 250 feet wide at its banks. The Floodway itself generally ranges from 2,500 to 3,000 feet wide, levee to levee, and extends for nearly eight river miles on the main stem of the Trinity River. The Trinity River main channel in the study area provides a maximum channel capacity of 13,000 cubic feet per second (cfs). When the volume of water exceeds the maximum capacity of the channel, water flows into the floodplain. Flows measured in the Trinity River range from a base flow of about 500 cfs to a record high flow of 184,000 cfs (1908). The May 1990 flood at 82,300 cfs (approximately a 40-year flood event) was the largest flood since 1908 and the largest flood since the original levee system was constructed.

Unsteady flow hydraulic modeling of the system was performed in order to inform several aspects of the risk assessment. The results from the hydraulic modeling produced stage hydrographs for a variety of inflow scenarios at several locations of interest throughout the levee system, which were used by the risk assessment team to analyze the seepage and stability conditions at those sections. The model was also used to predict the timing and depths of inundation of the protected areas for a variety of levee breach and overtopping scenarios, which was used as input for the consequences assessment in terms of loss-of-life.

Consequences

The detailed evaluation involved estimating consequences of the PFMs in the risk assessment. The Population at Risk (PAR) has two relatively homogenous groups, one behind the East Levee and the other behind the West Levee. Behind the East Levee, the PAR is primarily a commercial zone, filled with warehouses, offices, and retail buildings. Likewise, the population behind the East Levee consists largely, but not entirely, of commercial workers who work within the hazard zone mainly during business hours but reside elsewhere. Because of the migration of workers in and out of the floodplain, there is a significant difference between the PAR behind the East Levee during the day and the PAR at night (potentially 91,400 Day PAR and 35,500 Night PAR). Much of the night PAR are visitors staying in

hotels in the downtown area or institutionalized populations. It is important to note that such PAR are generally in hi-rises. Because this PAR is able to "vertically evacuate," they are less directly threatened by floodwaters.

Though smaller in number (19,600 Day PAR and 23,500 Night PAR), the PAR behind the West Levee is largely, but not entirely, made up of residential occupants. Most of the PAR lives in one-story single-family structures, with a smaller percentage living in multi-family units. According to 2000 Census data used in this analysis, households behind the West Levee are often low-income, without a fluent English speaker, and may not have access to a vehicle. Such demographic factors reduce the likelihood that the PAR will perceive the flood risk warnings, perceive significant risk differently and have the resources available to successfully evacuate.

For the consequence analysis, impacts of 56 events are estimated under three different conditions for a total of 168 simulations. Six overtopping failures were considered, two separate hydrologic events at three possible locations each; the two hydrologic events non-failure simulations were also estimated in order to estimate incremental consequences. Two geotechnical failure modes were considered, internal erosions and global instability. Each failure mode had 24 different simulations as there were eight locations considered along with three different hydrologic conditions. The reported best estimate is the mean of a Program Evaluation and Review Technique distribution which uses the three scenarios as the Min, Max, and Most Likely. In the low probability event of a failure of the Dallas Floodway Levee System, significant flooding velocity would occur in heavily populated areas, potentially leading to life safety risk.

f-N Chart

Following the development of the event trees and the load ranges (river stages) and estimating the consequences (life loss and single event damages) of the PFM, the annualized likelihood (probabilities) and consequences (loss-of-life estimates) were determined for each PFM using the @Risk program. An f-N Chart plots the estimated annualized probability of failure and the estimated consequences (loss-of-life estimates) to describe the risk. Figures 2-3 and 2-4 are the f-N Charts for the East and West Levee. Each PFM has a designated point (referred to as the best estimate) on the chart with a box that represents the Monte Carlo simulation uncertainty "clouds." A Tolerable Risk Guideline for Dams as detailed in Engineering Regulations (ER) 1110-2-1156 was plotted on the f-N Chart, and was used as a guide to establish whether a PFM has tolerable risk or does not fall within a tolerable level of risk in terms of life safety. Tolerable risks are risks that society is willing to live with to secure certain benefits, risks that society regards as broadly acceptable, risks that society is confident are being properly managed by the owner and risks that the owner keeps under review and reduces still further and is practicable.

Figure 2-3 Risk Assessment f-N Chart for the East Levee

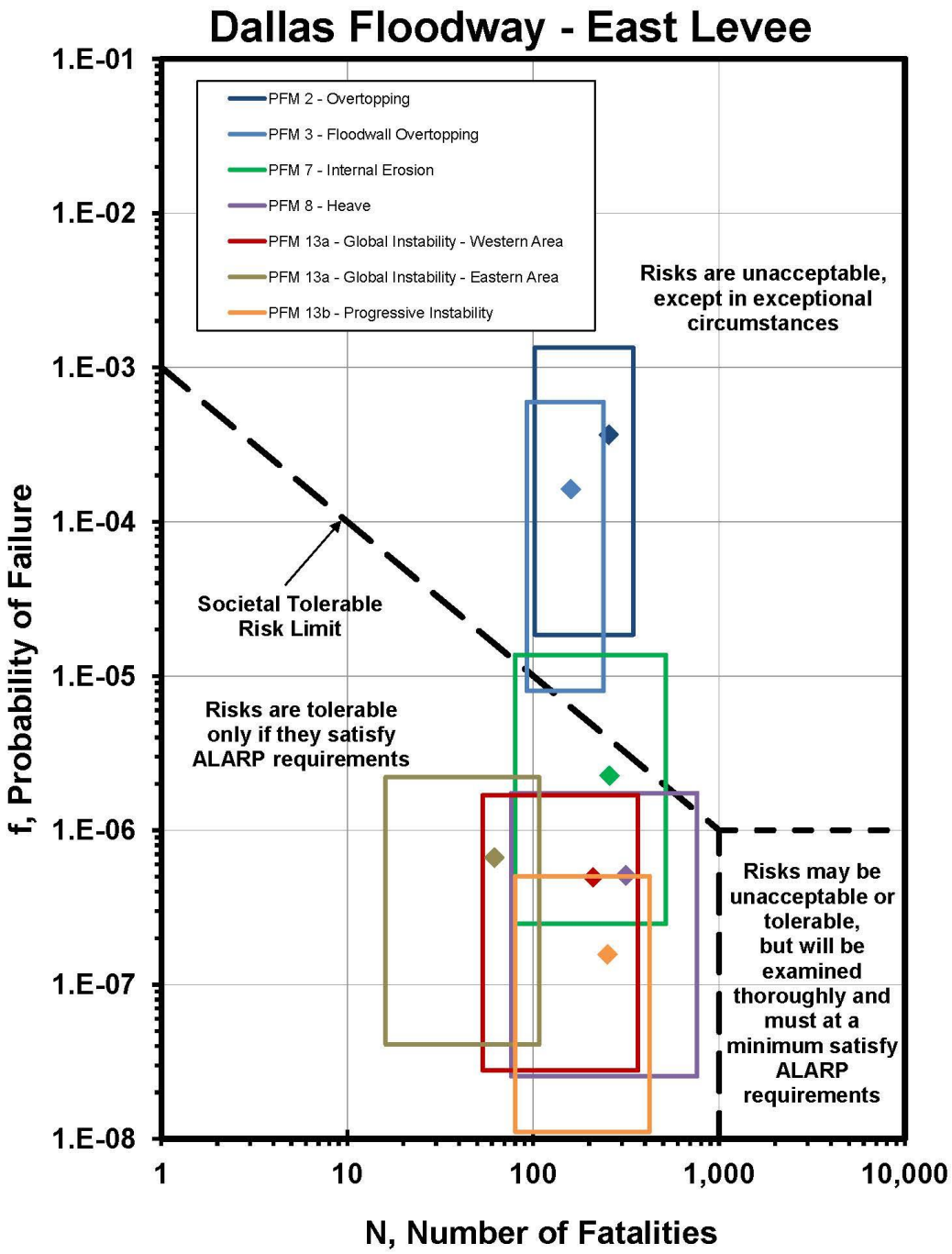
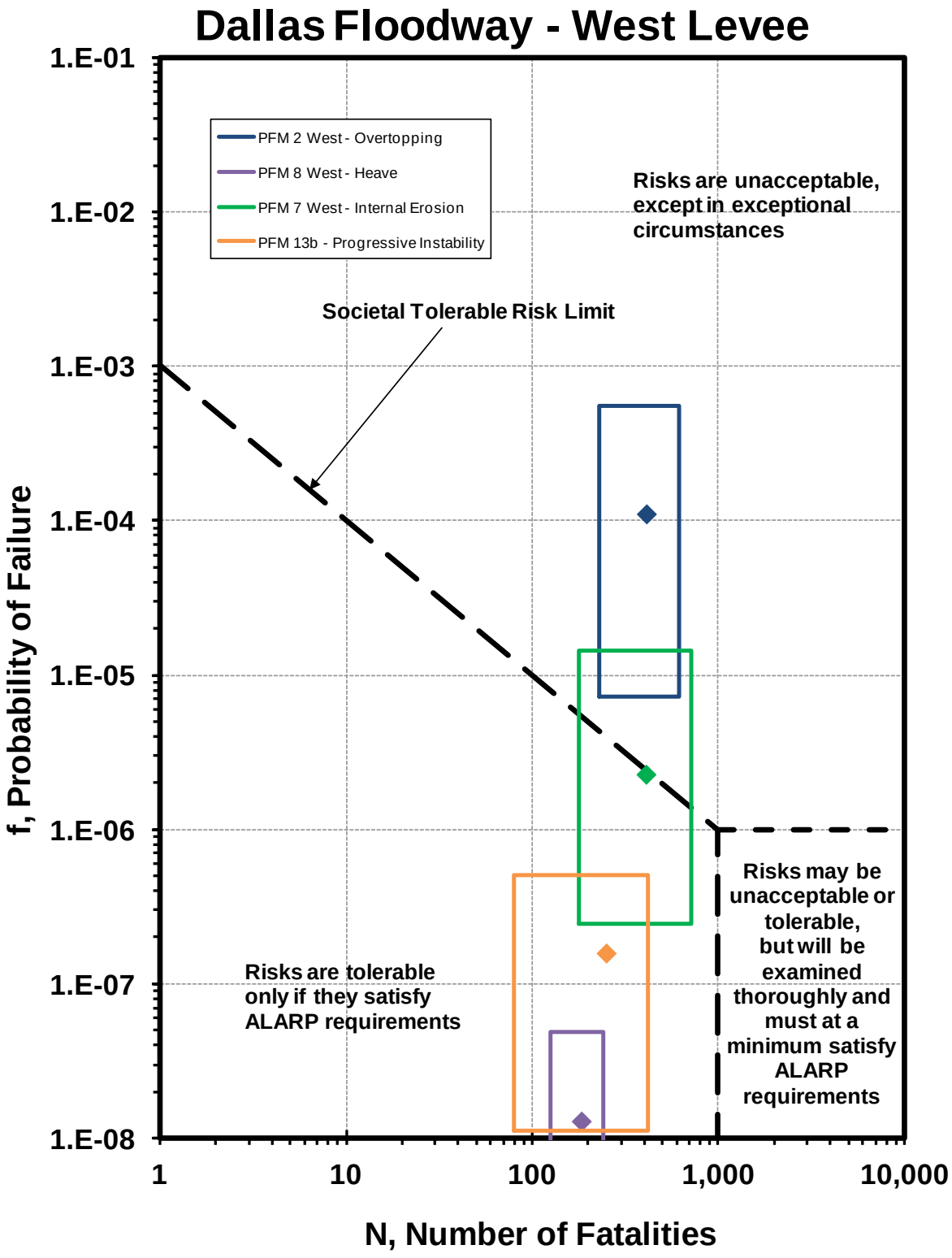


Figure 2-4 Risk Assessment f-N Chart for the West Levee



This study adapted the guidance and concepts detailed in ER 1110-2-1156 for use in this risk assessment to establish whether a PFM for the East and West Levees has tolerable risk in terms of life safety. For this study, if the best estimate of risk fell above or near (in uncertainty bounds) the recommended tolerable risk guideline then further evaluation and potential action was pursued. The PFMs evaluated in detail are plotted on the f-N Chart. Those that plot above or approach the recommended tolerable risk guideline including PFM #2 and PFM #7 were analyzed further for risk reduction in this study. Floodwall Failure (PFM #3) was not further evaluated because the DFE Project is assumed to be fully constructed and addresses this PFM in the future without-project condition.

In addition to the tolerable risk guidelines, the concept of "As Low As Reasonably Practicable" (ALARP) was applied to determine when the risk is considered to be tolerable. The concept of ALARP is that risks lower than the tolerable risk limit are tolerable only if further risk reduction is impracticable or if the cost is grossly disproportional to the risk reduction. In making a judgment whether risks are ALARP, the Corps took the following into account: level of risk in relation to the tolerable risk limit; the cost–effectiveness of the risk reduction measures; disproportion between the sacrifice and risk reduction achieved; compliance with Corps guidelines; and social concerns as revealed by consultation with the community and other stakeholders. Another risk management concept was applied for risk above the recommended tolerable risk guideline, so risk is brought down to below the limit except in exceptional circumstances as noted in the f-N Charts (Figures 2-3 and 2-4). Refer to the upper right corner of the f-N chart that states, "risks are unacceptable unless under exceptional circumstances." This qualifier is referring to a situation in which the risk is determined to be tolerable based on the special benefits the project provides to society. Additional discussion on ALARP and exceptional circumstances is provided in the evaluation of potential measures discussed later in the report (Section 3.4.6.3).

2.1.3 Major Findings of the Risk Assessment

2.1.3.1 Unacceptable Risk

The risk assessment showed that the estimates for risk identified two PFMs that exceed the recommended tolerable risk guideline established for dams. They were overtopping with breach of the East and West Levees, and overtopping of the floodwall on the East Levee.

Two other PFMs did not exceed the recommended tolerable limits but have estimated risks to life safety that plot close (in the uncertainty boundaries) to the limit of tolerability, and were therefore considered important enough to investigate further. These were internal erosion through the foundation for the East and West Levee and potential heave of the East Levee.

2.1.3.2 Risk Ranking

The PFMs were ranked from highest risk to lowest risk in the following order:

- Overtopping erosion of the levee embankments (PFM #2).
- Overtopping and undermining erosion of the concrete floodwall (PFM #3).
- Backward erosion piping of a sand layer connected to the river and exposed in a landside sump (PFM #7).
- Blowout or heave of a clay confining layer in a landside sump followed by backward erosion piping of the underlying sand layer (PFM #8).
- Global instability of a levee embankment slope that takes out the crest in a single slip through the embankment and foundation (PFM #13a).

- Progressive instability of a levee embankment slope due to localized slumping, saturation, and more slumping (PFM #13b).

The following presents the highlights of the PFMs evaluated in detail.

PFM #2: Overtopping and breach of a levee

- If a major flood occurs that brings the river stage to the levee crest, the crest will likely be overtopped in multiple locations.
- Overtopping of the embankments will likely occur first in the center reaches where surveys show the crest to be lowest relative to the anticipated river stages.
- Breach of the embankments due to overtopping is not certain due to the plasticity of the clay materials forming the levees and their foundations, and the limited duration of overtopping anticipated from the critical hydrograph shapes.
- If a breach does develop, it will likely do so slowly, again due to the somewhat erosion resistant soils.
- The risk for overtopping embankment erosion breach is strongly driven by the frequency of the overtopping floods (based on peak flow), even though the soils are somewhat erosion resistant.
- Areas will begin to flood upon overtopping of the embankments, but the depths and areas of inundation will significantly increase following breach.

PFM #3: Failure of a floodwall

- The concrete floodwall represents the lowest point in the line of protection, and thus will overtop first.
- Even though the floodwall will overtop first, it is not as tall of a structure as the levee embankments, and thus the breach inundation and consequences will be less severe.
- The chance of intervention is better for this potential failure mode than for overtopping breach of the levee embankments due to good access and the limited reach (~ 1,000 feet) that would need to be protected.
- Although this PFM was identified as an issue for the baseline condition, this floodwall will not be required for the functioning of the Dallas Floodway System when the Lamar Levee is constructed for the Dallas Floodway Extension (DFE) Project. Since the DFE was considered fully constructed in the future without-project condition, this was not an issue to be addressed further in this study. However, if the DFE project is never constructed this would remain a concern for the City of Dallas.

PFM #7: Internal erosion through the foundation

- The seepage path for such a potential failure mode would extend from the river to a sump on the protected side of the levee. This results in a long seepage path and low gradients such that progression of the failure mode would be unlikely.
- A continuous clean sand layer extending from the river to the sump is unlikely. Although sandy zones and layers are present in the foundations of the levees, they appear to have significant fines in many locations. To reduce the uncertainty for this failure mode, further evaluation of this area would be required to fully determine if a continuous sand layer exists.
- The uniformity coefficient of the sand is such that a low critical exit gradient is unlikely.

PFM #8: Heave leading to internal erosion through the foundation

- Estimated or predicted pore pressures are high enough in the sand layers beneath the clay caps to initiate and produce boils. However, backward erosion is unlikely to progress to the river for reasons cited above.

PFM #13a: Global Instability

- The stability of the levee embankments is primarily dependent on developed pore pressures, which are likely to be low due to the transient nature of the flood loading and the generally low permeability of the clay embankments and their foundations.

PFM #13b: Progressive instability of the East levee

- Progressive instability would likely require simultaneous sliding on the upstream and downstream slopes of an embankment.
- Progressive instability is driven by saturation of the desiccated embankment zones.
- It is unlikely that the entire crest would be breached during the progression of a flood.
- Progressive slumping would need to gradually eat away at the crest, and a very high river stage would be needed to result in breach.

This study used flood risk analysis for economic damages and life-safety risk. The HEC-FDA and HEC-FIA models were used to define baseline conditions for flood risk. Based on the results of the risk assessment, PFM #2 and PFM #7 were carried forward to estimate economic damages in the future without-project condition. The PFM #8 was listed above as a PFM of concern; however, economic damages were not estimated for the future without-project condition. The PFM #8 uncertainty bounds plot close to the tolerable risk guideline and remains a PFM of concern considering known ecosystem restoration and recreation features of the BVP that would be evaluated later in the study.

Floodwall Failure (PFM #3) was not evaluated any further for risk reduction because the DFE Project was assumed to be fully constructed and addresses this PFM in the future without-project condition. Global and Progressive Stability Failure (PFM #13) was low in probability and the uncertainty bounds were located below the risk guideline. Therefore, PFM #13 was not evaluated further for risk reduction. The City of Dallas installed cut-off walls from station 3+00 to 29+00 for a total length of 0.49 miles on the West Levee and from station 295+00 to 442+00 for a total length of 2.97 miles along the East Levee. The City of Dallas' cut-off walls were not included in the future without-project condition because of possible construction credit for such modifications and determination of whether they are integral to the overall levee system upgrades evaluated in this feasibility report.

2.1.4 Future Without-Project Conditions

2.1.4.1 Damage Reaches

Based on the characteristics of the floodplain, the study was split into two damage reaches. The following describes the damage reach determination process based on hydraulic, geotechnical, social, and environmental considerations.

Structures were assigned to one of two reaches representing either the East Levee or the West Levee. In the hydraulic HEC-RAS model, the areas behind the East and West Levees were divided up into multiple flood storage areas in order to model the effects of flood volume and flood spreading within the damage area during a levee failure. Ten storage areas were modeled behind the East Levee, and seven storage

areas were modeled behind the West Levee. However, the unsteady hydraulic modeling results showed that for each levee breach that was analyzed, all 10 storage areas behind the East Levee filled up to the same maximum water surface elevation (within 0.01 feet). Similarly, the storage areas behind the West Levee all filled up to the same maximum water surface elevation (within 0.01 feet) for a given levee breach. This phenomenon of the storage areas filling to a single elevation occurred consistently for any levee breach that was analyzed, whether it was from internal erosion, overtopping, an upstream location, or a downstream location. The flood inundation behind each levee was consistently represented by a single elevation. Therefore, after reviewing the results of the hydraulic model, it was decided that the HEC-FDA economic model would be divided into one reach for the East Levee and one reach for the West Levee. For the internal erosion failure mode (under-seepage), economic damages were estimated if the system was breached prior to overtopping with breaches occurring at one location on each levee, both near the Hampton Pump Station, the most critical geotechnical sections. As with overtopping and subsequent breaching, multiple breach locations would not lead to significant differing results for estimations of economic damages in the future without-project condition.

The area behind the East Levee is primarily a commercial zone and the West Levee is largely residential. Demographic factors such as race, income, educational status were specified for the study area in order to identify any potential impacts to protected populations along with characteristics that might impact the ability to evacuate including English fluency, age, disability, or no access to a vehicle. The demographic differences in PAR affecting evacuation were a primary driver for quantifying risk separately for the areas behind the East Levee and the West Levee in the risk assessment.

The study area was divided into three reaches for environmental resources, the confluence area, the main stem, and interior drainage system. For the future without-project condition, this approach was used to characterize habitat suitability and potential impacts within these three distinct areas. During the FRM (Trinity River flooding) planning process, the future without-project condition for environmental resources and cultural resources was used to avoid and minimize impacts to those resources. A Phase I Environmental Site Assessment was utilized to determine sites to avoid.

2.1.4.2 Geotechnical Parameters

Current geotechnical conditions within the study area would generally remain the same for the future without-project condition. Desiccation cracking will continue to result in slides and continue to be an operation and maintenance cost for the City of Dallas. Desiccation cracking was determined to be low risk in the risk assessment. The risk described here is based on the fact that the City of Dallas fixes slides (a result of desiccation) as they occur to maintain the integrity of the levee system. Although it was determined low risk, measures to address other failure modes might reduce concerns with the desiccation cracking problem.

Fragility curves were developed for the internal erosion failure mode of the East and West Levee to model economic damages with the potential failure of the levee system. Fragility curves were tested within the HEC-FDA modeling package and considered in the estimates of equivalent annual damages (EADs) but results varied greatly due to the very small exceedance probabilities associated with these curves. HEC-FDA allows for the use of either fragility curves or interior versus exterior flood stage relationships but not both. The latter methodology was used in the overtopping with a subsequent breach analysis, as well as the internal erosion analysis because it was deemed to be more stable and a much better representation of the flood inundation risks behind the levees since it takes into account all of the carefully-configured Unsteady HEC-RAS modeling capabilities associated with potential breach

formation and timing. The internal erosion failure mode was evaluated at one location on each levee, both near the Hampton Pump Station, the most critical geotechnical sections.

2.1.4.3 Hydrology and Hydraulics

Following the risk assessment, additional hydrologic and hydraulic analyses were performed for input into the HEC-FDA model. Hydraulic analyses were performed on the Trinity River main stem, the Elm Fork, and the West Fork of the Trinity River. Water surface profiles were computed for a wide range of flood events including the SPF and flood events greater in magnitude than the SPF. The SPF is defined as the flood that would be expected from the most severe combination of meteorological and hydrologic conditions that are considered to be reasonably characteristic of the geographical region involved, excluding extremely rare combinations. A detailed description of the hydrology and hydraulics models used to estimate economic damages for this study is contained in Appendix A (Hydrology and Hydraulics).

During the risk assessment, it was recommended that HEC-RAS with unsteady flow be used to account for the effects of timing and flood volume during a levee overtopping and breach. Therefore, an unsteady HEC-RAS analysis was performed for baseline and future without-project conditions to measure the performance of the existing Dallas Floodway Levee System against a range of flood events and to evaluate the economic consequences of the failure modes of concern.

Assumptions that were made regarding the potential failure of the levees have a significant effect on interior flooding depths, as well as the resulting estimates of economic damage and loss-of-life. For these reasons, the unsteady flow model was developed with close coordination with the Corps and various experts throughout the nation including team members from the Fort Worth District, the Corps Hydrologic Engineering Center (HEC), the Risk Management Center, and the Modeling, Mapping and Consequence Center production center. The team members reviewed the levee failure methodologies and assumptions as they were being modeled and made recommendations on improvements throughout the development process.

Two potential failure modes for the levee system were considered: internal erosion (piping) failures and levee overtopping resulting in a breach. Internal erosion involves a process whereby seepage of floodwater during a flood event was assumed to flow through the foundation of the levee template where porous strata exists and eventually flows through to the protected side of the levee. If this seepage occurs for a long enough period of time, it was assumed to erode the levee internally and potentially result in a levee breach. The internal erosion failure mode was added to the economic analysis following the determination that the life-safety risk could potentially be reduced by measures to address internal erosion.

The breach progressions for these two failure modes were entirely different and independent from one another. Therefore, the evaluation of these two failure modes required two different analyses for baseline conditions. Appendix A, Section 4, describes the assumptions and analysis for baseline conditions for the overtopping failure mode. The internal erosion failure mode was later analyzed as a separate baseline condition, and its analysis is discussed in Section 5.6 of Appendix A.

For purposes of evaluating flood risk, the area of concern was bounded outward from the East and West Levees, to the approximate limits of the SPF. The SPF flood event under existing conditions has a return interval of 2,500-year, or 0.04% Annual Exceedance Probability (AEP), and has an estimated future peak flow of 277,000 cfs. Floodplain inundation maps were created by intersecting the water surface elevations computed in the analysis with the land surface for the SPF flood event. The map shows the areas behind

the Dallas Floodway East and West Levees that are within the area estimated to be flooded by a levee breach due to overtopping under future without-project conditions (277,000 cfs). The assumed overtopping breach location for the East Levee was at river station 134952 (near the Hampton Road Bridge), which would have an incipient overtopping AEP of 0.066% (or a return interval of 1,500 years) under future without-project conditions. Overtopping locations are shown in Figure 2-5. The assumed overtopping and breach location for the West Levee was at river station 139920 (near the Westmoreland Road Bridge), which has an incipient overtopping AEP of 0.055% (or a return interval of 1,800 years) under Future Without-Project Conditions. The flooding depths for the internal erosion failure mode would be similar to what is shown for overtopping with breach assuming the same flood event, according to the hydraulic analysis. The estimated flooding depths for the SPF for both failure modes are shown in Figure 2-6.

Figure 2-5 Modeled Breach Locations for Overtopping

2.1.4.4 Economic Analysis

A structure file of the floodplain inundation area was developed to determine the potential flood damages for properties behind the East and West Levees if a failure were to occur. Tables displaying structure and content values by reach, type and major damage category at October 2013 price levels are presented in Appendix E (Flood Risk Management Analysis). A total of 9,057 structures were estimated within the SPF floodplain limits. These structures have a total estimated investment value of approximately $8.3 billion in structures at a 2010 level of development and $5.4 billion in contents. If the levees are breached during a major flood event, floodwaters could potentially inundate developed areas of the City of Dallas and result in damages to structures behind the East and West Levees. Estimates of EAD under the future

without-project condition were calculated. Damages were estimated using the risk and uncertainty within HEC-FDA version 1.2.5, through integration of frequency-damage data. Estimates of EADs are the summation of the base year expected annual damages, in this case 2015, plus the discounted value of the most likely future year expected annual damages, for this analysis, 2025. The future expected annual damages shown here are discounted over the 50-year period of analysis at the fiscal year 2014 Federal discount rate of 3.5%. Table 2-1 shows a breakdown of where these damages are predicted to occur behind the East and West Levee under an overtopping and breach failure estimate. Damage categories are defined as the following; *Comm*. (commercial), Ind. (industrial), *MFR* (multi-family residential), *Mobil* (mobile residences), *Public* (public), *POV* (personal occupancy vehicles), *SFR* (single-family residential), and *Tunnels* (businesses operating in the tunnel system under the Central Business District).

Table 2-1. Overtopping Equivalent Annual Damages Without-Project Condition (October 2013 Price Level; $000)

	Comm.	*Ind.*	*MFR*	*Mobil*	*Public*	*POV*	*SFR*	*Tunnels*	*Totals*
East	$3,131	$101	$99	$0	$1,427	$26	$30	$3	$4,815
West	$141	$23	$58	$0	$104	$72	$299	$0	$696
Total	**$3,271**	**$124**	**$156**	**$0**	**$1,531**	**$98**	**$328**	**$3**	**$5,511**

Internal erosion required a different future without-project condition with different inflow events and breach settings for EAD. Baseline EAD for internal erosion is discussed in greater detail in Section 3.4.5.2 of Chapter 3.

In the future without-project condition, the economic damages in the study area would remain unchanged, and the City of Dallas would accept the $5,511,000 estimate of equivalent annual damages. The economic risk of overtopping and breach, or a breach prior to overtopping would remain in the future without-project condition.

2.1.4.5 Life-Safety Analysis

Annualized estimates for probability and loss-of-life shown in Table 2-2 were used as baseline conditions to measure the performance of an alternative or structural/nonstructural measure in the plan evaluation discussed in Chapter 3. They are presented here to describe the future without-project conditions regarding life-safety risk for the study. Updated probability and consequence estimates due to overtopping and subsequent breach (PFM #2) and internal erosion (PFM #7) are presented in Table 2-2. The update was developed for the unsteady hydraulic modeling conducted for the economic analysis.

Table 2-2. Estimated Failure Probability and Loss-of-Life for Baseline Conditions of Overtopping and Subsequent Breach (PFM #2) and Internal Erosion (PFM #7)[1]

Annualized Failure Probability – PFM #2	
East Levee	5.42E-04
West Levee	5.42E-04
Annualized Life Loss – PFM #2	
East Levee	1.37E-01
West Levee	4.51E-01
Annualized Failure Probability – PFM #7	
East Levee	5.19E-06
Annualized Life Loss – PFM #7	
East Levee	1.33E-03

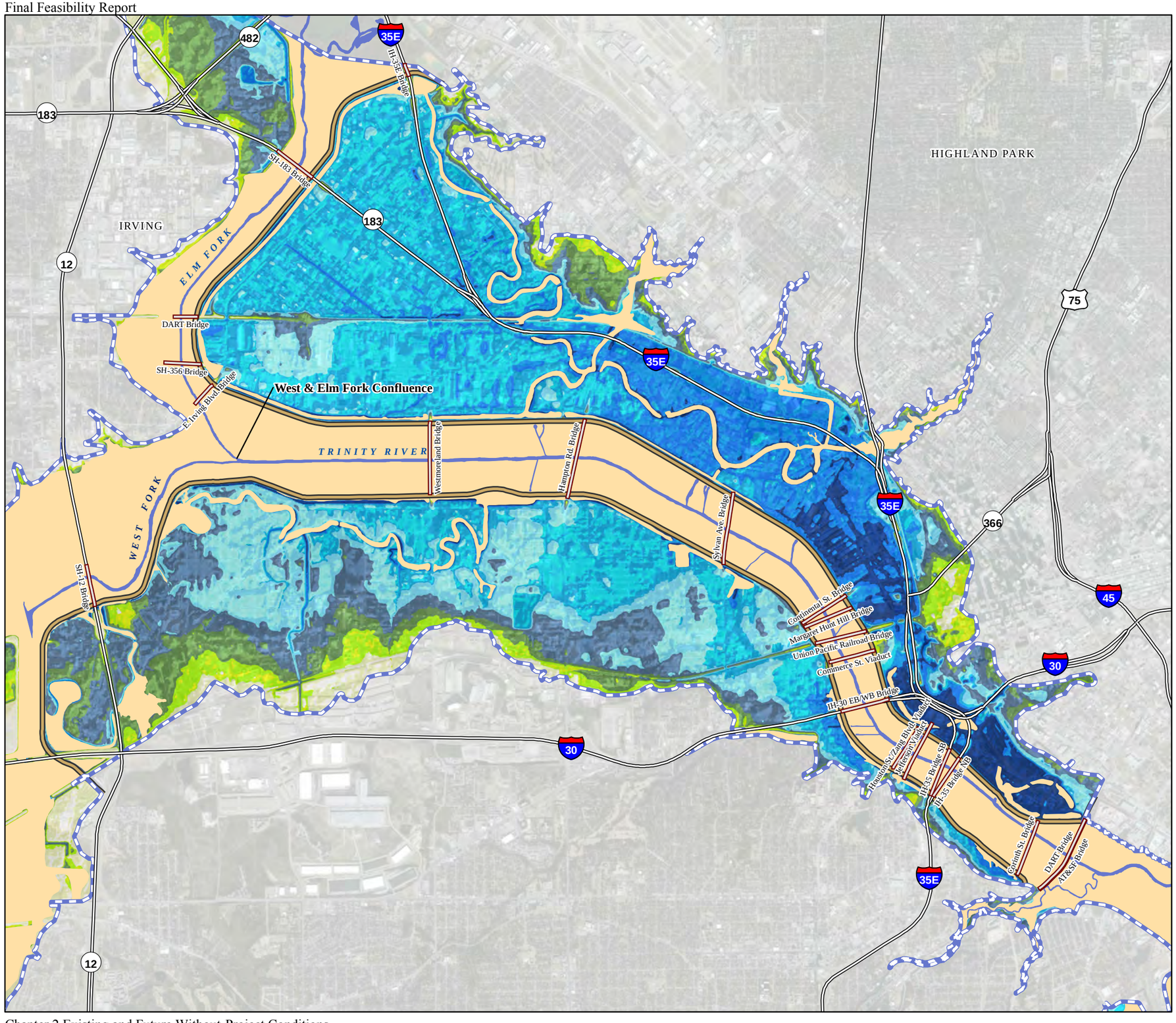
Note: [1]Table uses the revised risk assessment estimates.

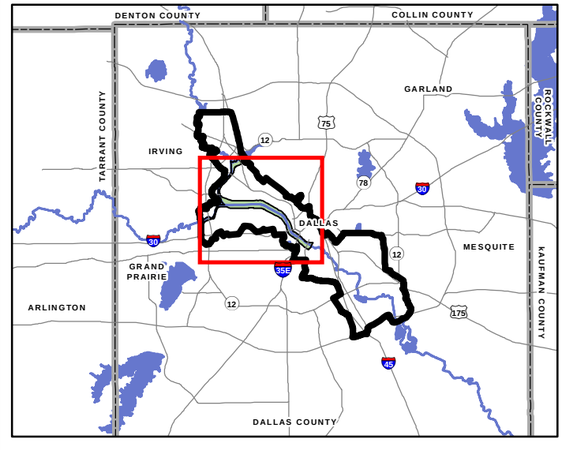
Figure 2-6
Flood Extents for the Future Without-Project SPF Event

LEGEND

Estimated SPF Flood Depth

- Minimal to No Flooding
- 0 to 5 Ft
- 5 to 10 Ft
- 10 to 15 Ft
- 15 to 20 Ft
- 20 to 25 Ft
- 25 to 30 Ft
- 30+ Ft
- SPF Extent
- 100-Year Riverine Flood Extent
- Surface Water
- Dallas Floodway Levee
- Bridge
- Freeway





0 0.5 1 Kilometers

0 0.5 1 Miles

GIS Sources: City of Dallas 2008a, NCTCOG 2008, USACE 2011

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The City of Dallas currently has a flood warning system in place. This flood warning system is described in the City of Dallas' Emergency Action Plan (EAP) for the Trinity River Federal Levee System, dated April 2010 (City of Dallas 2010). In the event of flooding, Police and Fire-Rescue Dispatch would issue a warning to affected residents using Reverse 911. In addition, City of Dallas officials would implement measures such as requesting broadcasters to disseminate Emergency Alert System broadcasts, issue news through cable override, special news advisories to radio, and television and cable news stations.

In the future without-project condition, the PAR in the study area was assumed to remain the same. The risk of an overtopping and breach, and failure due to internal erosion would remain in the future without-project condition; however, the City of Dallas would continue to implement their EAP to reduce the potential loss-of-life in a major flood event.

2.2 INTERIOR DRAINAGE

The East and West Levee Interior Drainage System (EWLIDS) consists of the Hampton, Baker, Able, Eagle Ford, Delta, Pavaho, and Charlie drainage basins and associated stormwater conveyance structures (Figure 4, Appendix L). After their construction in the 1930s the East Levee Interior Drainage System (ELIDS) originally consisted of two pumping plants ("A" [now Able] and "B" [now Baker]) and two pressure sewers (Dallas Branch and Belleview). The ELIDS now contains three pumping plants (Hampton, Baker, and Able) and associated sumps, four pressure sewers, and numerous gravity sluices. The West Levee Interior Drainage System (WLIDS) originally consisted of two pumping plants (C [now Charlie] and D [now Delta]) and one pressure sewer (Coombs Creek [now Old Coombs Creek]). Today, the WLIDS contains three pumping plants (Delta, Pavaho, and Charlie) and associated sumps, three pressure sewers, and gravity sluices. Table 2-3 presents the drainage basin and associated pump station and sump for the EWLIDS.

The existing Interior Drainage System (IDS) consists of the sumps areas, various pump stations and associated stormwater conveyance structures. The stormwater runoff control system in the City of Dallas consists of a wide array of physical components including overland flow paths, channels, detention storage, floodplains, and larger downstream storage areas. The stormwater control system physical components include the following:

- Sump ponds (natural topographically low areas in the terrain that collect, convey, and store stormwater);
- Major drainage ways (e.g., large concrete-lined surface channels leading toward sumps, and natural channels);
- Streets (part of overland flow, or the flow of stormwater on the surface until it reaches an inlet or a detention facility);
- Storm sewers (e.g., pressure sewers featured as part of the EWLIDS and smaller gravity storm sewers that gather portions of the basin and convey water to major drainage ways);
- Flow control devices (e.g., stormwater gates and gravity sluices (sluice gates) and pumps;
- Trash racks, storm inlets, or grates (e.g., trash racks installed near pumping plants remove large debris from the sump basins prior to pumping); and
- Detention facilities (e.g., water storage sumps and detention ponds that hold stormwater either until it is evaporated or allowed to flow or be pumped elsewhere).

Many of the sump ponds are old river channels that have been cut off from the West Fork, Elm Fork, and Main stem Trinity River by levees. These old channels are natural topographically low areas in the terrain that collect, convey, and store stormwater. In addition, there are storage ponds and levee borrow ditches that run adjacent to the levees that store stormwater. Drainage sumps that are portions of the historic river channels are classified as jurisdictional waters of the U.S. In addition, some stormwater runoff is captured higher up the basin in creeks and conveyed to the Floodway via pressure sewers.

Table 2-3. Pumping Plant to Sump to Basin Relationship

Basin	*Sump*	*Pumping Plant*
East Levee Interior Drainage System		
Hampton	Records Crossing/Nobles Branch	Hampton
Baker	Hampton-Oak Lawn	Baker
Able	Able	Able
West Levee Interior Drainage System		
Eagle Ford	Eagle Ford	None - sluice gate
Delta	Trinity Portland/Westmoreland-Hampton/ Frances Street	Delta
Pavaho	Pavaho	Pavaho
Charlie	Charlie/Corinth Street	Charlie

The current system was designed to correspond to original (1960s- and 1970s-era) 100-year, 24-hour storm events, which reflected stormwater basin conditions at that time. Primarily due to changes in the stormwater basins, the design storm event water levels no longer reflect current stormwater basin conditions (City of Dallas 2006, 2009).

Most of the pump stations and sumps are unable to manage a 100-year, 24-hour flood event, as the estimated flood stage from such an event is greater than the original design elevations of the stations. Table 2-4 describes the number of potentially affected and potentially flooded structures in the IDS broken out by sump area, drainage basin, and associated pump station. As identified within Table 2-4, the Able Sump has the potential to flood the greatest number of structures, while the Hampton-Oak Lawn Sump has the potential to cause the greatest amount of financial damage. Figure 2-7 shows the predicted inundation and flood risk extents from a 100-year storm event based on current pump capacity and design elevations of the IDS. A “potentially affected structure” is any structure touched by the predicted water surface elevation, and “potentially flooded” are those touched by the inundation area that have finished floor elevations below the predicted water surface elevation.

Table 2-4. Potentially Affected Structures and Their Appraised Values for the 100-year, 24-hour Storm Event

Sump	*Drainage Basin*	*Pump Station*	*Predicted 100-year, 24-hour Flood Elevation (feet)*	*Potentially Affected Structures (Appraised Value[1])*	*Potentially Flooded Structures (Appraised Value[1])*
East Levee Interior Drainage System					
Able	Able	Able	399.2	208 ($56.2 M)	131 ($42.5M)
Hampton-Oak Lawn	Baker	Baker	403.7	329 ($958.5 M)	104 ($291.7 M)
Record Crossing	Hampton	Hampton	405.8	444 ($544.0 M)	94 ($32.7 M)
Nobles Branch	Hampton	Hampton	409.3	49 ($92.0 M)	8 ($27.2 M)
West Levee Interior Drainage System					
Charlie	Charlie	Charlie	403.5	34 ($4.4 M)	3 (<$0.1 M)
Pavaho	Pavaho	Pavaho	408.2	1,047 ($33.5 M)	205 ($5.6 M)
Westmoreland-Hampton	Delta	Delta	408.5	71 ($8.5 M)	3 (<$0.1 M)
Frances Street	Delta	Delta	410.1	11 ($0.2 M)	3 ($0.1 M)
Trinity-Portland	Delta	Delta	412.0	59 ($4.3 M)	8 ($0.3 M)
Eagle Ford	Eagle Ford	None – sluice gate	417.2	34 ($11.4 M)	0
Corinth Street	Charlie	Charlie	402.1	12 ($0.2 M)	2 (<$0.1 M)

Notes: [1] Appraised value given in millions (M) of dollars. Values based on 2009 appraisal data.
Sources: City of Dallas 2006, 2009.

By design, pumping plants can manage (i.e., eject stormwater to the Floodway) stormwater up to their respective design storm event water levels. Where the predicted 100-year, 24-hour storm event water levels are greater than the original design storm event water levels, it indicates that the associated pumping plant is undersized to handle the predicted volume of stormwater, and flooding is likely. This problem would continue in the future without-project condition.

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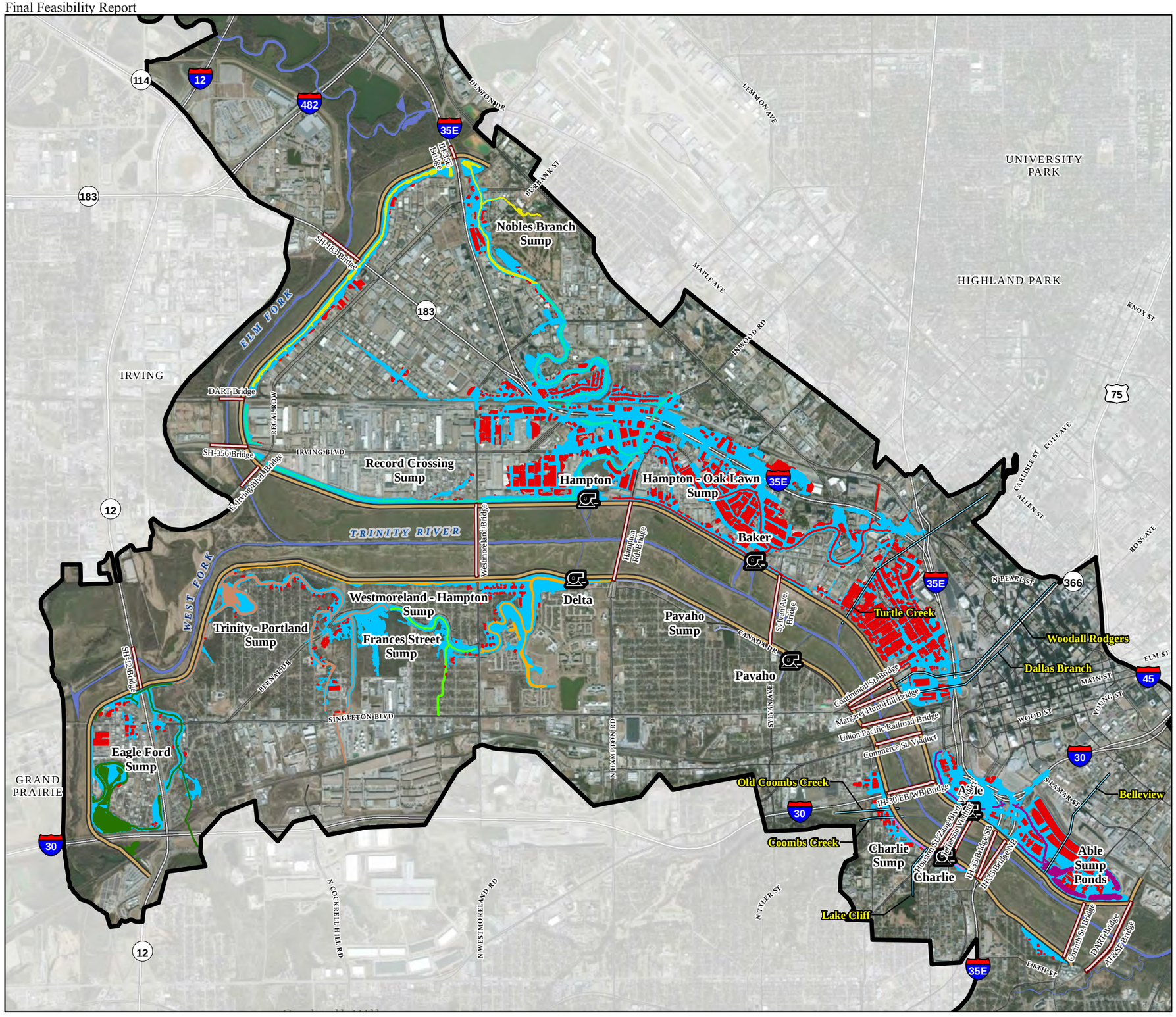


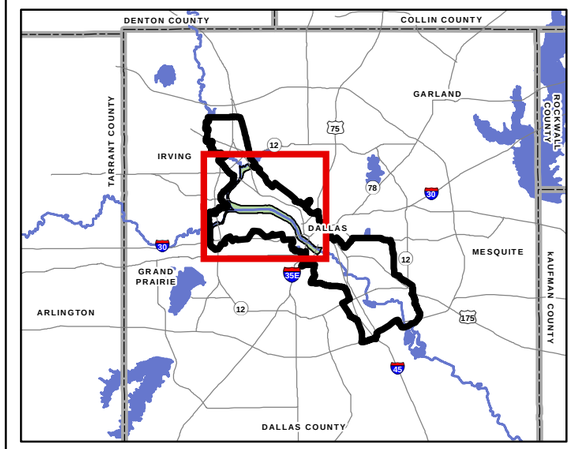
Figure 2-7
Inundation Areas and Potentially Affected Structures Resulting from the Predicted 100-Year, 24-Hour Storm Event under Existing Conditions

LEGEND

- Pumping Plant
- Dallas Floodway Levee
- Pressure Sewer
- Freeway
- Bridge
- Street
- Potentially Affected Structures
- 100-Year Inundation Area
- Study Area
- Surface Water

East Levee Sumps
- Able
- Hampton - Oak Lawn
- Nobles Branch
- Record Crossing

West Levee Sumps
- Charlie
- Eagle Ford
- Frances Street
- Pavaho
- Trinity - Portland
- Westmoreland - Hampton



0 0.5 1 2 Kilometers
0 0.5 1 Miles

Sources: City of Dallas 2008a, 2009c; NCTCOG 2008

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2.3 RIVERINE ECOSYSTEM

2.3.1 River

Past channelization and clearing in the Floodway, along with urbanization, has significantly degraded the natural terrestrial and aquatic habitat in the Floodway. The Trinity River now reflects little of its historic course, water quality, or habitat. Prior to the 1920s, the Trinity River's morphology through the City of Dallas included significant meandering. The construction of the Dallas Floodway Project has essentially eliminated these meanders, and with it, high-value habitat and connections to adjacent ecosystems (Corps 2000). Historic natural meandering of the river created pool and riffle complexes that provided for diverse aquatic habitats. Without meandering, the habitat complexity is limited. In a meandering system, pools typically form in the outside bank of bends and the riffles (sandbars) usually form between the bends. These pools and riffles were an integral part of the historic Trinity River in the mid-1850s that navigation along the river was "often … impeded by snags or sand bars or halted by low water" (Gard 2013). The construction of the Dallas Floodway Project eliminated the meanders thereby inhibiting the formation of pools and sandbars (riffle habitats).

Natural river corridors are comprised of the river, the riverbank, wetlands, and a series of one or more floodplain terraces that eventually connect to the adjacent upland habitats. The vegetation within the riverine corridor along these floodplain terraces provide physical benefits by filtering stormwater runoff before reaching the river and ecological benefits by providing diverse habitats and a travel corridor connecting fragmented habitats. Primary factors affecting these riverine functions are the width of the riverine corridor, the geometry and composition of the edge, and the connectivity of the corridor with adjacent habitats. Given the same riparian vegetation composition, a wider riverine corridor naturally provides more effective filtering than a narrower riverine corridor. Nutrients, sediment, and stormwater runoff entering the riverine corridor are selectively filtered depending on the shape and composition of the corridor edge. Straight corridor edges provide less effective filtering than a convoluted edge associated with a meandering corridor. In addition, the composition of the corridor edge greatly influences the effectiveness of nutrient and sediment filtering. Areas where there are abrupt transitions from grassland to riparian forest, sediment and nutrient functions concentrate in a narrow area along the transitional boundary, which has multiple adverse impacts on the ecosystem. A more complex system with gradual edges, transitioning naturally among grassland, wetland, shrubland, riparian forest, increases the filtering and spreads sediments and nutrients across a wider ecological gradient.

The width of the riverine corridor and the composition of the corridor edge are also of great importance for fish and wildlife resources. The more diverse and wider the riverine corridor, the greater the capacity for organisms to move within and along the riverine corridor. Gradual corridor edges and connections to adjacent wetland and upland habitats greatly improve the travel corridor functions of the riverine ecosystem.

The original Dallas Floodway Project construction removed natural structure and function from the Trinity River. It also altered the hydrology (with construction of the reservoirs upstream) and vegetation within the Floodway effectively reducing the riverine corridor width, and cut off connections to adjacent wetland habitats. Filtering and buffering functions of the riverine corridor have been greatly disrupted. Aquatic habitats such as cut banks, pools, sandbars, and other habitats have been greatly reduced by the straightening of the river. It is expected that the existing river conditions would prevail in the future without-project condition. Additional information on the environmental resources in the study area can be found in Appendix F (Environmental Resources).

2.3.2 Wetlands

Wetlands within the riverine corridor depend on a constant or recurrent inundation or saturation from flood events. Wetland functions within the riverine corridor benefit the fish and wildlife especially during migration periods. They also provide water storage (flood attenuation), filter sediment and nutrients, improve water quality, and provide a source for groundwater recharge. Wetlands are dynamic ecosystems dependent on seasonal flooding and provide a diverse habitat for fish and wildlife resources, especially when connections with the rest of the habitat and aquatic features are fully functional. Habitat types of concern in the study area include bottomland hardwood habitat and emergent wetlands.

2.3.2.1 Bottomland Hardwood

Bottomland hardwood habitats are wetland areas dominated by deciduous trees, usually along streams, that are occasionally flooded. Located primarily along the Trinity River and its inflows, many of these woodlands are periodically flooded and are predominately composed of cottonwood, cedar elm, green ash, pecan, black willow, and box elder. Other tree species present include bur oak, red mulberry, and sugar hackberry (see Appendix G, U.S. Fish and Wildlife Planning Aid Report). Bottomland hardwoods along the Trinity River are limited to a narrow strip along the main stem and in isolated areas near the confluence. The Great Trinity Forest, located downstream of the AT&SF Railroad Bridge in the DFE Project area represents some of the best remaining bottomland hardwood habitat in the region (Corps 2000).

2.3.2.2 Emergent Wetlands

Currently, wetlands within the Floodway consist of shallow depressions located in the floodplain that are isolated from the riverine habitats of the main river channel. They are also routinely mowed, and when they seasonally dry up, they become overcome by non-native invasive herbaceous vegetation. Connectivity between the river and floodplain wetlands is disrupted by the current structure of the channel banks. It is expected that these conditions would prevail in the future without-project condition.

2.3.3 Fish and Wildlife

Historically, the river channels, riparian corridors, and wetlands associated with floodplains of the Trinity River supported a wide variety of wildlife species for cover, food, and nesting areas including migratory songbirds and waterfowl, raptors, wading and shore birds, fish, amphibians, reptiles, and mammals. Predator control, hunting, use of pesticides, and various forms of air, water, and land pollution have affected fish and wildlife populations throughout the area. Dallas County wildlife is subject to reduction or elimination by habitat destruction through removal, physical alteration, and/or pollution. The surviving fish and wildlife live in a modified natural habitat within the immediate influence of an encroaching urban complex (Corps 1999). Wildlife species occurring in the area are those tolerant of human activity such as rabbits, songbirds, squirrels, and small rodents (Corps 2006). The Great Trinity Forest in the southern end of the study area provides fish and wildlife habitat and is a source area for fish and wildlife to disperse into the rest of the area. The areas upstream in the confluence and along Elm Fork provide higher quality habitats for fish and wildlife than the main stem because the stream and corridor are in more natural conditions.

Multiple fish and wildlife inventories have been conducted over the years around or within the study area. For example, seventy-seven wildlife species were documented in the Great Trinity Forest in 2008 and included 1 amphibian, 49 birds, 20 mammals, and 7 reptiles (City of Dallas 2008). The U.S. Fish and Wildlife Service (USFWS) also published, *Urban Development and Fish and Wildlife Habitat of the Dallas-Fort Worth Metroplex* provided an assessment of fish and wildlife resources of the Dallas area in

1989 (Johnston 1989). At that time, habitats within the Dallas-Fort Worth metropolitan area supported 291 species of birds, 36 species of mammals, 68 species of reptiles, 25 species of amphibians, and 66 species of fish (Johnston 1989). Recently, from February 2009 to December 2009, 280 bird species were observed in Dallas County and 183 bird species were observed at the Trinity River Audubon Center, approximately 5 miles south of the southern edge of the study area (Trinity River Audubon Center 2011). In Dallas County 81 species of reptiles and amphibians were reported including 4 species of salamanders, 20 species of toads and frogs, 1 alligator, 12 species of turtles, 1 anole, 13 species of lizards, and 30 species of snakes (National Audubon Society 1998; Stebbins 2003; Texas A&M University 2009).

Aquatic communities of the Trinity River have been and continue to be impacted by urbanization, loss of riparian zone and floodplain habitats, reduced complexity of instream physical habitat and availability of natural habitats, and elevated nutrient levels and elevated levels of pesticides. In certain areas, the river channel has riffles, runs, and pools, which provide habitat for several species of invertebrates and fish. Studies conducted by the Texas Parks and Wildlife Department (TPWD), the University of North Texas' Institute of Applied Sciences and University of Dallas (Dickson *et al.* 1989), identified 12 families and 46 species of fish within the Upper Trinity River Basin, which includes the Dallas Floodway study area. These studies verified that stream fisheries have improved since the 1970s and early 1980s, due primarily to improved water quality resulting from improved wastewater treatment. Sport fish present in the study area include largemouth bass, channel catfish, crappie, and white bass. Other species which tend to be more tolerant of moderate levels of nutrients and lower dissolved oxygen content in the area include common carp, river carpsucker, longnose gar, freshwater drum, several species of shiners, and bullhead catfish. Non-sport fish species found in the study area that are less tolerant to pollutants include gizzard shad, mosquito fish, and several sunfish species.

In 2004, the USFWS prepared a report entitled "*Assessment of Trinity River Fisheries within the Dallas Flood Control Project Area, Dallas County, Texas,"* that outlined results of fisheries surveys undertaken in the Dallas Floodway (USFWS 2004). In addition, open water fisheries sampling of Crow Lake, Bart Simpson Lake and DFE Cell D was conducted in 2009 and 2010 to obtain documentation of fisheries open water habitat and fish populations and health. Eleven species of fish were observed during June 2010 sampling and include inland silverside (*Menidia beryllina*), largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), white crappie (*Pomoxis annularis*), bluntnose darter (*Etheostoma chlorosoma*), logperch (*Percina caprodes*), spottail shiner (*Notropis hudsonius*), red shiner (*Cyprinella lutrensis*), threadfin shad (*Dorosoma petenense*), western mosquitofish (*Gambusia affinis*), and longnose gar (*Lepisosteus osseus*) (Corps 2010). These species are also likely to occur in the Trinity River.

More than 50 species of freshwater mussels are native to Texas. Freshwater mussels are one of the most imperiled groups of animals in the U.S. The decline of freshwater mussels is due to habitat fragmentation and changes in flow rates in streams and rivers caused by episodes of drought and flooding, ground water pumping, surface diversions, dams, urban and agricultural development; siltation; and contaminants in runoff. Invasive plants and animals also compete with, prey upon, and alter the habitats of native mussels (TPWD 2008). A Phase II presence/absence survey for state listed mussel species was recently performed at the IH-30 and IH-35 crossings of the Trinity River in the Dallas Floodway study area as part of the Federal Highway Administration (FHWA)/North Texas Tollway Authority (NTTA) Dallas Horseshoe project environmental assessment work efforts. Eleven species of mussels were found, including the Texas pigtoe (*Fusconaia askewi*), a state listed species that was only found at the IH-35 crossing; however, the Texas pigtoe is also likely to occur in the river channel within the confluence and main stem area of the Floodway. The USFWS has recently initiated investigation into the status of Texas mussels.

In summary, the existing river ecosystem supports a fair amount of fish and wildlife species; however, the degraded riverine ecosystem could be improved to provide more natural instream and riparian structure and function. It is expected the fish and wildlife that currently utilize the study area would remain the same in the future without-project condition.

2.3.4 U.S. Fish and Wildlife Service Recommendations

The USFWS provided a Planning Aid Report that contains recommendations that could be beneficial for the restoration of natural habitat impacted by urban development in the study area. A Final Fish and Wildlife Coordination Act Report is included in Appendix G. The recommendations are summarized as follows:

- Widen the riparian woodland corridor along the creeks and their associated tributaries as much as possible;
- Improve the existing riparian corridor and upland forests by thinning portions where it's too dense, and planting mast producing trees and shrubs where they are lacking;
- Provide brush and log piles in all existing habitats to provide cover for small mammals;
- Conduct Hazardous, Toxic, and Radioactive Waste tests where restoration work is proposed;
- Create off-stream wetlands;
- Plant locally available native aquatic plants and shrubs around the water edges;
- Construct proposed waterbodies with shelved floors of variable depths and appropriate substrates for habitat cover and spawning conditions;
- Implement a fish stocking plan, and do not use carp for vegetation control;
- Implement a monitoring program;
- Construct pool, riffle, run sequences where possible;
- Retain canopy cover where possible;
- Create native grasslands where possible;
- Implement a mowing program that promotes tall grass growth, but does not interfere with tall grass nesting birds; and
- Consider Birds of Conservation Concern 2002 during project planning.

CHAPTER 3
PLAN FORMULATION & COMPREHENSIVE ANALYSIS

3.1 PROBLEMS AND OPPORTUNITIES

3.1.1 City of Dallas' Balanced Vision Plan and Interior Drainage Plan

Following Trinity River flooding in 1989 and 1990, the City of Dallas (in conjunction with regional stakeholders) began looking at ways to outline a long-range vision for the entire Trinity River Corridor (TRC). The vision aimed to reclaim the Trinity River as a great natural resource in order to create a unique public domain and achieve a model of environmental stewardship. In the subsequent years of planning and community input, the City of Dallas and stakeholders developed concepts for addressing five key issues:

- Flood Risk Management (FRM);
- Environmental Restoration and Management;
- Parks and Recreation;
- Transportation; and
- Community and Economic Development (City of Dallas 2003).

The outcome of this effort culminated in "The Balanced Vision Plan" (BVP) for the TRC (December 2003, amended March 2004). The BVP aims to create an environment that brings residents and development closer to a healthier TRC without diminishing the long-term effectiveness of the Dallas Floodway Project. The 2004 updates (not depicted) include more sinuosity of the Trinity River, extending and widening the Urban Lake, a larger island downstream of the Natural Lake, and utilizing water from the Central Wastewater Treatment Plant to fill the Natural Lake.

The same levees that provide FRM benefits to the City of Dallas from Trinity River flood events also prevent the local stormwater runoff from draining directly to the river. The City of Dallas reports entitled, "*The Interior Levee Drainage Study, East Levee – Phase I, Dallas, Texas*," dated September 2006, and "*The Interior Levee Drainage Study, West Levee - Phase II, Dallas, Texas,"* dated February 2009 (City of Dallas 2006, 2009) identify means to reduce the stormwater flood risk for structures located within the predicted flood area for the 100-year, 24-hour storm event.

3.1.2 The Modified Dallas Floodway Project for Section 5141 of WRDA 2007

The BVP and Interior Drainage Plan (IDP) were developed by the City of Dallas to address problems and opportunities of which some of those are above those normally considered by the United State Army Corps of Engineers (Corps). Transportation, and community and economic development projects do not align with the traditional Corps missions and are generally the responsibility of local entities or other Federal agencies. However, the Corps does have an interest in FRM and ecosystem restoration and an ancillary interest in providing recreation development. The City of Dallas and the Corps decided the major recreation features of the BVP were beyond what the Corps would normally participate and decided that they should not be included for cost sharing purposes and the City of Dallas should seek approval to construct those features through a separate Section 408 process. Therefore, the recreation features were eliminated from consideration as a federal interest. Problems and opportunities were identified and goals and objectives were developed which align with the identified Corps mission areas of

FRM and ecosystem restoration. These objectives were used to measure the success of individual measures, and were instrumental in deciding which parts of the BVP and IDP to include in the Recommended Plan for the Modified Dallas Floodway Project (MDFP) for Section 5141 of WRDA 2007.

3.1.3 Flood Risk Management Problems, Opportunities and Objectives

The risk assessment developed for the Dallas Floodway Project details perceived vulnerabilities of the Dallas Floodway Project and its components. In addition to the risks associated with the levees themselves, the City of Dallas was also experiencing frequent inundation due to interior drainage on the protected side of the levees. While interior drainage is normally a local responsibility, the current authorization allows for Corps participation in this problem. Federal Emergency Management Agency (FEMA) was proposing to remap the floodplain behind the levees not only due to the levee issues identified in Periodic Inspection (PI) Report No. 9, but also because there is not currently 100-year level of flood risk levels provided by the Interior Drainage System (IDS) associated with the Dallas Floodway Project. The non-Federal sponsor is seeking FEMA certification for National Flood Insurance Program purposes as their floodplain management choice. Once the IDP features are implemented and the impact area of the 100-year floodplain is modified/improved, the areas outside the 100-year flood event would not be required to pay mandatory flood insurance and no development restrictions would be enforced. Using the risk assessment to inform the baseline risks with the Dallas Floodway Project and the knowledge of the conditions of the existing IDS, the following problem and opportunity statements, and associated objectives were developed (Table 3-1).

Table 3-1. Flood Risk Management Problems, Opportunities and Objectives

<table>
<tr><th>Problem 1</th><th>Opportunity 1</th><th rowspan="6">Objective 1

Ensure the reliability and integrity of the current infrastructure and improve the functioning to further reduce residual flood risk to property while promoting life safety for the Dallas Floodway Project over a 50-year period of analysis.</th></tr>
<tr><td>There is approximately $13.7 billion (in structure and content value) in floodplain investment behind the Dallas Floodway Project that is at risk from a failure of the levee system. There is approximately $5 million in remaining equivalent annual damages with the Dallas Floodway Project in place.</td><td>Reduce the likelihood of potential flood damages behind the levees.</td></tr>
<tr><th>Problem 2</th><th>Opportunity 2a</th></tr>
<tr><td rowspan="2">The levee system could overtop, overtop and breach, or breach prior to overtopping and could result in flood damages and loss-of-life.</td><td>Prevent the levees from overtopping, overtopping and breaching, and/or breaching prior to overtopping.</td></tr>
<tr><th>Opportunity 2b</th></tr>
<tr><td>Improve the City of Dallas’ Emergency Action Plan to address flood warning and evacuation.</td></tr>
<tr><th>Problem 3</th><th>Opportunity 3</th></tr>
<tr><td>Desiccation cracking on the levees has led to slope failures in the past and will continue to contribute to slope failures in the future. Desiccation cracking was determined to be low risk; however, they do lead to increased Operation and Maintenance (O&M) cost.</td><td>Reduce future O&M costs of the Dallas Floodway Project by increasing stability and decreasing slope failures.</td></tr>
</table>

Problem 4	*Opportunity 4*	*Objective 2*
Undersized pumps and sumps result in flood damages behind the Dallas Floodway Project and general flooding on the protected side of the levees.	Increase pump and sump capacity to be able to discharge the 100-year flow.	Reduce the risk of flooding due to interior drainage.
Problem 5		
FEMA updates may result in remapping of 100-year flood zones behind levee system that are not protected by 100-year interior drainage projects.		

3.1.4 Aquatic Ecosystem Restoration Problems, Opportunities and Objectives

Channelization of the Trinity River led to a number of ecological consequences for the riverine ecosystem. Historically, the Trinity River contained natural channel forming processes that supported the function, structure, and diversity of riparian and aquatic components of the riverine ecosystem. The losses to structure and function of the riverine system resulting from channelization and maintenance include:

- Lack of diverse in-channel habitat complexity due to the current structure of the Trinity River channel;
- Steep, uniform channel bank slopes;
- Riparian vegetation along the existing channel is relatively limited in extent, density, and diversity; and
- Transition from in-channel to floodplain habitat is abrupt and limits habitat quality.

The degradations listed above provide an image of the structurally and functionally homogenous and restrained riverine system which characterizes the existing condition and future without-project condition of the Trinity River. The result is degraded riverine habitat which no longer supports the historic level of organism diversity at any trophic level. The restoration of some of the historic structure, function and dynamic nature of the Trinity River such as those listed above, will capitalize on the opportunity to provide benefits to fish and wildlife in the Dallas Metroplex. Table 3-2 summarizes the aquatic ecosystem restoration problems and opportunities into one statement, followed by the corresponding objective.

Table 3-2. Aquatic Ecosystem Problems, Opportunities and Objectives

Problem 6	*Opportunity 5*	*Objective 3*
River function and habitat has been degraded over time due to relocation of the river channel within the Dallas Floodway.	Restore a more naturally functioning river within the Dallas Floodway to benefit fish and wildlife.	Restore to the extent possible the aquatic and riparian ecosystem of the Trinity River within the boundaries of the Dallas Floodway Project over a 50-year period of analysis.

3.1.5 Water Related Problems, Opportunities and Objectives

Other Trinity River Corridor Project (TRCP) proposals address ancillary ecosystem restoration, as well as parks, recreation, transportation, and community and economic development. The community and economic development projects are embedded in the Comprehensive Analysis projects. These local features require a Section 408 review by the Corps. For the items of the BVP and IDP not recommended under Section 5141 of WRDA 2007 to modify the existing Dallas Floodway Project, the City of Dallas

wishes to pursue under Section 408. The local features included in the Comprehensive Analysis with their key "primary" issue indicated in parentheses:

- Trinity Parkway (transportation);
- Trinity River Standing Wave (parks and recreation);
- Santa Fe Trestle Trail (parks and recreation);
- Pavaho Wetlands (environmental restoration and management);
- Dallas Horseshoe Project (transportation);
- Sylvan Avenue Bridge (transportation);
- Jefferson Memorial Bridge (transportation);
- Dallas Water Utilities Waterlines (water and wastewater service [community projects]);
- Continental Bridge (parks and recreation);
- East Bank/West Bank Interceptor Line (water and wastewater service [community projects]); and
- Remaining IDP and BVP features (flood risk, environmental restoration and parks and recreation).

There are limited recreational opportunities available in the Dallas Floodway, and most people do not perceive the Dallas Floodway as a desirable destination for active recreation, festivities, or nature observation. There is also inadequate access to the Dallas Floodway, which hampers the public's ability to enjoy the limited existing recreational opportunities. There is a latent recreation demand for open space and water related recreation in the downtown area. While this is not a primary mission area for the Corps, there is an opportunity to increase recreational opportunity along the vast areas of the Dallas Floodway Project.

Transportation improvements are proposed to address traffic congestions, and deficiencies with the existing roadway facilities within the downtown area of the City of Dallas to address current and projected transportation needs and deficiencies in existing roadway facilities. The primary purpose of the transportation improvements is to provide safe and efficient transportation solutions to manage traffic congestion and improve safety in the area of the Dallas Central Business District.

Overall, the Corps goal in the Comprehensive Analysis was to ensure the projects affecting the MDFP meet Corps engineering and safety standards. The Corps problems, opportunities and objective for the Comprehensive Analysis are listed in Table 3-3. The objective was developed to achieve the overall goal and allow for other local and Federal entities to submit their Section 408 submittal packages for Corps approval once the Comprehensive Analysis was complete. The local features in the Comprehensive Analysis follow a separate Section 408 review process for approval.

Table 3-3. Water Related Problems, Opportunities and Objectives

Problem 7	*Opportunity 6*	*Objective 4*
There is latent recreation demand for open space and water related recreation in the downtown Dallas area.	Increase recreational opportunity along the vast areas of the Dallas Floodway Project.	Ensure local projects do not impact the functioning or integrity of the Dallas Floodway System.
Problem 8	*Opportunity 7*	
Several proposals to modify the Dallas Floodway Project have the potential to impact the functioning of the Dallas Floodway Project.	The Corps could take a bigger role in project design and implementation to ensure major project features do not impact the authorized functioning of the Dallas Floodway Project.	

3.2 PLANNING GOALS, OBJECTIVES AND CRITERIA

3.2.1 City of Dallas' Balanced Vision Plan and Interior Drainage Plan

The City of Dallas' overall goal is to create an environment that brings residents and development closer to a healthier TRC without diminishing the long-term effectiveness of the Dallas Floodway Project. The objectives prepared during the course of developing the BVP by the City of Dallas results in diverse and potentially conflicting objectives of:

- Providing improved flood risk management for the full length of the TRC in a way that also allows for the achievement of environmental, recreational, mobility, and economic goals;
- Implementing environmental responsibility, restoration, and proper management initiatives in the midst of an urban setting;
- Creating a recreation and urban open space amenity that does not interfere with vehicular traffic or periodic floodwaters;
- Meeting stated regional transportation goals in a way that supports economic development and air quality improvement; and
- Creating community and economic opportunities for the neighborhoods bordering the Trinity River and thus, forming the centerpiece for a major urban region (December 2003, amended March 2004).

3.2.2 Water Resources Development Act 2007 Section 5141 Project Objectives

While the City of Dallas had broad goals for the entire TRC, the Corps goal was somewhat limited to determining what combination of BVP and IDP aligns with Corps missions. The following are objectives for recommending features of the BVP and IDP to be implemented under Section 5141 of WRDA 2007. The National Economic Development (NED) analysis used a 50-year period of analysis for the FRM component of the BVP. A 50-year period of analysis was used for the aquatic and riparian ecosystem objective listed below even though formulation for National Ecosystem Restoration (NER) was not required in accordance with the current Implementation Guidance (IG). It is important to note traditional formulation for NER including cost effectiveness and incremental cost analysis was not performed. The major environmental restoration and management features of the City of Dallas' BVP were analyzed as a whole and not evaluated in increments. A period of analysis was not provided for the objective developed to address interior drainage. Economic analysis was not performed on the proposed features in the City of Dallas' IDP that address interior drainage. The Fort Worth District measured performance of the IDP by estimating the reduction in the amount of affected structures in the interior drainage floodplain.

- Ensure the reliability and integrity of the current infrastructure and improve the functioning to further reduce residual flood risk to property while promoting life safety for the Dallas Floodway Project over a 50-year period of analysis.
- Reduce the risk of flooding due to interior drainage.
- Restore to the extent possible the aquatic and riparian ecosystem of the Trinity River within the boundaries of the Dallas Floodway Project over a 50-year period of analysis.

The features that met the objectives were considered technically sound and environmentally acceptable and could be considered for the Recommended Plan for the MDFP. Other criteria for technically sound included adequate feasibility-level engineering and design, including a risk analysis. For environmental

acceptability, the MDFP was analyzed as part of the larger BVP and IDP analyzed in the Environmental Impact Statement (EIS).

Economic analyses and recommendation of an NED and NER plan were not required to recommend the BVP or IDP to modify the existing Dallas Floodway Project. The planning objectives were developed to support the Recommended Plan for the MDFP using sound judgment and prudent analytical approaches. Features of the BVP and IDP related to flood risk were formulated using criteria as shown in Table 3-4:

Table 3-4. Flood Risk Management Objectives and Decision Criteria

Objective 1	*Measurement 1*	*Decision Criteria 1*
Ensure the reliability and integrity of the current infrastructure and improve the functioning to further reduce residual flood risk to property while promoting life safety for the Dallas Floodway Project over a 50-year period of analysis.	Show reduction in Equivalent Annual Damages using the Hydrologic Engineering Center – Flood Damage Reduction Analysis model.	The alternative that maximizes net economic benefits was considered for modification to the Dallas Floodway Project.
	Measurement 2	*Decision Criteria 2*
	Show reduction in Annualized Loss-of-Life estimates using the Hydrologic Engineering Center – Flood Impact Analysis model.	An alternative that reduces the annualized Loss-of-Life was considered for modification to the Dallas Floodway Project.
	Measurement 3	*Decision Criteria 3*
	Estimated Cost to Save a Statistical Life Analysis.	An alternative that reduces the annualized Loss-of-Life and meets "As-Low-As-Reasonably-Practicable" criteria to address efficiency with a project proposal to reduce risk was considered for modification to the Dallas Floodway Project.
	Measurement 4	*Decision Criteria 4*
	Show reductions in O&M costs using Net Present Value.	If an alternative sufficiently reduces the cost of O&M versus the present method of maintenance (fix-as-fails) it was considered for modification to the Dallas Floodway Project.
	Measurement 5	*Decision Criteria 5*
	Qualitative life safety concerns with the current conditions of the East and West Levee.	Other reasons such as the levee mowing hazards, construction cost efficiencies, and achieving overall BVP goals were considered whether a modification to the Dallas Floodway Project was warranted.
Objective 2	*Measurement 6*	*Decision Criteria 6*
Reduce the risk of flooding due to interior drainage.	Show reductions in the number of structures affected by the 100-year, 24-hour storm event located on the landward side of the Dallas Floodway Project.	An alternative that reduces the number of structures affected by the 100-year, 24-hour storm event was considered for modification to the Dallas Floodway Project.
		Decision Criteria 7
		Qualitative life safety concerns with the current conditions of the East and West Levee Interior Drainage System were considered.

Features of the BVP related to aquatic ecosystem restoration were formulated using criteria presented in Table 3-5. It is important to note traditional formulation for NER including cost effectiveness and incremental cost analysis was not performed. The major environmental restoration and management features of the City of Dallas' BVP were analyzed as a whole and not evaluated in increments.

Table 3-5. Aquatic Ecosystem Objectives and Decision Criteria

Objective 3	*Measurement 7*	*Decision Criteria 8*
Restore to the extent possible the aquatic and riparian ecosystem of the Trinity River within the boundaries of the Dallas Floodway Project over a 50-year period of analysis.	Show increases in Average Annual Habitat Units over a 50-year period for the environmental restoration and management features of the BVP.	Major BVP environmental restoration and management features that align with the overall NER Objective by increasing the net quantity and/or quality of desired ecosystem resources were considered for modification to the Dallas Floodway Project.

During the Comprehensive Analysis, local features were reviewed against Corps engineer regulations and safety standards to ensure the projects would not have a significant adverse impact on the function of the MDFP. The review findings are contained in the technical appendices of this feasibility report. The findings are based on the level of design development of the individual local features at the time of the Comprehensive Analysis. Upon completion of the Comprehensive Analysis the local interests were provided the results to use as an input into their Section 408 package. Technical analysis are contained in the individual local feature's Section 408 packages and not included in the feasibility report. Features of the Comprehensive Analysis were evaluated using criteria presented in Table 3-6. It is important to note that the criteria established by the Trinity River and Tributaries Regional Environmental Impact Statement (TREIS) and Record of Decision (ROD) were only applied in the Comprehensive Analysis as a whole collection of projects. The TREIS ROD established criteria for actions that require a Corps permit to address hydrologic and hydraulic impacts for FRM purposes.

Table 3-6. Water Related Objectives and Decision Criteria

Objective 4	*Measurement 8*	*Decision Criteria 9*
Ensure local projects do not impact the functioning or integrity of the Dallas Floodway System.	Local features were reviewed against Corps engineering and safety standards and for compatibility with the MDFP with the primary purpose of FRM.	Upon completion of the Comprehensive Analysis, local interests were provided input and allowed to submit a Section 408 package for review. However, this should not be construed as Section 408 approval under Policy and Procedural Guidance for 33 U.S. Code 408.
	Measurement 8a	
	Engineering and safety standards for the review include: • Hydraulic neutrality (ROD criteria); • Compliance with Engineer Regulations, Manuals and Technical Letters; • No increase in risk through a risk analysis; and • Completion of the EIS for the entire BVP and IDP.	

3.3 PLANNING CONSTRAINTS

The following was identified as a constraint in the planning study:

- Features that increase risk to life safety were not considered for the MDFP.

3.4 PLAN FORMULATION FOR THE FLOOD RISK MANAGEMENT PLAN – TRINITY RIVER FLOODING

3.4.1 National Economic Development Analysis on the Flood Risk Management Component of the Balanced Vision Plan

The following planning assumptions were used for the NED planning effort:

- The Locally Preferred Plan for the Dallas Floodway Extension (DFE) Project, as authorized and currently under construction, was assumed to be in-place as an existing condition. However, the analysis in the risk assessment did not assume the Lamar Levee tied into the East Levee (a "with-project" condition for the DFE Project) and therefore, it identified risk at the floodwall located in the downstream end of the East Levee.
- The City of Dallas' proposed modifications to the existing Dallas Floodway Project to meet FEMA 100-year requirements for flood insurance purposes were not part of the future without-project condition. Possible construction credit for such modifications were decided upon completion of the Comprehensive Analysis and determination of whether they were integral to the overall levee system upgrades recommended in this feasibility report.
- Remediation efforts by the City of Dallas on the East Bank/West Bank Interceptor tunnel was underway at the time of this study and considered complete in the future without-project condition.
- The City of Dallas Maintenance Deficiency Correction Projet (MDCP) items were included in the future without-project condition. See Section 3.4.9 of this report for more information. The 21 remaining items related to the following were either addressed or "closed-out" in this feasibility report:
  - Encroachments for bridges, electrical power towers, and a jail;
  - Levee height does not meet original design grade;
  - Extensive cracking due to desiccation;
  - AT&SF Railroad Bridge flow obstructions; and
  - Dallas Floodway Project currently does not meet current Corps design criteria regarding relevant factors of safety for embankment stability and seepage gradients.
- The Dallas Floodway Project will be evaluated as a total project providing for comparable performance on both sides of the river.
- PI Report No. 9 items #34 and #145 (rated Unacceptable) were noted levee height deficiencies of the East and West Levees based on the 2003 crest survey and the 1950s design elevation. The existing height of the levee system was the basis of plan formulation for the NED analysis on the FRM component of the BVP. The project delivery team concluded the levee height (compared to the original design grade) was not necessarily an Operations and Maintenance (O&M) item that the City of Dallas would be required to restore.

- The levee system baseline condition does not include the Trinity Parkway in the Floodway. During the Comprehensive Analysis alternative alignments for the Trinity Parkway, along with their habitat mitigation requirements were evaluated for compatibility with the Dallas Floodway Project's primary purpose of FRM.
- Indirect (or incidental) damages were not used in the estimate for Equivalent Annual Damages (EAD), and not considered a driver for plan formulation for the NED analysis. Additional details can be found in Appendix E (Flood Risk Management Analysis).

3.4.2 NED Management Measures

The following measures were considered for their potential to meet the FRM objectives of the study. Plan formulation rationale for FRM was to identify a plan that maximizes NED in combination with a plan that reduces risk to life safety to a tolerable level and maintains or improves levee resiliency. Plans that do not meet these criteria were eliminated from further consideration. The Fort Worth District ran HEC-FDA to estimate the reduction in expected flood damages. The Risk Management Center (RMC) developed the HEC-FIA model to estimate life-safety risk for without and with-project conditions. Results of the initial screening of measures are discussed herein.

3.4.2.1 Nonstructural Measures

Floodplain Management

The technique of controlled land use is particularly helpful in planning for future development, but is of limited use in highly developed areas like the area surrounding the Dallas Floodway Levee System. This measure would have the potential to contribute to reducing economic damages in the study area, but was eliminated from further consideration for plan formulation because the City of Dallas presently participates in the National Flood Insurance Program, has adopted the Trinity River CDC process, and enforces zoning regulations for development in the floodplain.

Flood Forecasting and Warning Systems

The City of Dallas currently has a flood warning system in place. This flood warning system is described in the City of Dallas Emergency Action Plan (EAP) for the Trinity River Federal Levee System, dated April 2010. In the event of flooding, Police and Fire-Rescue Dispatch would issue a warning to affected residents using Reverse 911. In addition, City of Dallas officials would implement measures such as requesting broadcasters to disseminate Emergency Alert System broadcasts, issue news through cable override, special news advisories to radio, television, and cable news stations. The risk assessment identified opportunities to assist the City of Dallas in improving their EAP through reduced response times, increased evacuation rates, or reducing the vulnerabilities of the population that remains during a flood event; therefore, this measure was carried forward for further evaluation to meet the objective to reduce residual flood risk and promote life safety. This measure could be added in combination with other structural and nonstructural measures.

Emergency Response and Public Awareness/Education

Mobilization rate improvement measures include transportation network improvements, utilization of public transportation, and emergency response improvements. Safe haven/zones could be identified and involve facilitation for that portion of the population that cannot mobilize to seek shelter. Measures would also include education of the City of Dallas EAP, overcoming obstacles related to age/language, and implementation of a "good neighbor"/"buddy" system. This measure was carried forward to be

implemented in combination with other structural and nonstructural measures to meet the objective to reduce residual flood risk and promote life safety.

Flood Proofing

Typically, flood proofing techniques include water-tight door and window seals, raising floor elevations of structures, installation of check valves on gravity flow water and sewer lines, incorporation of seepage controls, and sandbagging of door openings during emergency situations. This measure would contribute to reducing economic damages in the study area. Such measures are typically implemented by individuals on individual structures. Due to the relatively large number of structures in the damage area and the estimated depths of flooding resulting from catastrophic flood events from levee overtopping with breach, this measure was not considered a viable measure for broad application across the study area and was eliminated from further consideration.

Structure Relocation

Plans for structure relocation would involve moving the existing structures to a more non-flood-prone site. The practicality of this measure depends on the frequency of flooding, the value of the property, its importance to the community, and the need for land use areas that are more compatible with floodplain constraints. This measure would contribute to reducing economic damages in the study area. Considering the performance of the Dallas Floodway Project, relocation of the thousands of structures subject to catastrophic flood events within the City of Dallas (to provide additional flood risk reduction in the event of levee overtopping and breach) would be an impractical and cost prohibitive solution. Based on these findings, relocation was not considered any further.

Permanent Evacuation

Evacuation involves the acquisition and removal or demolition of frequently flooded structures from the floodplain. Floodplain evacuation is normally considered in areas without existing FRM projects. One advantage of floodplain evacuation is it generally provides high marginal benefits, because targeted structures are those being damaged at the most frequent events and there are no residual damages because the structures are permanently removed. Floodplain evacuation can also expand open space and enhance natural and beneficial uses and facilitate the secondary use of newly vacated land. In the case of the protected area of the Dallas Floodway Project, which provides a high level of flood risk reduction (approximately 1,500-year), floodplain evacuation in broad application would never be economically justified. Floodplain evacuations would have to be in targeted areas that received high floodwaters if there were a breach and would have to be considered as a life-safety measure. Broad application of this measure would not be cost effective and was not considered further**.**

Permanent evacuation in an area on Rockefeller Boulevard located adjacent to the Floodway that is not protected by the West Levee or the proposed Cadillac Heights Levee (DFE Project feature) was carried forward as a targeted buyout to meet the economic and life-safety objectives.

Instrumentation

Instrumentation to include installation of piezometers in critical areas was carried forward for evaluation to inform the technical team as to the continuity of the basal sand layer under the levee. This measure will likely be installed as part of any structural measure or by itself to continue to monitor the levee system in the future.

3.4.2.2 Structural Measures

Structural measures consist of structures designed to control, divert, or exclude the flow of water from the flood prone areas to the extent necessary to reduce damages to property, hazard to life or public health, and general economic losses. Because the Dallas Floodway Project is an existing levee system, the structural measures considered most appropriate in dealing with the residual flood problems were limited.

The structural measures investigated include AT&SF Railroad Bridge modification, river channel widening, vegetation removal, levee raises, a concrete floodwall on top of the existing levee, flattened side slopes, levee armoring, controlled overtopping, and seepage cut-off walls.

AT&SF Railroad Bridge Modification

A historic railroad bridge is located at the downstream end of the Dallas Floodway Project called the AT&SF Railroad Bridge. The modification of the abandoned AT&SF Railroad Bridge was identified as a measure due to its impact to the Standard Project Flood (SPF) water surface profile, its location at the downstream end of the Dallas Floodway Project, and the fact that the bridge is no longer needed for rail traffic. Hydraulic analysis has shown that the bridge causes a rise in the SPF water surface profile due to its numerous closely spaced piers, low-deck height, and large earth embankments within the Floodway. This measure was carried forward for detailed investigation to determine whether it contributes to the economic and life-safety objectives.

Channel Widening

Based on previous analysis, it was determined that channel widening could provide a reduction in the water surface elevations in the upstream portion of the Floodway; however, it was screened out in an initial screening of measures. The screening process used a measure predictive analysis and concluded the channel widening measure would have a low likelihood of reducing the probability or consequences associated with an overtopping event. Therefore, channel widening did not warrant further analysis in this study for reducing flood damages and risk to life.

Vegetation Removal

This involves removing the woody vegetation within the Floodway to reduce the water surface profile to achieve flood damage reduction benefits and contribute to reducing the frequency of overtopping of the levees. Like the channel widening measure, the measure was screened out because it was concluded this measure would have a low likelihood of reducing the probability or the consequences associated with an overtopping event. Therefore, vegetation removal did not warrant further analysis in the plan formulation process.

Levee Floodwalls

This measure would include construction of a concrete floodwall on the levee crest. The specific measure considered in this preliminary analysis was for construction of a floodwall to a height equal to 2 feet above the current SPF water surface elevation. The floodwall measure was only considered for 2 feet or above the current SPF. Based on the preliminary analysis conducted in 1998, it was concluded that this measure was economically justified. In spite of these preliminary findings, it was subsequently concluded by the project delivery team that this measure was not technically sound. One reason among many was the levee crest is not of adequate width to allow a floodwall to be installed and also have access for emergencies and flood fighting. As such, this measure was not carried forward for further consideration.

Levee Height Modification (Levee Raises)

The levee raises do not include an all-inclusive raise of the entire levee system. The measure involves using earthen fill to raise the low areas of the levee system to a height consistent with a targeted peak flood water surface profile. Measures that raise the levee crest height reduce the frequency of overtopping, and delay initiation of an overtopping levee breach, but may also provide benefits to the protected area by lowering the total volume of water that overtops the levees. Evaluation of this measure was expected to show a reduction in economic damages and loss-of-life estimates, and the measure was carried forward for detailed evaluation.

Levee Armoring

Levee armoring was considered based on the potential to limit the development of a levee breach following an overtopping event. This measure involves armoring the levee crest and the landside levee slope to a crest height consistent with a targeted peak flood water surface profile similar to the levee raise measure described above. The armoring would be placed using articulated concrete block. Two additional materials for armoring were considered, including turf reinforcement mats and scour protection mats. These two methods provided significant cost savings; however, all materials would require site specific modeling to determine technical viability for their application. Only articulated concrete block was carried forward for analysis during detailed investigations to evaluate reduction in damages and loss-of-life estimates.

Controlled Overtopping

Proposed levee modifications may include what is commonly called "levee resiliency measures." Resiliency measures are expected to reasonably provide cost effective flood risk reduction either alone or in combination with other types of flood risk reduction measures or alternatives. Since the highest risk of flooding from levee failure for the Dallas Floodway Project was identified as overtopping with levee breaching, resiliency measures are expected to focus on reducing the risk of flooding or depths of flooding associated with overtopping failure of the levees. One of these resiliency measures considered is referred to as "controlled overtopping."

The controlled overtopping measure focuses on design considerations outlined in Engineer Technical Letter 1110-2-299 (1986) entitled "Overtopping of Flood Control Levees and Floodwalls." This guidance deals with designing levee systems to reduce the negative impacts of overtopping of levees since prevention of overtopping can never be absolutely assured. Some considerations for good overtopping design for flood risk reduction outlined in the Engineer Technical Letter are: (1) the measure focuses the overtopping in a reach having the least negative impacts; (2) controls the initial overtopping to reduce the impact of sudden overtopping failure or breach; (3) reduces the chance of overtopping in less desirable areas; (4) reduces project maintenance and replacement costs; (5) reduces the risk associated with flow velocity resulting from overtopping inundation; and (6) reduces the risk to life loss due to extending the timing of flood inundation.

Some types of resiliency measures that may be considered to address these goals for risk reduction are: (1) identify levee reaches for initial overtopping that have the least negative impacts; (2) design levee crest for overtopping to reduce risk of levee breaching using armoring at the crest and interior slopes; (3) use levee superiority design to control the initial overtopping location; (4) use levee flattening or similar methods to reduce the risk of levee breaching; (5) use interior area dikes or similar methods to reduce the rate of flood spreading; and (6) improve levee access for flood fighting. The controlled overtopping resiliency measure was carried forward for evaluation to address the life-safety objective.

Seepage Mitigation

Problems associated with internal erosion due to seepage and heave at the levee foundation were identified in the risk assessment as risks near to exceeding the recommended tolerable risk guideline. Three mechanisms for reducing seepage at the levee foundation were evaluated: (1) a weighted clay seepage berm laced on the land side of the levee; (2) a cut-off wall at the toe of the river side of the levee; and (3) a sand seepage blanket on the land side of the levee. The seepage berm and blanket on the land side were ruled out based upon real estate concerns and concerns regarding the reduction of the volume in the sump areas on the protected side of the levees.

Cut-off walls with a clay cap on the riverside of the East and West Levees were carried forward to prevent possible breaches in the levee system prior to overtopping. These measures have potential economic and life-safety risk reduction benefits and were carried forward for further consideration.

Side Slope Flattening

Desiccation cracking in the levee system was not considered to be high risk based on the risk assessment results. The desiccation cracking and the number of slope failures has led to increased operation and maintenance cost. Side slope flattening to address desiccation cracking has the potential to reduce life-cycle maintenance cost of slope repairs for the City of Dallas. A life-cycle costs analysis would compare the expected costs under two scenarios: (1) continue to fix slides as they occur; or (2) invest in modifications now that reduce the frequency and cost of future slope failures. Side-slope flatting was considered as a feature to reduce O&M costs and contribute to the economic objective.

3.4.3 Screening of Measures

Based on the conclusions described in the preceding section, the following measures were carried forward for detailed evaluation due to their ability to contribute to the objectives of the FRM component of the BVP:

- AT&SF Railroad Bridge Modification;
- Levee Height Modification;
- Levee Armoring;
- Controlled Overtopping;
- Seepage Cut-Off Walls;
- Side Slope Flattening;
- Improved Emergency Action Planning and Flood Warning;
- Localized Buyouts; and
- Instrumentation.

3.4.4 Key Risks and Uncertainties

Risk and uncertainties related to cost and benefit calculations can affect plan formulation and identification of an NED Plan. The following were key risks and uncertainties related to formulation of the NED Plan.

3.4.4.1 Cost Estimating

The following are some of the risk and uncertainties related to the initial array of alternatives and their cost estimates. It was assumed that all work will be done within the existing Floodway and real estate costs would not be included because the City of Dallas should own all real estate within the existing levee system. There are some bridges within the construction limits but it was assumed that if affected by an

alternative, a seal can be placed during construction to prevent future damage that might occur as a result of a levee raise. Houston Street Bridge was an exception; it would only require sand-bagging. It was assumed that all borrow material needed to complete the levee work was available within a 12-mile round trip of any place on the levee. Suitable levee material was identified within the West Dallas Lake footprint. West Dallas Lake is a recreation component of the BVP and is described in greater detail in the Comprehensive Analysis section. Encountering contaminants of concern during construction was considered. Environmental Site Assessment Phase I site visits were conducted and there were no significant concerns noted. Finally, quantity estimate methodologies were considered low risk because they were determined to be at an appropriate level of detail for comparison of alternatives in the initial array. Contingencies were applied to the costs based on these risks inputted into an abbreviated cost risk analysis.

3.4.4.2 Hydrology and Hydraulics

There were hydrology and hydraulics uncertainties related to levee breaching for "with-" and "without-" project conditions, but the effects of those uncertainties were minimized to the extent possible by the fact that the same assumptions were applied consistently for every alternative. For the AT&SF Railroad Bridge modification, one key uncertainty was related to the degree of debris accumulation on the structure and its effect on upstream water surface elevations. Bi-weekly conference calls with review team members from panel of subject matter experts took place during the duration of this analysis to maintain transparency and accountability in the assumptions that were being made. More information on the Hydrology and Hydraulics analysis is contained in Appendix A.

3.4.4.3 Economics

Uncertainty related to economics can come from several sources. One source is the structure elevation, which has two components: the topographic ground elevation that a structure sits on, and the structure's estimated first floor elevation. Another source is the value of the structure and its contents. The final source of uncertainty is in the inundation depth/percent damage relationship (usually known as depth-damage functions) used to estimate damages to a structure for a given level of flooding. Parameter settings in HEC-FDA account for these uncertainties. Additional information on the uncertainties for the FRM analysis is contained in Appendix E.

3.4.5 Initial Array of NED Alternatives

The initial array of alternatives were separable stand-alone alternatives that function independently of each other. The first two alternatives are nonstructural alternatives. It was realized early on that the AT&SF Railroad Bridge modification was easy to add as a first added element for any structural alternative. Therefore, all alternatives were formulated with the bridge modification in place. The initial array of alternatives evaluated include nonstructural, the AT&SF Railroad Bridge modification, levee height modifications considering a variety of flows including the 260,000, 265,000, 269,000, 273,000, 277,000, and 289,000 cfs, levee armoring a variety of flows including the 255,000, 260,000, 265,000, 269,000, 273,000, 277,000, 289,000, and 302,000 cfs, and seepage cut-off walls in select locations. The following sections display the evaluation results of the alternatives.

3.4.5.1 Nonstructural

Additional localized risk reduction measures were evaluated to see whether remaining residual risk not captured by more comprehensive alternatives could contribute to the life-safety objective.

Improved EAP and Flood Warning - High Risk Area Identification

The City of Dallas has an existing in-depth EAP that identifies elderly populations over 65, special needs households, and other structures that should to be targeted for evacuation during flood events. In order to make quantifiable changes in the potential for loss-of-life estimates, the high risk areas would be the areas that flood first, deepest, along with those with the special needs. It would be recommended that emergency action personnel would target these structures first. There would likely not be any significant reduction in loss-of-life estimates with this measure implemented due to uncertainties in the model. With-project floodplain inundation maps will be provided to the City of Dallas to update their EAP.

Permanent Localized Buyouts at Rockefeller Boulevard

The permanent evacuation of all or some of 16 structures on Rockefeller Boulevard was evaluated economically for its potential as a stand-alone measure or potentially combined with other measures. These structures were considered for economic evaluation since some of these structures were damaged in the May 1990 flood of record. Based on the hydrologic and hydraulic analysis, which includes the assumption of the completed DFE Project, only three of the 16 structures are located within the 1% Annual Exceedence Probablility (AEP) (100-year) floodplain. Six structures are located between the 1% AEP floodplain and the 0.4% AEP (250-year) floodplain and ten are located between the 250-year and the 0.2% AEP (500-year) floodplains. These structures are located near the mouth of Cedar Creek which is a small tributary of the Trinity River. During design development for the DFE Project, it was found that it was not practical for the proposed Cadillac Heights Levee component of the DFE Project to be located where these structures would be protected by the levee from Trinity River flooding. Even though these structures are not located where they would be directly protected by the proposed Cadillac Heights Levee, the DFE Chain of Wetlands component of the DFE Project in combination with the DFE Project levee components alters the expected frequency of flooding sufficiently to provide significant flood risk benefits for these structures that did not exist in 1990. These flood frequency changes resulting from the completed DFE Project as well as any other floodplain impacts that have occurred since 1990 were considered in the economic analysis for the Rockefeller Boulevard structures.

Estimated values and damages by event are depicted in Table 3-7. The future without-project condition EAD for the area is approximately $1,600 per year. Preliminary estimates for first costs included structure demolition and real estate costs acquisition costs equal to the structure's estimated value. Total costs for evacuating the three structures in the 1% AEP are estimated at $116,600 which annualizes to $5,300. Annual benefits are $1,000 producing approximately -$4,400 annual net benefits with a 0.2 benefit-to-cost ratio. Preliminary first costs for evacuating the six structures in the 0.4% AEP are $233,300, annualizing to $10,600. Annual benefits of $1,500 produce net benefits of -$9,100 with a benefit-to-cost ratio of 0.1. Annualized costs for the ten structures in the 0.2% AEP are $17,700 against $1,600 in annual benefits producing net benefits of -$16,100. Evacuating all nineteen structures would cost at least $622,000 which annualizes to $28,300. Annual benefits are virtually identical to 0.2% AEP evacuation producing -$26,700 in net benefits with a benefit-to-cost ratio of 0.1. The results of three evacuation scenarios are described in Table 3-8. Evacuating structures along Rockefeller Boulevard would not be economically viable and was therefore removed from further consideration in the NED analysis.

Table 3-7. Number, Value, and Damage of Floodplain Properties and POVs by Event (October 2012 Price Level; $000)

	50% AEP		20% AEP		10% AEP		4% AEP		2% AEP		1% AEP		0.4% AEP		0.2% AEP
Damage Category	*#*	*Value*	*#*	*Value*	*#*	*Value*	*#*	*Value*	*#*	*Value*	*#*	*Value*	*#*	*Value*	*#*	*Value*
Single-Family	0	$0.00	0	$0.00	0	$0.00	0	$0.00	1	$34.48	3	$96.38	6	$178.90	10	$304.44
POV	0	$0.00	0	$0.00	0	$0.00	0	$0.00	1	$6.78	3	$20.34	8	$54.24	10	$67.80
Total	**0**	**$0.00**	**0**	**$0.00**	**0**	**$0.00**	**0**	**$0.00**	**2**	**$41.26**	**6**	**$116.72**	**14**	**$233.14**	**20**	**$372.24**

Damage Category	*#*	*Damage*	*#*	*Damage*	*#*	*Damage*	*#*	*Damage*	*#*	*Damage*	*#*	*Damage*	*#*	*Damage*	*#*	*Damage*
Single-Family	0	$0.00	0	$0.00	0	$0.00	0	$0.00	1	$5.56	3	$25.61	6	$90.73	10	$138.52
POV	0	$0.00	0	$0.00	0	$0.00	0	$0.00	1	$1.95	3	$12.16	8	$47.05	10	$65.87
Total	**0**	**$0.00**	**0**	**$0.00**	**0**	**$0.00**	**0**	**$0.00**	**2**	**$7.50**	**6**	**$37.77**	**14**	**$137.78**	**20**	**$204.39**

Table 3-8. Preliminary Estimates for the Permanent Evacuation of Rockefeller Boulevard (2012 Price Level)

	1% AEP (100-Year)	*0.4% AEP (250-Year)*	*0.2% AEP (500-Year)*	*Total*
INVESTMENT				
Estimated First Cost	$116,600	$233,300	$388,800	$622,000
Annual Interest Rate	3.750%	3.750%	3.750%	3.750%
50-year Period of Analysis (years)	50	50	50	50
Construction Period (months)	12	12	12	12
Interest During Construction	$2,400	$4,700	$7,900	$12,600
Investment Cost	$119,000	$238,000	$396,600	$634,600
Interest	$4,500	$8,900	$14,900	$23,800
Amortization	$800	$1,700	$2,800	$4,500
Operations, Maintenance, Repair, Replacement, and Rehabilitation ($/year)	$0	$0	$0	$0
TOTAL ANNUAL CHARGES	**$5,300**	**$10,600**	**$17,700**	**$28,300**
Without Project EAD	$1,600	$1,600	$1,600	$1,600
Residual EAD	$700	$200	$0	$0
Flood Reduction Benefits	$1,000	$1,500	$1,600	$1,600
TOTAL BENEFITS	**$1,000**	**$1,500**	**$1,600**	**$1,600**
NET BENEFITS	**($4,400)**	**($9,100)**	**($16,100)**	**($26,700)**
BENEFIT-COST RATIO	**0.2**	**0.1**	**0.1**	**0.1**

3.4.5.2 Structural

AT&SF Railroad Bridge Modification

The abandoned AT&SF Railroad Bridge spans the main stem of the Trinity River and is located at the downstream end of the Dallas Floodway Project. The AT&SF Railroad Bridge is at the division between the Dallas Floodway Project and the DFE Project. The removal of portions of the original bridge was identified as a measure since it has a significant impact on the upstream water surface during major flood events due to its closely spaced piers and wide embankments in the Floodway and is no longer needed for rail traffic. The bridge is a further risk to the levee system due to the potential for the closely spaced piers with cross bracing to cause significant debris accumulation and result in further increased water surface elevations upstream of the bridge during major flood events. The wood trestles on the bridge have approximately 14-foot spacing, instead of the typical 50-foot spacing on most bridge designs.

The AT&SF Railroad Bridge modification plan requires removal of portions of the bridge and includes: (1) removing approximately 1,100 feet of wood trestle bridge on the left bank side of the Floodway from the new Santa Fe Trestle Trail Bridge to the left bridge abutment at the East Levee; (2) removing a 660-foot concrete railroad bridge segment on the right bank side; and (3) removing two embankments on the right bank side of the Floodway.

Hydraulic analysis for an assumed 50% debris accumulation with subsequent levee overtopping of the SPF flood event shows that the effects of modifying the bridge would provide significant economic benefits (Table 3-9). Also shown are the results of an economic analysis for a hydraulic analysis representing an estimated debris accumulation calibrated to the water surface profile for the 1990 flood event. This same debris accumulation for the 1990 flood event was assumed to occur during an SPF flood

event with a subsequent overtopping of the levee and the economic analysis (Table 3-9) shows the AT&SF Railroad Bridge modification remains economically feasible with a lower estimate of debris blockage. Historically, every major flood event has resulted in significant debris accumulations on the bridge, so it would be reasonable to assume there will be debris accumulation during a major flood event. Therefore, all of the formulation included the AT&SF Railroad Bridge modification as a first added increment. See Section 5.2.3 in Appendix A (Hydrology and Hydraulics) for a detailed discussion of the debris analysis for the AT&SF Railroad Bridge.

Table 3-9. NED Formulation for the AT&SF Railroad Bridge Modification (October 2012 Price Level/4% Federal Interest Rate)

	No Debris	*Debris (50% Blockage)*	*1990 Flood Debris*
INVESTMENT			
Estimated First Cost	$2,221,000	$2,221,000	$2,221,000
Annual Interest Rate	4.000%	4.000%	4.000%
50-year Period of Analysis (years)	50	50	50
Construction Period (months)	12	12	12
Interest During Construction	$48,000	$48,000	$48,000
Investment Cost	$2,268,000	$2,268,000	$2,268,000
Interest	$91,000	$91,000	$91,000
Amortization	$15,000	$15,000	$15,000
OMRR&R ($/year)	$0	$0	$0
TOTAL ANNUAL CHARGES	**$106,000**	**$106,000**	**$106,000**
Without Project EAD	$5,015,000	$6,290,000	$5,697,000
Residual EAD	$4,984,000	$4,984,000	$4,984,000
Flood Reduction Benefits	$31,000	$1,306,000	$713,000
TOTAL BENEFITS	**$31,000**	**$1,306,000**	**$713,000**
NET BENEFITS	**($75,000)**	**$1,201,000**	**$607,000**
BENEFIT-COST RATIO	**0.29**	**12.32**	**6.73**

Levee Height Modifications with AT&SF Railroad Bridge Modification

Levee height modifications were considered for both 4H:1V and 3H:1V levee side slopes on the river side. An initial investigation was performed to determine which flow rates to evaluate. The initial investigation showed a target flow rate of 269,000 cfs with 4H:1V side slopes, including the AT&SF Railroad Bridge modification had positive net benefits. The flow rates evaluated and presented in Table 3-10 were centered on the 269,000 cfs because of its performance in a preliminary economic evaluation.

A Value Engineering report recommended the levee raise alternatives be reduced from 3H:1V and the effective levee crest width be reduced to 14 feet from 16 feet. The reduction in crest width recommendation was rejected because it was thought to produce a safety hazard for the City of Dallas personnel that routinely drive equipment on the top of the levee for operation and maintenance purposes. The 3H:1V recommendation was adopted. The 4H:1V is expected to further reduce risk caused by desiccation cracking and levee instability; however, the desiccation cracking problem with the levee system was not considered to be high risk based on the results of the risk assessment. This is assuming the slides are fixed by the City of Dallas as they occur to maintain the integrity of the levee system. The

4H:1V side slopes were eliminated from consideration for the FRM Plan because the 3H:1V side slopes performed better economically and the desiccation cracking problem was not high risk.

Table 3-10 presents the results of the economic analysis for the levee raises with the AT&SF Bridge modification assuming a 4H:1V and 3H:1V side slope. The economic analysis demonstrates the 277,000 cfs levee raise with a 3H:1V side slope with the AT&SF Railroad Bridge modification provides the most net benefits of $1,214,000 as a separable element. The 4H:1V side slope levee raises have less net benefits than the 3H:1V side slopes. Table 3-11 and Figures 3-1 and 3-2, show that levee raises considered resulted in at least a 50% reduction in annualized loss-of-life and failure probability, indicating that they have an overall reduction in risk.

The 4H:1V side slopes were evaluated because of the frequent slides and they were also included in the City of Dallas' BVP. The 4H:1V side slopes were replaced by the 3H:1V side slopes because they performed better economically. The desiccation cracking and the number of slope failures has led to increased operation and maintenance cost. To address the operation and maintenance cost and the performance issue with the slope failures, the City of Dallas wishes to pursue construction of the 4H:1V side slopes. A life-cycle cost analysis was conducted to compare the expected costs of future levee repairs under two scenarios: (1) continue the ad-hoc approach to fix slides as they occur; or (2) invest in modifications now to reduce the frequency and cost of future slope failures. The City of Dallas currently estimates that it has spent approximately $1,035,000 annually over the last eleven years on repairs caused by slides. Based on these annual expenditures, the following analysis determined whether it was more feasible for the City of Dallas to continue the present method of maintenance or if the investment in 4H:1V side slopes will sufficiently reduce annual maintenance expenses to make the investment worthwhile. Currently, the City of Dallas fixes slides as they occur. A life-cycle cost analysis using net present value (NPV) was conducted to determine if flattening the side slopes to 4H:1V was economically advantageous.

Under the current conditions, the NPV of fixing the slides as they occur is $34,304,000 and consists entirely of the discounted annual maintenance for the 50-year period of analysis. Flattening the side slopes to 4H:1V increases the NPV to $65,479,000. This value consists of $41,983,000 of initial construction and annual maintenance costs including the period of construction. The NPV of the total investment is $64,479,000. For this project to break even at the 50-year economic life, the NPV of the current maintenance scenario would have to increase by $31,174,000 or 91% (Table 3-12). In other words, the City of Dallas spends approximately $1,000,000 annually to fix slides. To break even, they would need to spend approximately $2,000,000 annually to make the investment worthwhile using NPV analysis. Using NPV analysis, the side slope flattening construction is not as economically advantageous to the current maintenance program; however, based on safety concerns, efficiencies during construction and the performance issue with the slope failures, the City of Dallas wishes to pursue construction of the 4H:1V side slopes at 100% non-Federal cost as a betterment.

Table 3-10. NED Formulation for 4H:1V and 3H:1V Levee Height Modifications with AT&SF Railroad Bridge Modification (October 2012 Price Level/4% Federal Interest Rate)

	260K Raise +AT&SF	*265K Raise +AT&SF*	*269K Raise +AT&SF*	*273K Raise +AT&SF*	*277K Raise +AT&SF*	*289K Raise +AT&SF*[2]
4V:1H Side Slopes						
INVESTMENT						
Estimated First Cost	$2,688,000	$2,901,000	$5,160,000	$10,390,000	$18,747,000	N/A
Annual Interest Rate	4.00%	4.00%	4.00%	4.00%	4.00%	N/A
50-year Period of Analysis (years)	50	50	50	50	50	N/A
Construction Period (months)	12	12	12	38	76.5	N/A
Interest During Construction	$58,000	$62,000	$111,000	$666,000	$2,528,000	N/A
Investment Cost	$2,746,000	$2,964,000	$5,271,000	$11,056,000	$21,275,000	N/A
Interest	$110,000	$119,000	$211,000	$442,000	$851,000	N/A
Amortization	$18,000	$19,000	$35,000	$72,000	$139,000	N/A
OMRR&R[1] ($/year)	$5,000	$6,000	$8,000	$20,000	$30,000	N/A
TOTAL ANNUAL CHARGES	**$133,000**	**$143,000**	**$253,000**	**$535,000**	**$1,020,000**	N/A
Without Project EAD	$5,015,000	$5,015,000	$5,015,000	$5,015,000	$5,015,000	N/A
Residual EAD	$4,562,000	$4,174,000	$3,881,000	$3,805,000	$3,471,000	N/A
Flood Reduction Benefits	$452,000	$841,000	$1,133,000	$1,210,000	$1,544,000	N/A
TOTAL BENEFITS	**$452,000**	**$841,000**	**$1,133,000**	**$1,210,000**	**$1,544,000**	N/A
NET BENEFITS	**$319,000**	**$697,000**	**$881,000**	**$675,000**	**$523,000**	N/A
BENEFIT-COST RATIO	**3.40**	**5.88**	**4.48**	**2.26**	**1.51**	N/A
3V:1H Side Slopes						
INVESTMENT						
Estimated First Cost	$2,248,000	$2,302,000	$2,880,000	$4,221,000	$6,330,000	$11,524,000
Annual Interest Rate	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%
50-year Period of Analysis (years)	50	50	50	50	50	50
Construction Period (months)	12	12	12	13	22	48
Interest During Construction	$48,000	$50,000	$62,000	$271,000	$854,000	$1,632,000
Investment Cost	$2,296,000	$2,352,000	$2,942,000	$4,491,000	$7,183,000	$13,156,000
Interest	$92,000	$94,000	$118,000	$180,000	$287,000	$526,000
Amortization	$15,000	$15,000	$19,000	$29,000	$47,000	$86,000
OMRR&R[1] ($/year)	$5,000	$6,000	$8,000	$20,000	$30,000	$30,000
TOTAL ANNUAL CHARGES	**$112,000**	**$115,000**	**$144,000**	**$229,000**	**$364,000**	**$642,000**
Without Project EAD	$5,015,000	$5,015,000	$5,015,000	$5,015,000	$5,015,000	$5,015,000
Residual EAD	$4,562,000	$4,174,000	$3,881,000	$3,805,000	$3,471,000	$3,243,000
Flood Reduction Benefits	$452,000	$841,000	$1,133,000	$1,210,000	$1,544,000	$1,772,000
TOTAL BENEFITS	**$452,000**	**$841,000**	**$1,133,000**	**$1,210,000**	**$1,544,000**	**$1,772,000**
NET BENEFITS	**$340,000**	**$726,000**	**$989,000**	**$981,000**	**$1,179,000**	**$1,129,000**
BENEFIT-COST RATIO	**4.04**	**7.31**	**7.87**	**5.28**	**4.24**	**2.76**

Note: [1] Estimate based on net increase in O&M expenses compared to existing conditions.

[2] The net benefits were declining for the 289K cfs levee raise with 4H:1V side slopes, and the Fort Worth District stopped developing costs for this plan when the 3H:1V side slopes were showing higher net benefits. Therefore, the column for the 289K cfs + AT&SF is N/A.

Table 3-11. NED Formulation Considering Loss-of-Life for Levee Height Modifications with AT&SF Railroad Bridge Modification (October 2012 Price Level/4% Federal Interest Rate)

NED Formulation

Plan	*Without Project*	*260K Raise + AT&SF*	*277K Raise + AT&SF*	*302K Raise + AT&SF*
INVESTMENT				
Estimated First Cost	N/A	$2,360,000	$6,211,000	N/A
Total Annual Charges	N/A	$117,000	$330,000	N/A
Total Benefits	N/A	$452,000	$1,544,000	N/A
Net Benefits	N/A	$335,000	$1,214,000	N/A
Benefit-to-Cost Ratio	N/A	3.86	4.68	N/A

Loss-of-Life for PFM #2 (Revised Risk Assessment)

Annualized Failure Probability				
East Levee	5.42E-04	2.43E-04	1.95E-04	1.44E-04
West Levee	5.42E-04	4.22E-04	1.95E-04	1.44E-04
Annualized Life Loss				
East Levee	1.37E-01	6.56E-02	4.53E-02	3.23E-02
West Levee	4.51E-01	3.66E-01	1.84E-01	1.40E-01

Incremental % Change in Loss-of-Life for PFM #2 (Revised Risk Assessment)

Annualized Failure Probability				
East Levee	0%	-55.2%	-19.6%	-26.5%
West Levee	0%	-22.3%	-53.7%	-26.5%
Annualized Life Loss				
East Levee	0%	-52.0%	-30.9%	-28.7%
West Levee	0%	-18.9%	-49.7%	-23.9%

Table 3-12. NPV for Side Slope Flattening (October 2012 Price Level/4% Federal Interest Rate)

Expense	*NPV of Slope Changes*
Construction	$39,211,000
Maintenance and Repair	$26,267,000
Total	**$65,479,000**
	NPV of Current Conditions
Maintenance and Repair	$34,304,000
Total	**$34,304,000**
% Change	91%

Figure 3-1 Flood Risk Management Risk Assessment f-N Chart for Levee Raises and Levee Armoring (East Levee)

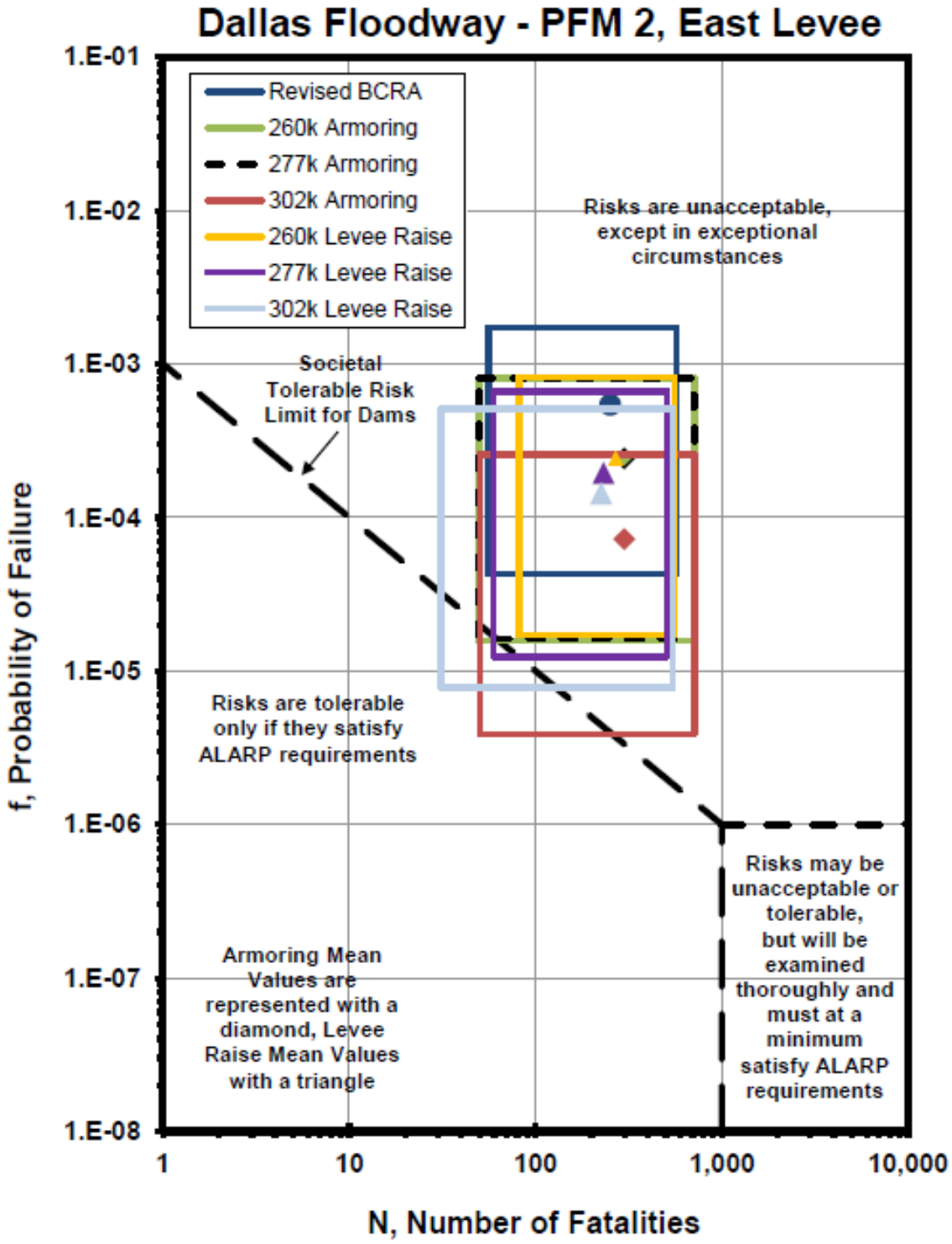
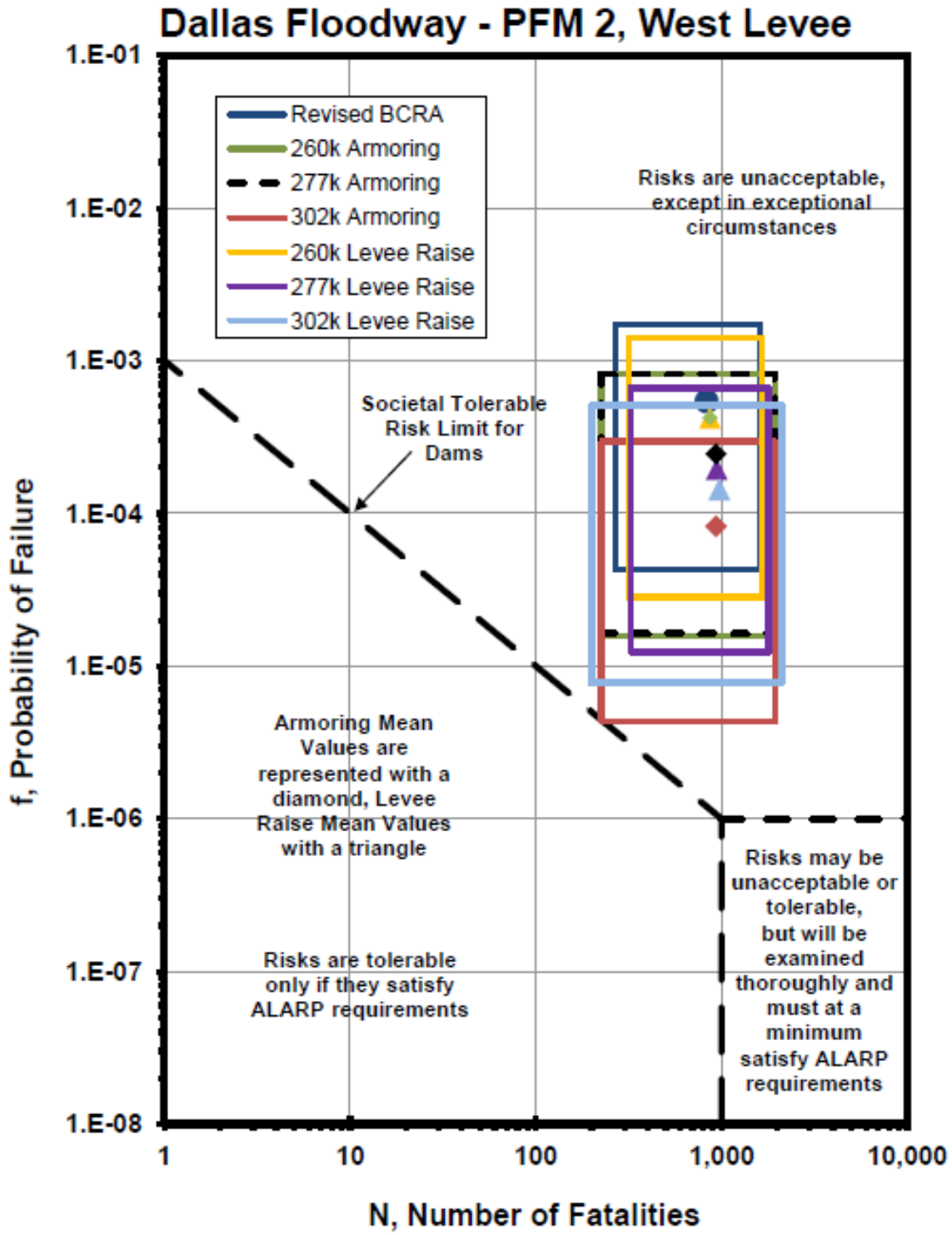


Figure 3-2 Flood Risk Management Risk Assessment f-N Chart for Levee Raises and Levee Armoring (West Levee)



Levee Armoring

This measure involves armoring the levee to designated flow rates similar to the levee raise measure. The armoring would be placed using articulated concrete block. The intent of the armoring alternative was to determine whether a breach following an overtopping event could provide economic benefits and reduce life-safety risk more so than using earthen fill. Based on the economics presented in Table 3-13, the lower level armoring alternatives (up to 265,000 cfs) were justified from an economic perspective. While lower levels of armoring proved to be economically justified, the 277,000 cfs levee raise provided more economic net benefits. Armoring provides benefits by delaying the initiation of an overtopping breach. The levee armoring alternative prevents breach on the armored portions of the levee which correspond to the low areas of the levee system. However, breach can still occur on unarmored portions of the levee at higher flood events. Table 3-14 shows a 50% reduction in the annualized probability failure and life loss from armoring up to the 277,000 cfs. While this alternative provided life-safety benefits, implementing armoring in combination with the 277,000 cfs levee raise would cost approximately $76,000,000 and it would not reduce the overall failure probability and consequences below the recommended tolerable risk guideline for dams; however, levee armoring (as a controlled overtopping technique) was evaluated further for life-safety benefits as described in the final array, Section 3.4.6.

Seepage Cut-Off Walls

This measure was proposed at the toe of the river side of the levee to deal with the potential for under seepage at the toe of the levee leading to breach. This three foot wide seepage cut-off wall will be composed of a soil bentonite mixture and key-into bedrock at a depth of 5 feet. The extent of the cut-off wall was determined through geotechnical evaluation of the borings in the Dallas Floodway Project. Since this was a different probable failure mode than what was used to formulate for overtopping, this required a different baseline condition with different inflow events and breach settings. Because the seepage walls would not prevent damages from events that overtop the levees, an effort was made to separate the economic benefits associated with flood events below the top of the levee versus above the top of the levee. Therefore, two scenarios were modeled: (1) with peak flows ranging from approximately 50% of the levee height to the highest event overtopping the levee; and (2) with peak flows ranging from 50% of the levee height to the highest event not overtopping the levee (Table 3-15). The no overtopping scenario produced without-project EAD of $858,000 and since the seepage cut-off wall was assumed to eliminate under seepage, the residual EAD goes to zero. For the levee overtopping scenario, using the assumption that the without-project condition was additive between the EAD produced for addressing the overtopping Potential Failure Mode (PFM) and the best estimate for without-project damages that could occur due to under seepage with no overtopping, the without-project EAD is $5,873,000. The benefits to be derived would then be the elimination of the portion of EAD associated with the no overtopping which would be the without-project EAD associated with overtopping. In either scenario, the total benefits are $858,000. Cut-off walls are therefore not economically justified. As indicated in Table 3-16 and on Figure 3-3, seepage cut-off walls provided the most reduction in estimated risk (for PFM #7) of any of the alternatives by providing reductions greater than 90%. In addition, as displayed in Figure 3-3, the reduction in risk dropped the probable failure mode completely into a tolerable range. This alternative would not contribute to NED, but was carried into the final array as a possible combination plan based on its contribution to life safety.

Table 3-13. NED Formulation for Levee Armoring - Articulated Concrete Block (October 2012 Price Level/4% Federal Interest Rate)

	255K Armoring +AT&SF	*260K Armoring* +AT&SF	*265K Armoring* +AT&SF	*269K Armoring* +AT&SF	*273K Armoring* +AT&SF	*277K Armoring* +AT&SF	*289K Armoring* +AT&SF	*302K Armoring* +AT&SF
INVESTMENT								
Estimated First Cost	$4,317,000	$4,580,000	$7,065,000	$32,743,000	$53,634,000	$76,606,000	$166,148,000	$211,279,000
Annual Interest Rate	4.000%	4.000%	4.000%	4.000%	4.000%	4.000%	4.000%	4.000%
50-year Period of Analysis (years)	50	50	50	50	50	50	50	50
Construction Period (months)	15	32	52	69	69	69	69	69
Interest During Construction	$112,000	$246,000	$629,000	$3,947,000	$6,465,000	$9,234,000	$20,028,000	$25,468,000
Investment Cost	$4,429,000	$4,827,000	$7,694,000	$36,690,000	$60,100,000	$85,840,000	$186,175,000	$236,747,000
Interest	$177,000	$193,000	$308,000	$1,468,000	$2,404,000	$3,434,000	$7,447,000	$9,470,000
Amortization	$29,000	$32,000	$50,000	$240,000	$394,000	$562,000	$1,219,000	$1,551,000
OMRR&R ($/year)	$0	$0	$0	$0	$0	$0	$0	$0
TOTAL ANNUAL CHARGES	$206,000	$225,000	$358,000	$1,708,000	$2,798,000	$3,996,000	$8,667,000	$11,021,000
Without Project EAD	$5,015,000	$5,015,000	$5,015,000	$5,015,000	$5,015,000	$5,015,000	$5,015,000	$5,015,000
Residual EAD	$4,593,000	$4,362,000	$4,183,000	$3,891,000	$3,512,000	$2,469,000	$2,469,000	$2,469,000
Flood Reduction Benefits	$421,000	$653,000	$832,000	$1,123,000	$1,503,000	$2,545,000	$2,545,000	$2,545,000
TOTAL BENEFITS	$421,000	$653,000	$832,000	$1,123,000	$1,503,000	$2,545,000	$2,545,000	$2,545,000
NET BENEFITS	$215,000	$428,000	$474,000	($585,000)	($1,295,000)	($1,451,000)	($6,121,000)	($8,475,000)
BENEFIT-COST RATIO	2.04	2.90	2.32	0.66	0.54	0.64	0.29	0.23

Table 3-14. NED Formulation Considering Loss-of-Life for Levee Armoring - Articulated Concrete Block (October 2012 Price Level/4% Federal Interest Rate)

NED Formulation

Plan	*Without Project*	*260K Armoring + AT&SF*	*277K Armoring + AT&SF*	*302K Armoring + AT&SF*
INVESTMENT				
Estimated First Cost	N/A	$4,580,000	$76,606,000	$211,279,000
Total Annual Charges	N/A	$225,000	$3,996,000	$11,021,000
Total Benefits	N/A	$653,000	$2,545,000	$2,545,000
Net Benefits	N/A	$428,000	($1,451,000)	($8,475,000)
Benefit-to-Cost Ratio	N/A	2.9	0.64	0.23

Loss-of-Life for PFM #2 (Revised Risk Assessment)

Annualized Failure Probability				
East Levee	5.42E-04	2.43E-04	2.42E-04	7.22E-05
West Levee	5.42E-04	4.22E-04	2.45E-04	8.22E-05
Annualized Life Loss				
East Levee	1.37E-01	7.27E-02	7.26E-02	2.16E-02
West Levee	4.51E-01	3.66E-01	2.29E-01	7.68E-02

Incremental % Change in Loss-of-Life for PFM #2 (Revised Risk Assessment)

Annualized Failure Probability				
East Levee	0.0%	-55.2%	-0.1%	-70.2%
West Levee	0.0%	-22.2%	-41.8%	-66.5%
Annualized Life Loss				
East Levee	0.0%	-46.9%	-0.1%	-70.2%
West Levee	0.0%	-18.9%	-37.4%	-66.5%

Table 3-15. NED Formulation for Seepage Cut-Off Walls (October 2012 Price Level/4% Federal Interest Rate)

	No Overtopping	*W/ Overtopping*
INVESTMENT		
Estimated First Cost	$36,120,000	$36,120,000
Annual Interest Rate	4.000%	4.000%
50-year Period of Analysis (years)	50	50
Construction Period (months)	74	74
Interest During Construction	$4,697,000	$4,697,000
Investment Cost	$40,817,000	$40,817,000
Interest	$1,633,000	$1,633,000
Amortization	$267,000	$267,000
OMRR&R ($/year)	$0	$0
TOTAL ANNUAL CHARGES	**$1,900,000**	**$1,900,000**
Without Project EAD	$858,000	$5,873,000
Residual EAD	$0	$5,015,000
Flood Reduction Benefits	$858,000	$858,000
TOTAL BENEFITS	**$858,000**	**$858,000**
NET BENEFITS	**($1,042,000)**	**($1,042,000)**
BENEFIT-COST RATIO	**0.45**	**0.45**

Table 3-16. NED Formulation Considering Loss-of-Life for Seepage Cut-Off Walls (October 2012 Price Level/4% Federal Interest Rate)

NED Formulation

Plan	*Without Project*	*Seepage Cut-Off Walls*
INVESTMENT		
Estimated First Cost	N/A	$36,120,000
Total Annual Charges	N/A	$1,900,000
Total Benefits	N/A	$858,000
Net Benefits	N/A	($1,042,000)
Benefit-to-Cost Ratio	N/A	0.45

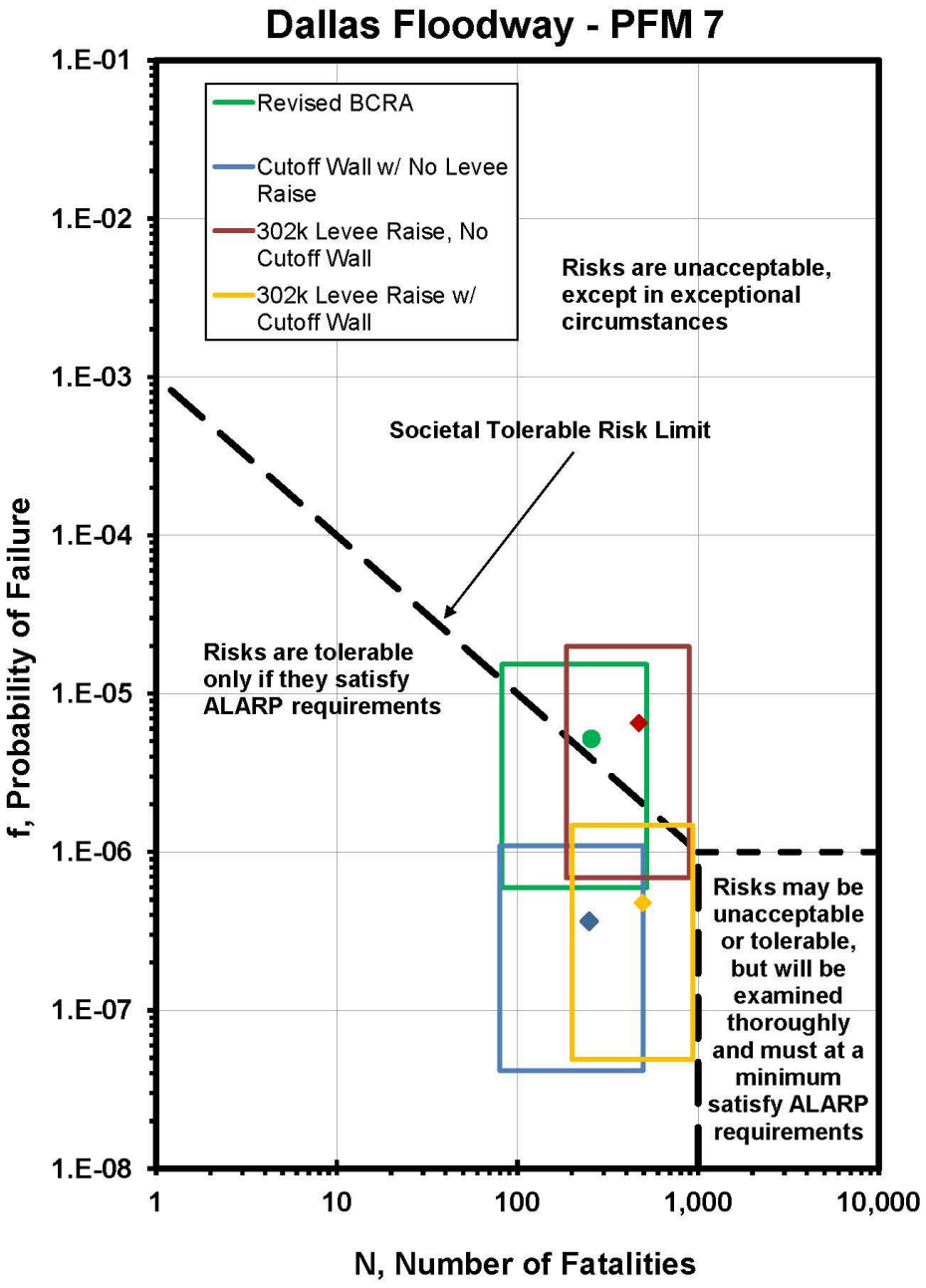
Loss-of-Life for PFM #7 (Revised Risk Assessment)

Annualized Failure Probability (P)		
East Levee	5.19E-06	3.66E-07
Annualized Life Loss (L)		
East Levee	1.33E-03	9.12E-05
Annualized Risk (P x L)		
East Levee	6.91E-09	3.34E-11

% Change in Loss-of-Life for PFM #7 (Revised Risk Assessment)

Annualized Failure Probability (P)		
East Levee	0.0%	-92.9%
Annualized Life Loss (L)		
East Levee	0.0%	-93.2%

Figure 3-3 Flood Risk Management Risk Assessment f-N Chart for Seepage Cut-Off Walls



3.4.6 Evaluation of Final NED Array

The 277,000 cfs levee raise with the AT&SF Railroad Bridge modification was the plan with the most economic benefits as a stand-alone alternative. Two additional plans were analyzed in the final array of alternatives for their ability to complement the 277,000 cfs levee raise and AT&SF Railroad Bridge modification, including the 277,000 cfs levee raise with the AT&SF Railroad Bridge modification with controlled overtopping and the 277,000 cfs levee raise with AT&SF Railroad Bridge modification with cut-off walls.

3.4.6.1 277,000 cfs Levee Raise with the AT&SF Railroad Bridge Modification with Controlled Overtopping

The controlled overtopping measure focuses on design considerations outlined in Engineer Technical Letter 1110-2-299 (1986) entitled "Overtopping of Flood Control Levees and Floodwalls." This guidance deals with designing levee systems to reduce the negative impacts of overtopping of levees since prevention of overtopping can never be absolutely assured. Controlled overtopping analysis presented herein primarily focused on the potential for reduction of flood damage by means of altering the timing of the overtopping inundation and potentially delaying or preventing the breaching of the levee once it is overtopped. The HEC-RAS unsteady flow model for the Dallas Floodway Project was used to analyze the effects of controlled overtopping measures at various lengths, levee heights, and locations when combined with the 277,000 cfs levee raise alternative. This controlled overtopping measure could be described as a notch in the levee having armoring on the levee crest and landside slope to prevent breaching of the levee while flow is within the notch. However, similarly to the levee armoring alternatives, if levee overtopping for some flood events exceeds the notch-capacity, then levee breaching may occur at a location on the levee outside the notch.

Out of the notching alternatives evaluated, the most significant benefit occurred with the largest notch size analyzed at 2-feet deep and 3,000 feet in weir length. The analysis suggests that a relatively large controlled overtopping notch was required to result in any significant change to inundation depths, and that change only occurs for a relatively narrow range of overtopping flood events. For the highest overtopping flood events the notch would not prevent a breach in the levee and the resulting inundation depth would essentially be unchanged by the notch for these flood events. This further suggests that the economic justification for this measure was unlikely since the potential economic benefit indicated in the hydraulic analysis would be modest if not negative. Such an expected modest benefit would not outweigh the significant cost of a large controlled overtopping notch. Therefore, it was assumed that further detail for economic justification for this measure was not warranted. Another factor to consider was the area is in an urban environment, and siting a controlled overtopping location would be difficult because there is a lack of an ideal overtopping location. Life-safety considerations for this alternative are discussed further in Section 3.4.6.3.

3.4.6.2 277,000 cfs Levee Raise with AT&SF Railroad Bridge Modification and Seepage Cut-Off Walls

As described previously, the 277,000 cfs levee raise with the AT&SF Railroad Bridge modification in combination with the cut-off walls would not further contribute to NED; however, it is displayed here to show what this type of combination plan would look like if the cut-off walls were required to be part of the NED analysis (Table 3-17).

Table 3-17. 277,000 cfs Levee Raise with the AT&SF Railroad Bridge Modification and Seepage Cut-Off Walls (October 2012 Price Level/4% Federal Interest Rate)

	277K Levee Raise + AT&SF (Addresses Overtopping and Breach PFM)	*Cut-Off Walls (Addresses Internal Erosion PFM)*	*Combined*
INVESTMENT			
Estimated First Cost	$6,211,000	$36,120,000	$42,331,000
Annual Interest Rate	0.04	0.04	0.04
50-year Period of Analysis (years)	50	50	50
Construction Period (months)	22	74	74
Interest During Construction	$230,000	$4,697,000	$5,505,000
Investment Cost	$6,441,000	$40,817,000	$47,836,000
Interest	$258,000	$1,633,000	$1,913,000
Amortization	$42,000	$267,000	$313,000
OMRR&R ($/year)	$30,000	$0	$30,000
TOTAL ANNUAL CHARGES	**$330,000**	**$1,900,000**	**$2,257,000**
Without Project EAD	$5,015,000	$858,000	$5,873,000
Residual EAD	$3,471,000	$0	$3,471,000
Flood Reduction Benefits	$1,544,000	$858,000	$2,402,000
TOTAL BENEFITS	**$1,544,000**	**$858,000**	**$2,402,000**
NET BENEFITS	**$1,214,000**	**($1,042,000)**	**$145,000**
BENEFIT-COST RATIO	**4.68**	**0.45**	**1.06**

3.4.6.3 Life-Safety Considerations

To determine whether life-safety risk was fully addressed in the final array evaluation, the 277,000 cfs levee raise, levee armoring, and seepage cut-off walls were evaluated to determine whether As Low As Reasonably Practicable (ALARP) considerations were met. The ALARP considerations provide a way to address efficiency with a project proposal to reduce risk. The concept allows risks to be tolerable if there are no practicable ways to address the risk or if further risk reduction costs are grossly disproportional to the risk reduction. Using annualized cost estimates and changes in probabilities of life loss, an estimated cost to save a statistical life was developed for the 260,000 cfs and 302,000 cfs levee armoring plans, the 277,000 cfs levee raise and the seepage cut-off walls as stand-alone alternatives. The net cost per statistical life saved was estimated to be over $1,000,000,000 for the cut-off walls. The estimated number was high because cut-off walls address PFM #7 which had a relatively low estimated probability of occurrence in the future without-project condition. Annual costs divided by low estimated probability of occurrence produce high costs per statistical life saved estimates. The 277,000 cfs levee raise has an estimated net cost per statistical life saved of $920,000 and the levee armoring plans of 260,000 cfs and 302,000 cfs, has approximately $1,500,000 and $31,700,000, respectively. The estimates show that the 277,000 cfs levee raise has the lowest net cost per statistical life saved. The estimated cost to save a statistical life for cut-off walls was disproportionate to the reduction in risk and therefore cut-off walls would not be considered reasonable. The cost to save a statistical life for controlled overtopping was not performed; however, it was expected to perform similar to a 260,000cfs armoring plan. The expected changes in probability, along with a rough order of magnitude cost, controlled overtopping was not expected to be efficient at reducing risk. A

large controlled overtopping notch would be required at significant cost. Similar to the armoring plans, the breach could not be controlled outside a notch and it was expected there would be little reduction in risk. In addition, controlled overtopping would include flooding the developed side of the levee earlier due to the notch required in the levee.

Figure 3-4 shows the total risk for various alternatives including levee armoring and levee raises in combination with seepage cut-off walls. This figure shows the changes in estimated risk by adding seepage cut-off walls to levee raises and levee armoring. Levee armoring was included in this section as a frame of reference and was not considered in the final array as a stand-alone alternative or in combination with cut-off walls. Life-safety risk was reduced for levee armoring and levee raises in combination with cut-off walls, but not below the recommended tolerable risk guideline. Cut-off walls, when evaluated as a stand-alone alternative for risk reduction of PFM #7 reduces risk below the recommended tolerable risk guideline as shown in Figure 3-3. From a total risk perspective, total risk of the PFM #7 and PFM #2 is dominated by the higher risk failure mode PFM #2 and total risk is located above the recommended tolerable risk guideline. The combined 277,000 cfs levee raise with the cut-off walls as shown in Figure 3-4 does little to reduce the overall total life-safety risk.

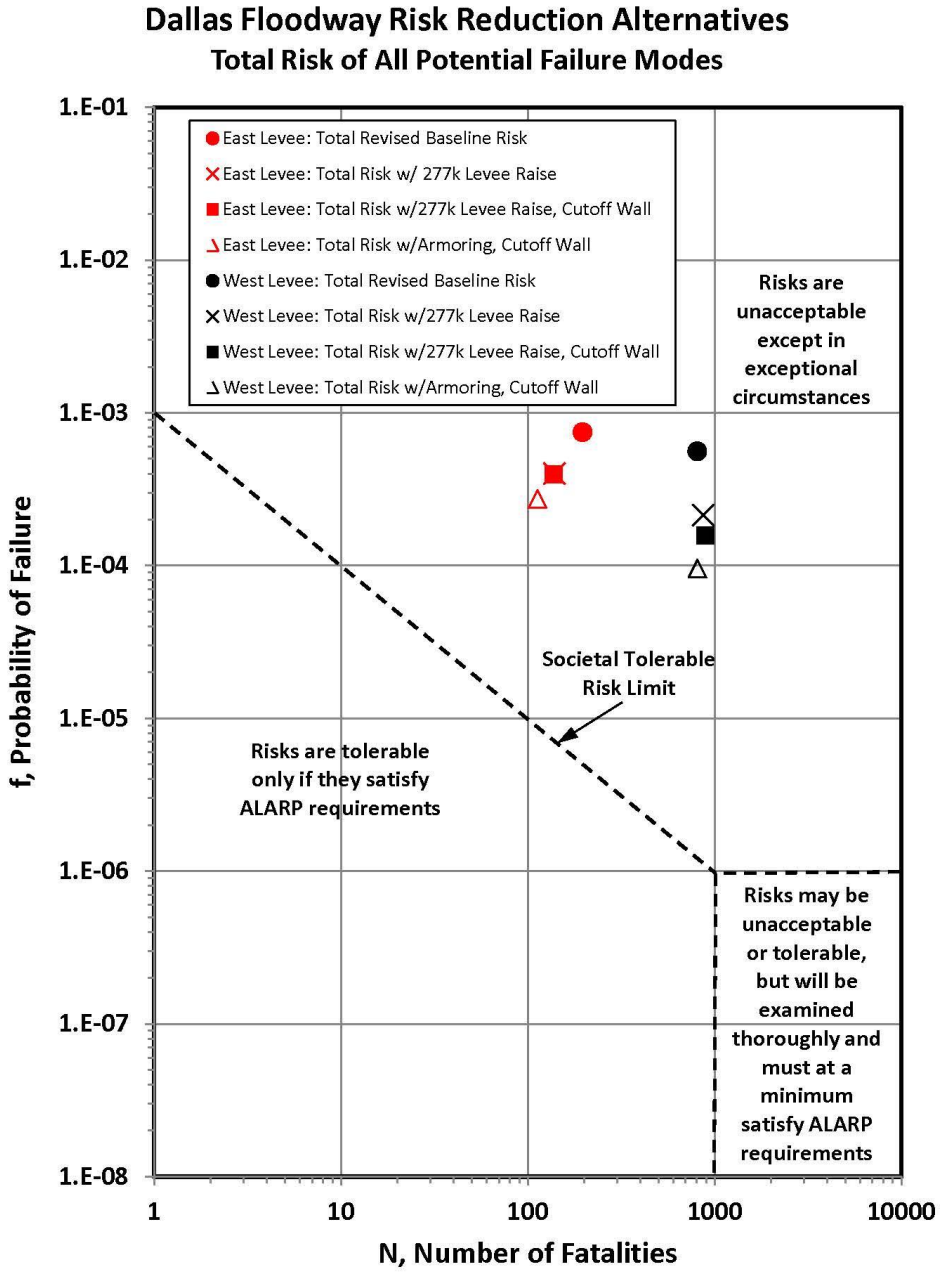
3.4.7 Comparison of Final NED Array

The NED Plan is the 277,000 cfs levee raise with 3H:1V side slopes in combination the AT&SF Railroad Bridge modification. Controlled overtopping added to the 277,000 cfs levee raise did not show significant changes in water surface elevations, which would not translate to economic justification, so the Fort Worth District felt that further consideration was not warranted. Controlled overtopping was also not expected to reduce life-safety risk. The seepage cut-off walls provided significant overall reduction in annualized loss-of-life for PFM #7 as a stand-alone alternative for that failure mode; however based on further evaluation, the combined plan did not reduce total risk to a tolerable level. Cut-off walls were also not a cost effective means to reduce life-safety risk based on the estimated net cost of a statistical life saved. The 277,000 cfs levee raise and AT&SF Railroad Bridge modification provides greater economic and life-safety benefits compared to the other alternatives.

3.4.8 Tentatively Selected Plan - FRM Component of the BVP (Trinity River Flooding)

The BVP included up to a 2-foot levee raise with 4H:1V side slopes. The IG for Section 5141 of the WRDA 2007 required the levee system be evaluated per Corps NED guidance. It was determined through the formulation process that 4H:1V side slopes had fewer net benefits than the 3H:1V side slopes, and was not determined to be the NED Plan. The NED – Tentatively Selected Plan (TSP) was the 277,000 cfs levee raise with 3H:1V side slopes and the AT&SF Railroad Bridge modification based on their contribution to NED and life-safety benefits. In addition, floodplain inundation maps are available for the City of Dallas to update their EAP. Based on the safety hazard of mowing steep side slopes and its inclusion in the BVP, the local sponsor wishes to pursue construction of 4H:1V side slopes on the entire length of the riverward side of the East and West Levees, including the forks at 100% non-Federal cost. See Appendix L, Figures L-5 through L-18 of the NED – Tentatively Selected Plan.

Figure 3-4 Flood Risk Management Total Risk for Alternatives Considered



3.4.9 Periodic Inspection No. 9 Considerations

During formulation, all the remaining PI Report No. 9 inspection items were individually addressed and a case made whether: (1) the items should be cleared from the list with no further action; (2) a change in rating in future inspections was warranted; (3) it contributed to a PFM and should be carried forward for potential inclusion in plan formulation for corrective action; or (4) it remain with the City of Dallas as Operations, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R). A path forward for each remaining item is described in greater detail in Appendix B (Geotechnical), Section 17.

The PI No. 9 inspection checklist provided ratings for flood damage reduction systems as a whole, as segments within the system, or as individual features (items). The rating can be "Acceptable" (A), "Minimally Acceptable" (M), "Unacceptable" (U), or "Observed" (Obs). An unacceptable rating is given to an item if one or more serious deficiencies exist that need to be corrected. A minimally acceptable rating is given if one or more minor deficiencies exist. Unacceptable items which would prevent the levee system from performing as intended need to be corrected within a two-year period, otherwise the project could be eliminated from participation in the Public Law 84-99 program. The 21 remaining items were either addressed or "closed-out" in this feasibility study as follows.

3.4.9.1 Encroachments for bridges, electrical power towers, and a jail

Based on the results of the risk assessment, utility penetrations and bridge penetrations in the embankment were not seen as credible failure modes. The Fort Worth District subsequently has reviewed existing boring data and prior Section 408 approvals (if they existed) for the encroachments. Based on the review, ratings will be revised to M or A during the next annual inspection.

A jail built adjacent to the East Levee was not specifically addressed by any of the PFMs in the risk assessment. The sponsor has subsequently provided as-builts and existing geotechnical information on the jail construction. Based on analysis of the new data, the Fort Worth District will revise the jail rating to M or A during the next annual inspection.

3.4.9.2 Levee height does not meet original design grade

The PI No. 9 noted levee height deficiencies of the East and West Levees based on the 2003 crest survey and the 1950s design elevation. A decrease in levee height could lead to overtopping and breach. The Fort Worth District evaluated the levee raises and the levee raises are part of the Recommended Plan. The levee height deficiency will stay a U until the levee raises are completed; however they will be classified as a non-system determining U.

3.4.9.3 Extensive cracking due to desiccation

The extent, length, and depth of the desiccation cracks place the East and West Levees in an unacceptable category. Desiccation cracking was considered under PFM #5 and #13 of the risk assessment. These failure modes were not considered to be high risk based on the risk assessment. The City of Dallas plans to implement 4H:1V side slopes at 100% non-Federal cost. The 4H:1V side slopes help reduce the number and frequency of slides, thus becoming less of an O&M issue for the City of Dallas. Because they were considered low risk in the risk assessment, the Fort Worth District will consider revising the U rating for desiccation cracking during the next annual inspection.

3.4.9.4 AT&SF Railroad Bridge flow obstructions

The PI No. 9 noted the AT&SF Railroad Bridge is an obstruction to flow in the channel. Obstruction of flow leads to higher water surfaces in the Floodway which could contribute to overtopping of the levee in

the event of high flows. The Fort Worth District evaluated the AT&SF Bridge and the bridge modification is part of the Recommended Plan. The AT&SF Bridge will stay a U until the bridge modification is completed; however it will be classified as a non-system determining U.

3.4.9.5 Dallas Floodway Project currently does not meet current Corps design criteria regarding relevant factors of safety for embankment stability and seepage gradients.

Use of transient versus steady state seepage analyses was a major change from previous geotechnical analyses used in the study. It made the difference between the levee system not meeting Corps design standards (factor of safety) to meeting them in most cases. During the risk assessment it was decided that a factor of safety less than 1.0 would be a reasonable representation for a failure condition. The factors of safety were greater than 1.0 for almost all cases in this study using transient analysis. The critical sections (worse case is less than 1.0 factor of safety) for a global slope stability failure resulting in failure of the levee were determined to be station 220+00 East Levee and 10+00 West Levee. The Fort Worth District evaluated cut-off walls in this study to address the failure condition, but they were not economically justified, or considered an efficient life-safety risk reduction measure. The City of Dallas' cut-off walls installed for their interim 100-year fixes run along the East Levee from station 285+00 to 442+00 for a total of 15,700 feet or approximately 2.97 miles and along the West Levee from levee station 3+00 to 29+00 for a total of 2,600 feet or 0.49 mile. The following summarizes "with-project" conditions for the BVP; however, it is important to note here because it is related to the close-out of this item in PI No. 9. Additional discussion of the with-project conditions for the BVP is provided in the Comprehensive Analysis results for geotechnical engineering, later in this chapter. The existing cut-off walls the City of Dallas has constructed on the East Levee at Station 285+00 will be extended downstream to approximately Continental Avenue (approximately Station 170+00) to mitigate for the increase in risk (underseepage) due to the River Relocation. Thus, the critical sections at station 220+00 East Levee and 10+00 West Levee have seepage mitigation features in place and factors of safety have improved. Ensuring integrity of the levee system is the number one priority for the Corps and the City of Dallas. Meeting deterministic criteria will be confirmed during Pre-construction, Engineering and Design (PED) phase when designing BVP and IDP features.

3.5 PLAN FORMULATION FOR THE FLOOD RISK MANAGEMENT PLAN - INTERIOR DRAINAGE FLOODING

The same levees that protect the City of Dallas from Trinity River flooding also block local stormwater runoff from the interior (developed) side of the levee from reaching the Trinity River. Thus, the City of Dallas manages interior drainage by allowing the stormwater runoff to pool in sumps (low areas) in interior areas before pumping or gravity feeding the stormwater into the Dallas Floodway. For the last 75 years, the City of Dallas (in cooperation with the Corps) has employed this strategy for managing stormwater in the East and West Levee Interior Drainage System (EWLIDS). The existing EWLIDS consists of six pumping plants, eighteen sump storage ponds, seven pressure conduits, and three drainage structures as generally shown on Figure 4 of Appendix L of this report. Additional figures of the IDP features are included in the EIS, Appendix G.

Recent flood events have demonstrated that improvements are needed to the EWLIDS to reduce the risk of interior flooding. Following these flood events, a comprehensive study was undertaken to determine the needs for interior drainage improvements and have identified an Interior Drainage Plan to provide a reduction in flood risk to the interior areas (City of Dallas 2006, 2009). The following summarizes the development of the Interior Drainage Plan Alternatives.

3.5.1 Development of the IDP

The purpose of the IDP component is to achieve protection from 100-year, 24-hour storm event flooding for the area served by the EWLIDS. In order to identify action alternatives to carry forward for analysis, a two-step screening process was followed: (1) Courses of Action Development and then (2) Alternative Development. This process and the resulting identified proposed IDP features are defined in the reports prepared by the City of Dallas entitled, "*The Interior Levee Drainage Study Phase-1 Report, Dallas, Texas*," and "*The Interior Levee Drainage Study West Levee – Phase II, Dallas, Texas."* The following sections describe this two-step process and the resulting proposed IDP features.

Proposed improvements to the Pavaho, Baker and Able Pumping Plants were processed as Section 408 projects due to pressing safety concerns and separate NEPA documents were prepared to expedite the analysis and construction of proposed stormwater FRM actions. A description of the actions are provided here because the actions are eligible for potential cost share in the MDFP.

3.5.1.1 Measure Development

In this initial screening step, potential courses of action were analyzed to address existing stormwater flooding concerns by initiating engineering studies that identified potential courses of action. The study findings were then reviewed to determine their feasibility. Those courses of action deemed feasible warranted additional screening (step two), while those potential courses of action that were determined to not be feasible were eliminated.

Measures

The following potential courses of action were identified to address existing stormwater flooding concerns:

- Increase Sump Storage Capacity;
- Alter Sump Inflow Hydrographs;
- Increase Pumping Capacity;
- Construct Pressure Sewers; and
- Improve Conveyance between Sump Ponds.

These potential courses of action could work independently, or in combination with one or more other courses of action, to address existing stormwater flooding concerns. A description of each of these potential courses of action and associated measures follows.

Increase Sump Storage Capacity

A potential approach to managing stormwater is to increase the size of the retention basins, or sumps. When land is readily available, agencies can consider increasing the size of sumps to increase the amount of available volume for stormwater storage; as the size of the sump increases, the required pumping capacity decreases.

Each sump within the EWLIDS was examined for expansion potential, both in horizontal and vertical directions, but found that only in a few locations was this feasible, albeit at a small scale. In these locations, the small amount of available land would not significantly increase the volume of sump storage capacity. Furthermore, the developed nature of the area and high property values surrounding the existing sumps limit their potential for large-scale expansion. In the project area, significant amounts of private property would have to be acquired to augment existing sump storage capacity, and displacing residents and/or businesses is not a desired approach. Therefore, this measure was eliminated. Nonstructural

buyouts are not explicitly named in the IDP measures, but wasconsidered eliminated for the same reasons described here.

Alter Sump Inflow Hydrographs

Decreasing the magnitude or altering the timing of the inflow of stormwater to the sump is possible by increasing the amount of detention storage. When land is readily available, it is possible to increase the size of detention storage, which provides the capability to decrease the magnitude of peak water levels (alter the hydrograph).

The feasibility of increasing the amount of stormwater detention storage to a sufficient level to alter the hydrograph was investigated. However, the investigation did not identify any areas that would be feasible, primarily for the same reasons as presented for the potential Increase Sump Storage Capacity Course of Action discussion. Therefore, this measure was eliminated.

Increase Pumping Capacity

Increasing the capacity of the pumping plants to handle stormwater is possible through rehabilitating existing pump stations, constructing new pump stations at existing pumping plants, and/or constructing new pumping plants. In addition, existing pump stations in need of significant rehabilitation and with high O&M costs could be decommissioned and more efficient pump stations constructed in their place.

Increasing the pumping capacity of the EWLIDS was determined to be a feasible course of action for addressing existing stormwater flooding concerns. Therefore, this measure was carried forward.

Construct Pressure Sewers

Constructing new pressure sewers to collect and convey stormwater to the Dallas Floodway is possible under certain conditions: (1) a potential pressure sewer basin must be capable of generating enough hydraulic head to generate sufficient pressure, and (2) the station must be large enough to contribute a significant amount of flow to the sump to make the system economically viable.

Potential areas were investigated, but no areas were determined to provide enough hydraulic head and area to contribute a significant amount of flow at a reasonable cost. Therefore, this measure was eliminated.

Improve Conveyance between Sump Ponds

Improving the conveyance between sump ponds can increase the capacity of a stormwater sump and pump system to collect and move stormwater efficiently to the Dallas Floodway. This can be done by replacing or increasing the size of existing connections in the sumps, or adding new connections.

Several areas in the existing sumps were identified that present opportunities for improving stormwater conveyance between the sump ponds. This course of action would not alleviate existing stormwater flooding concerns as stand-alone measure; however, it would contribute to reducing flooding concerns when included with another course of action. Therefore, this measure was carried forward.

Measures Carried Forward

The IDP determined that increasing pumping capacity and improving conveyance between sump ponds are the selected courses of action for addressing existing stormwater flooding concerns in the EWLIDS. The other measures were eliminated from further analysis.

3.5.1.2 East and West Levee Interior Drainage Alternative Development

In part two of a two-step approach, the potential measures in each basin were identified as to work independently, or, as part of adjacent basin improvement measures to address existing stormwater flooding concerns. For some basins, investigations have identified only one measure, while multiple measures were identified for other basins. Each measure had associated scales, or component actions, associated with the presented measure. Those determined feasible were included in the IDP, while those that were not feasible were not considered for implementation under Section 5141 of WRDA 2007, as amended.

East Levee Interior Drainage System – Interior Drainage Plan Improvement Measures

Hampton Basin

No alternative evaluated eliminated the need to construct a pump station in Hampton Basin. The cost for increasing sump storage was too high. The measures to decrease existing stormwater flooding concerns in the Hampton Basin (HB) is HB-1 and consists of increasing the pumping capacity of the Hampton Pumping Plant by constructing a new 500,000-gpm pump station and outfall, rehabilitating the existing pump stations (New Hampton Pump Station), and installing three, 60-inch culverts beneath Empire Central Drive. The Old Hampton Pump Station would be demolished. Table 3-18 summarizes the proposed measures for Hampton Basin. This was identified as the least cost alternative considered.

Table 3-18. Hampton Basin Measures

Component Code	*Measure*
HB-1	Construct New 500,000-gpm Pump Station and Outfall Rehabilitate Existing Pump Stations Install Three, 60-inch Culverts beneath Empire Central Drive (Nobles Branch Sump) Demolish the Old Hampton Pump Station

Note: HB = Hampton Basin

Baker Basin

Similar to Hampton Basin, no alternative evaluated eliminated the need to construct a pump station in Hampton Basin. The cost for increasing sump storage was too high. The measures to decrease existing stormwater flooding concerns in the Baker (Hampton-Oak Lawn Basin) Basin consists of constructing a new Baker Pumping Plant to 700,000-gpm pump station and outfall. Table 3-19 summarizes the proposed measures for Baker Basin (BB). An Environmental Assessment (EA) was developed for this IDP feature and the project is being processed under Section 408. This IDP feature is currently under construction.

Table 3-19. Baker Basin Measures

Component Code	*Measure*
BB-1	Construct New 700,000-gpm Pump Station and Outfall (Baker No. 3 Pump Station) Minor Improvements to the Existing Baker Pump Station Minor Improvements to the Hampton-Oak Lawn Sump

Note: BB = Baker Basin

Able Basin

The measure to decrease existing stormwater flooding concerns in the Able Basin consists of constructing a new Able Pumping Plant (Able No. 3) to 876,000-gpm pump station and outfall. Table 3-20 summarizes the proposed measure for Able Basin. Sump improvements were considered for the Able Basin (AB). Sump improvements were eliminated from consideration, but they are being pursued as part of a separate transportation project. An EA was developed for this IDP feature and the project is being processed under Section 408. This IDP feature is currently under construction.

Table 3-20. Able Basin Measures

Component Code	*Measure*
AB-1	Construct New 876,000-gpm Pump Station and Outfall (Able No. 3 Pump Station)

Note: AB = Able Basin

East Levee IDP Summary

Table 3-21 summarizes the improvement measures for the ELIDS, and which measures are included in the IDP. Overall, these features were selected based upon being the least cost alternatives for each basin.

Table 3-21. East Levee IDP Summary

Component Code	*Measure*
HB-1	Construct New 500,000-gpm Pump Station and Outfall Rehabilitate Existing Pump Stations Install Three, 60-inch Culverts beneath Empire Central Drive (Nobles Branch Sump) Demolish the Old Hampton Pump Station
BB-1	Construct New 700,000-gpm Pump Station and Outfall (Baker No. 3 Pump Station) Minor Improvements to the Existing Baker Pump Station Minor Improvements to the Hampton-Oak Lawn Sump
AB-1	Construct New 876,000-gpm Pump Station and Outfall (Able No. 3 Pump Station)

Note: HB = Hampton Basin, BB = Baker Basin, AB = Able Basin

West Levee Interior Drainage System – Interior Drainage Plan Improvement Alternatives

Delta and Pavaho Basins

In identifying potential solutions to decrease existing stormwater flooding concerns in the Pavaho Basin, engineers determined that due to the connection between the Pavaho Basin (PB) and Delta Basin (DB), it made sense to treat the two basins as one system when considering improvement measures. Thus, this discussion includes the Delta and Pavaho Pumping Plants, and the Trinity-Portland, Frances Street, Westmoreland-Hampton, and Pavaho Sumps. In addition, as there is an existing culvert connecting the Eagle Ford and Trinity-Portland Sumps, this section includes a discussion of potential improvement measures to this culvert. Potential improvement measures in the Delta and Pavaho Basins include a range of pump station and sump conveyance improvements. Table 3-22 summarizes the potential stormwater flooding reduction measures for DB and PB.

Table 3-22. Delta and Pavaho Basin Measures

Component Code	*Measure*
DB-1A	Demolish Existing Delta Pump Station Construct New 250,000-gpm Pump Station at Delta Install Two, 10-foot by 6-foot Culverts under Westmoreland Avenue Install One, 6-foot by 4-foot Culvert at the Ledbetter Dike Control Structure
DB-1B	Rehabilitate Existing Delta Pump Station Construct New 166,000-gpm Pump Station at Delta Install Two, 10-foot by 6-foot Culverts under Westmoreland Avenue Install One, 6-foot by 4-foot Culvert at the Ledbetter Dike Control Structure
DB-2	Construct New 150,000-gpm Pump Station in Trinity-Portland Sump
DB-3	Demolish Existing Delta Pump Station Construct New 400,000-gpm Pump Station at Delta Install One, 6-square foot Culvert between Trinity-Portland and Eagle Ford Sumps Install Three, 10-foot by 6-foot Culverts under Westmoreland Avenue Install One, 6-foot by 4-foot Culvert at the Ledbetter Dike Control Structure
DB-4	Construct New 250,000-gpm Pump Station in Trinity-Portland Sump Rehabilitate Existing Delta Pump Station Install One, 6-square foot Culvert between Trinity-Portland and Eagle Ford Sumps
PB-1	Demolish Existing Pavaho Pump Station Construct New 500,000-gpm Pump Station at Pavaho
PB-2	Demolish Existing Pavaho Pump Station Construct New 375,000-gpm Pump Station at Pavaho Install Two, 10-foot by 6-foot Culverts under Sylvan Avenue Install One, 10-foot by 8-foot Culvert under Canada Drive
PB-3	Perform Minor Improvements to the Existing Pavaho Pump Station Construct New 381,000-gpm Pump Station at Pavaho

Note: DB = Delta Basin, PB = Pavaho Basin

Improvement measures for the Delta and Pavaho Basins address the two basins as one combined system. Thus, the recommended improvement measure must represent the most hydraulically effective solution for the entire combined system. Based on this criterion, the improvement measures DB-1A, DB-1B, DB-2, DB-3, PB-1, and PB-2 were eliminated (City of Dallas 2009). Measure PB-3 was analyzed in an EA prepared for the Pavaho Pumping Plant Improvements (Corps 2010). Construction of the Pavaho Pump Station is complete.

Eagle Ford Basin

The improvements considered to decrease existing stormwater flooding concerns in the Eagle Ford Basin include a range of gravity sluice options and two pumping plant construction options. Table 3-23 summarizes the potential stormwater flood reduction measures for Eagle Ford Basin.

Table 3-23. Eagle Ford Basin Measures

Component Code	*Measure*
EF-1	Add Seven, 4.5-square foot Gravity Sluices Adjacent to Existing Gravity
EF-2	Demolish Existing Gravity Sluices Install Two, 10-square foot Gravity Sluices
EF-3	Add One, 10-foot by 12-foot Gravity Sluice Adjacent to Existing Gravity
EF-4	Retain Existing Gravity Sluices Construct New 100,000-gpm Pumping Plant
EF-5	Demolish Existing Gravity Sluices Construct New 150,000-gpm Pumping Plant

Note: EF = Eagle Ford

As previously noted, there is a culvert connecting the Eagle Ford Sump to the Trinity-Portland Sump (City of Dallas 2009). Thus, based on the recommended improvement measures for the Delta and Pavaho Sumps, none of the potential improvement measures would be necessary. Therefore, the Eagle Ford improvement measures are not included in the IDP.

Charlie Basin

Several improvement measures to decrease existing stormwater flooding concerns in the Charlie Basin were identified. These measures included a range of gravity sluice options and pumping plant improvement options. Table 3-24 summarizes the potential stormwater flooding reduction measures for Charlie Basin (CB).

Table 3-24. Charlie Basin Measures

Component Code	*Measure*
CB-1	Rehabilitate Existing Charlie Pump Station Install Two, 10-square foot Gravity Sluices through the West Levee
CB-2A	Demolish Existing Charlie Pump Station Construct New 225,000-gpm Pump Station
CB-2B	Rehabilitate Existing Charlie Pump Station Construct New 145,000-gpm Pump Station adjacent to Charlie Pump Station

Note: CB = Charlie Basin

Due to greater risks associated with hydraulic uncertainties and the risks and challenges associated with constructing additional gravity sluices through the West Levee, the CB-1 option was eliminated. As a result of the age of the existing Charlie Pump Station and the fact that the pump floor elevation is susceptible to stormwater flooding from the 100-year, 24-hour event, a better option is to demolish the existing pump station and replace it with a new pumping station at a slightly higher elevation. Thus, the CB-2B was eliminated from further consideration. The CB-2A alternative was selected as part of the IDP.

West Levee IDP Summary

Table 3-25 summarizes the identified improvement measures for the WLIDS, and the measures included in the IDP.

Table 3-25. West Levee IDP Summary

Component Code	*Measure*
DB-4	Construct New 250,000-gpm Pump Station in Trinity-Portland Sump Rehabilitate Existing Delta Pump Station Install One, 6-square foot Culvert between Trinity-Portland and Eagle Ford Sumps
PB-3[1]	Perform Minor Improvements to the Existing Pavaho Pump Station Construct New 381,000-gpm Pump Station at Pavaho
CB-2A	Demolish Existing Charlie Pump Station Construct New 225,000-gpm Pump Station

Notes: DB = Delta Basin, PB = Pavaho Basin, CB = Charlie Basin
[1] PB-3 was analyzed in the EA prepared for the Pavaho Pumping Plant Improvements (Corps 2010)

3.5.2 IDP Structure Evaluation

Table 3-26 lists the features of the East and West Levee Improvements that constitute the IDP. In summary, the measures considered for the IDP were:

- Increase Sump Storage Capacity (nonstructural buyout);
- Alter Sump Inflow Hydrographs;
- Increase Pumping Capacity;
- Construct Pressure Sewers; and
- Improve Conveyance between Sump Ponds.

The IDP determined that increasing pumping capacity and improving conveyance between sump ponds was best for addressing existing stormwater flooding concerns in the EWLIDS. The other measures were eliminated from further analysis, primarily based on cost, but also on hydraulic performance as indicated in the previous sections. Three of the proposed IDP improvements are under construction or complete (Pavaho, Able and Baker – highlighted gray), and were processed under Section 408.

Table 3-26. Interior Drainage Plan Features (East and West Levee)

Component Code	*Measure*
HB-1	Construct New 500,000-gpm Pump Station and Outfall Rehabilitate Existing Pump Station (New Hampton) Install Three, 60-inch Culverts beneath Empire Central Drive (Nobles Branch Sump) Demolish the Old Hampton Pump Station
BB-1[1]	Construct New 700,000-gpm Pump Station and Outfall (Baker No. 3 Pump Station) Minor Improvements to the Existing Baker Pump Station Minor Improvements to the Hampton-Oak Lawn Sump
AB-1[1]	Construct New 876,000-gpm Pump Station and Outfall (Able No. 3 Pump Station)
DB-4	Construct New 250,000-gpm Pump Station in Trinity-Portland Sump Rehabilitate Existing Delta Pump Station Install One, 6-square foot Culvert between Trinity-Portland and Eagle Ford Sumps

Component Code	*Measure*
PB-3[1]	Perform Minor Improvements to the Existing Pavaho Pump Station Construct New 381,000-gpm Pump Station at Pavaho
CB-2A	Demolish Existing Charlie Pump Station Construct New 225,000-gpm Pump Station

Notes: HB = Hampton Basin, BB = Baker Basin, AB = Able Basin, DB = Delta Basin, PB = Pavaho Basin, CB = Charlie Basin
[1] PB-3, AB-1, and BB-1 were analyzed in EAs prepared under Section 408

Table 3-27 compares the number of potentially affected and potentially flooded structures under current conditions with those predicted with the IDP. A "potentially affected structure" is any structure touched by the predicted water surface elevation, and "potentially flooded" are those touched by the inundation area that have finished floor elevations below the predicted water surface elevation. The table refers to the area drained by each pumping plant. As shown in Table 3-27, reduction in structures affected by the 100-year, 24-hour storm event was estimated for purposes of meeting the objective to reduce interior drainage flood risk. The estimated reduction is 83% on the East Levee and 92% on the West Levee.

It appears in Table 3-27 that the Charlie Basin and the Eagle Ford Basin flood risk is not addressed with the IDP. That is not the case, the Charlie Basin features do not reduce the number of structures exposed to the 100-year, 24-hour storm event; however, the existing Charlie Pump Station itself is susceptible to stormwater flooding from the 100-year, 24-hour event, and a new pumping station at a slightly higher elevation is recommended. Also, there is a culvert connecting the Eagle Ford Sump to the Trinity-Portland Sump, thus making it part of the Delta and Pavaho Basins, and addressed by the IDP improvements proposed for those basins.

3.5.3 Tentatively Selected Plan - IDP

A variety of structural and nonstructural plans were developed that address the flood risk due to interior drainage flooding in the City of Dallas' IDP. These plans were screened, combined and scaled as detailed in the City's IDP reports for their ability to contribute to flood risk reduction and consideration of their cost. The plan formulation resulted in a set of measures to implement within each drainage basin in the study area. Implementation of the IDP would reduce predicted 100-year, 24-hour storm event, resulting in a significant reduction in the number of structures potentially affected by flooding. This risk reduction would serve to reduce potential stormwater flooding impacts to people and property in the City of Dallas. In addition, proposed improvements would modernize and extend the service life of existing facilities for at least another 50 years.

Reductions in structures affected by the 100-year, 24-hour storm event were measured to determine whether the IDP feature met the objective for the study. The estimated reduction in number of structures affected by interior drainage flooding is 83% for the East Levee and 92% for the West Levee. Furthermore, reducing flood risk is a primary mission of the Corps and something that the Corps has a significant stake in. Therefore, the IDP features are recommended for inclusion in the MDFP. The Able, Baker and Pavaho Pump Station features will be constructed prior to signing a Project Partnership Agreement (PPA).The City of Dallas has the ability to request credit for implementation of those features. Additional discussion on what the City of Dallas intends to request for credit is provided in Chapter 5.

Table 3-27. Potentially Affected Structures and the Reduction in Number of Structures in the 100-year, 24-hour Storm Event

Sump	*Drainage Basin*	*Pump Station*	*Predicted 100-year, 24-hour Flood Elevation (feet)*	*Existing Condition*			*Future With-Project Condition (Pump Stations)*		*Percent Change (Potentially Flooded Structures)*	*Percent Change (Potentially Flooded Structures)*
				Potentially Affected Structures (Appraised Value[1])	*Potentially Flooded Structures (Appraised Value[1])*	*Total Structures/ Drainage Basin*	*Potentially Affected Structures*	*Potentially Flooded Structures*		
East Levee Interior Drainage System										
Able	Able	Able	399.2-	208 ($56.2 M)	131 ($42.5 M)	208/131	48	0	100%	83%
Hampton-Oak Lawn	Baker	Baker	403.7	329 ($958.5 M)	104 ($291.7 M)	329/104	Unknown[2]	4	96%	
Record Crossing	Hampton	Hampton	405.8	444 ($544.0 M)	94 ($32.7 M)	493/102	Unknown[2]	53	48%	
Nobles Branch	Hampton	Hampton	409.3	49 ($92.0 M)	8 ($27.2 M)					
West Levee Interior Drainage System-										
Charlie	Charlie	Charlie	403.5	34 ($4.4 M)	3 (<$0.1 M)	46/5	40	5	0%	92%
Corinth Street	Charlie	Charlie	402.1	12 ($0.2 M)	2 (<$0.1 M)					
Pavaho	Pavaho	Pavaho	408.2	1,047 ($33.5 M)	205 ($5.6 M)	1,047/205	41	4	98%	
Westmoreland-Hampton	Delta	Delta	408.5	71 ($8.5 M)	3 (<$0.1 M)	141/14	51	7	50%	
Frances Street	Delta	Delta	410.1	11 ($0.2 M)	3 ($0.1 M)					
Trinity-Portland	Delta	Delta	412.0	59 ($4.3 M)	8 ($0.3 M)					
Eagle Ford	Eagle Ford	None – sluice gate	417.2	34 ($11.4 M)	0	N/A	10	0	0%	

Notes: [1] Appraised value given in millions (M) of dollars. Values based on 2009 appraisal data.
[2] Information not available. Potentially flooded numbers are estimated based on changes in flood elevation estimates.
Sources: City of Dallas 2006, 2009.

3.6 PLAN FORMULATION FOR THE ECOSYSTEM RESTORATION PLAN

Major BVP features that would be considered as Corps ecosystem restoration features include:

- River Relocation;
- Corinth Wetlands;
- Natural Lake; and
- Other various surface treatment wetlands throughout the Floodway.

The proposed River Relocation is an ecosystem restoration feature that has high potential of an uplift in function and is a feature that fits within the Corps mission of ecosystem restoration and should therefore be considered for inclusion into the plan if it meets the planning objectives.

The proposed Corinth Wetlands includes expanding an existing wetland at the downstream end of the Floodway. This wetland is currently degraded due to the current operations and maintenance activities within the Floodway. The proposal would improve the operation and maintenance and quality of the wetland to provide additional fish and wildlife habitat, especially for migratory birds. This feature is consistent with a typical Corps ecosystem restoration project and should be considered for inclusion into the plan if it meets the planning objectives.

The Natural Lake is one of the proposed primary borrow sources for the Trinity Parkway. The Trinity Parkway is being processed by the Corps under a separate 404 Permit Application as a single and complete project and it needs the borrow sites to minimize hydraulic impacts. If the Trinity Parkway is constructed, the plan would be to convert the borrow area into a lake. Even though it is called the Natural Lake, its primary purpose is to provide recreational opportunities for boating and kayaking. The edges of the lake would have soft sides, and therefore emergent vegetation is proposed to provide environmental quality features but the primary purpose would still be recreation which is above and beyond what the Corps would normally participate. With this in mind, construction of the Natural Lake is not recommended for consideration in the MDFP.

Finally, the BVP includes several areas that would function as fringe wetlands or marshlands. These features are generally associated with recreation features such as the athletic fields. While they would provide an increase in habitat values from a structure and function perspective, the ongoing operations and maintenance, recreational activities, and lighting would generally prevent fish and wildlife from utilizing the areas without being frequently disturbed. Even though these features would serve an ecosystem function, they are not considered for inclusion in the MDFP. The Corps encourages the City of Dallas to incorporate these features into their design due to the benefits that they would serve from an environmental quality perspective, such as filtering nutrients.

3.6.1 River Relocation and Corinth Wetlands

The River Relocation would restore the sinuosity to the Trinity River and allow the river to naturally form aquatic habitats such as pools, sandbars (riffles), and more diverse variety of instream structures. The channel banks of the existing Trinity River were constructed with uniform 1H:1V slopes. The proposed channel design mimics the more natural channel bank conditions observed downstream in the Great Trinity Forest reaches of the river (immediately downstream), with flat terraces situated low in the channel along the insides of meander bends. The milder channel slope banks reduce the abrupt edge condition within the riverine corridor and facilitate greater movement (biotic and abiotic material) within

the corridor. The proposed channel design will enhance the existing complex profile by maintaining the average longitudinal profile slope through the project area and facilitating improved, more natural scour and deposition patterns around the newly created meander bends. Local bedrock controls were integrated into the proposed channel design, where possible, as anchors for constructed pool depressions in the profile and as gradient controls. The proposed channel design includes a revegetation plan that will re-establish native vegetation species at elevations on channel banks determined to be most conducive to their establishment and growth. Riparian vegetation will also contribute to bioengineered bank stabilization designed to limit or prevent bank erosion in high energy reaches with sensitive adjacent infrastructure. Because of the steep, uniform nature of existing channel bank slopes, the transition from in-channel to floodplain habitat is abrupt and limited in habitat quality. The proposed channel realignment design improves on this condition in two ways. First, the proposed in-channel addition and the more gradually sloped banks with terraces will improve connectivity through creation of more gradual elevation gradients between the channel and floodplain during high flows. When combined with the Corinth Wetlands, and other wetland projects, the channel realignment design will significantly improve floodplain habitat and connectivity.

3.6.1.1 BVP Ecosystem Restoration Element Selection Discussion

Since the IG for Section 5141 of WRDA 2007 did not require that the Corps formulate for NER per normal planning guidance, no attempt was made to justify ecosystem restoration components of the MDFP using National Significance discussions and/or cost effectiveness and incremental cost analysis. Restoration components were generally selected on the basis of which BVP elements most closely met the intent of Corps policy guidance for ecosystem restoration projects. This was accomplished by: (1) evaluating the changes or improvements to habitat in the study area quantitatively using Habitat Evaluation Procedures (HEP); (2) qualitative discussions of the alignment with Corps policies for ecosystem restoration; and (3) qualitative discussions of the outputs of the ecosystem restoration features aligning with National and Regional Significance. The following provides a summary of the selection process. Additional detail is provided in Appendix F, Environmental Resources.

Changes and Improvements in Habitat Quality and Quantity

The area assessed for environmental benefits include the extent of the FEMA predicted 500-year riverine flood event. This lies within the total study area described in Section 1.4 of this report. An interagency team of Corps, Texas Prks and Wildlife Department (TPWD) and USFWS biologists conducted the habitat evaluations for the study. Environmental benefits are expressed in this assessment as changes in acres of habitat type and habitat units. Habitat units (HU) are an indication of habitat quality, and developed using an indicator species that represents the habitat types in the study area. The habitat types of bottomland hardwoods, emergent wetlands, grasslands, open water, and urban were selected because they represent the major habitat types in the study area. Habitat types were subdivided by location into "Confluence, Mainstem and IDS" evaluation areas to assess possible differences in project feature impacts in the analysis, but are consolidated here. Appendix F (Environmental Resources) of this report provides additional detail on the environmental resource analysis. The information presented here for year 50 provides a representation for habitat changes for the MDFP at the end of the 50-year period of analysis.

Table 3-28 compares the change in habitat acres in the study area between the existing conditions, future without-project condition, the MDFP and the MDFP with cumulative future without-project conditions over the 50-year period of analysis. The table includes the impacts associated with the River Relocation, Corinth Wetlands, and the FRM features (from Sections 3.4.8 and 3.5.3). The year 2029 was the

estimated year construction of the environmental features was complete and is the base year for the analysis. For purposes of estimating habitat benefits for the MDFP, a comparison of the MDFP and the MDFP with cumulative projects to the future without-project condition was used. These are the changes shown in the "Change" columns of Tables 3-28, 3-29 and 3-30. The "cumulative" condition assumes habitat conditions with the future projects listed in Section 1.2.4 in Appendix F are implemented.

As shown in Table 3-28, the greatest increase in acres would be to aquatic riverine from the realignment of the river. There would be a loss of 24.07 acres of grasslands, 29.61 acres of bottomland hardwoods, and 10.4 acres of emergent wetlands and a gain of 223.53 acres of aquatic riverine habitat as shown under the MDFP with cumulative conditions column of Table 3-28. There is a loss in acres to bottomland hardwoods and emergent wetlands, generally in the IDS group and occurring on the Mainstem during construction of the River Relocation. The loss of emergent wetlands and bottomland hardwood habitat is offset by the River Relocation and the Corinth Wetlands as part of the MDFP, which will result in a lift of functional habitat units over the period of analysis. The lift in functional habitat units is described in the next few paragraphs.

Table 3-28. Estimated Changes to Habitat Acreages within the Study Area under the Modified Dallas Floodway Project at Year 50

Habitat Type	*Existing Conditions*	*Future Without-Project Condition Year 50*	*Modified DFP*	*Change[1]*	*MDFP (Cumulative)*	*Change[1]*
Bottomland Hardwood	1,412.63	1,431.35	1,411.54	-19.81	1,401.74	-29.61
Emergent Wetland	418.58	414.08	388.25	-25.83	403.68	-10.4
Grassland	4,283.57	3,925.77	4,099.60	173.83	3,901.70	-24.07
Aquatic Riverine	421.33	387.71	619.57	231.86	611.24	223.53
Open Water	206.65	186.69	228.99	42.30	228.97	42.28
Habitat Subtotal	***6,742.75***	***6,345.60***	***6,747.95***	***402.35***	***6,547.33***	201.73
Urban Area	10,400.01	10,797.16	10,394.81	-402.35	10,595.43	-201.73
Total	**17,142.76**	**17,142.76**	**17,142.76**	**-**	**17,142.76**	**-**

Note: [1] "Change" refers to the difference between the MDFP alone and under cumulative conditions at year 50 as compared to the future without-project condition at year 50.

Table 3-29 compares the habitat units in the study area between existing conditions, future without-project conditions, the MDFP and the MDFP (with cumulative projects) at year 50 in the 50-year period of analysis. The greatest decrease of HUs would occur to grassland habitat. This is not because the value of the habitat is degrading, but because grassland would be converted to other habitat types upon implementation of the MDFP. The greatest increase would be to aquatic riverine habitat values partly from increasing the acreage of aquatic riverine habitat and partly from increasing the value of that habitat as a result of adding river meanders and more natural channel design features as part of the river restoration. The increase in emergent wetland habitat values are due to the creation of higher quality wetlands and improvements to the Corinth Wetlands at the southeastern end of the project area. The increase in bottomland hardwood habitat values, even though there is a loss of acreage (see Table 3-28), is due to an increase in the quality of the habitat along the river terraces.

Table 3-29. Estimated Changes to Habitat Units within the Study Area under the Modified Dallas Floodway Project at Year 50

Habitat Type	*Existing Conditions*	*Future Without-Project Conditions Year 50*	*MDFP*	*Change*[1]	*MDFP (Cumulative)*	*Change*[1]
Bottomland Hardwood	388.92	389.59	422.33	32.74	418.10	28.51
Emergent Wetland	97.53	94.48	113.50	19.02	117.02	22.54
Grassland	2,309.00	2,227.24	1,825.38	-401.86	1,741.72	-485.52
Aquatic Riverine	345.77	332.84	508.22	175.38	501.92	169.08
Open Water	143.76	129.90	143.12	13.22	143.12	13.22
Total	**3,284.98**	**3,174.05**	**3,012.55**	**-161.50**	**2,921.88**	**-252.17**

Note: [1] "Change" refers to the difference between the MDFP alone and under cumulative conditions at year 50 as compared to the future without-project condition at year 50.

Table 3-30 presents the annualized habitat units in the study area between existing conditions, future without-project conditions, and the MDFP and the MDFP (with cumulative projects) over the 50-year period of analysis. While the information presented at year 50 provides a representation for habitat changes for the MDFP at the end of the 50-year period of analysis, the Average Annual Habitat Units (AAHUs) represents the cumulative HUs for all years in the period of analysis.

Table 3-30. Estimated Changes to Average Annual Habitat Units within the Study Area under the Modified Dallas Floodway Project

Habitat Type	*Average Annual Habitat Units*				
	Future Without-Project Conditions	*MDFP*	*Change*[1]	*MDFP (Cumulative)*	*Change*[1]
Bottomland Hardwood	273.35	278.16	4.81	275.55	2.20
Emergent Wetland	68.02	76.94	8.92	79.44	11.42
Grassland	1,559.56	1,300.47	-259.09	1,243.28	-316.28
Aquatic Riverine	235.60	360.55	124.95	356.29	120.69
Open Water	96.92	106.79	9.87	106.79	9.87
Total	**2,233.45**	**2,122.91**	**-110.54**	**2,061.35**	**-172.10**

Note: [1] "Change" refers to the difference between the MDFP alone and under cumulative conditions at year 50 as compared to the future without-project condition at year 50.

Bottomland hardwood habitat shows a gain of 4.81 AAHUs for the MDFP and a lesser gain of 2.20 AAHUs for the MDFP (cumulative) conditions. This doesn't seem like much gain, but the reason is due to the establishment and maturation process of bottomland hardwood species. The MDFP includes the planting of high quality, native hard- and soft-mast producing trees as part of implementation of the river restoration and river terrace features, however, since hardwood trees are slow growing they show little habitat value during target years 1–10 and moderate habitat values through years 10-50. The higher habitat values don't show until the tree is +50 years old. If habitat values for bottomland hardwoods within the MDFP area were projected through 75 or 100 years, which is more reflective of the actual time that it takes bottomland hardwoods to reach maturity and maximize their habitat value, the AAHU values calculated over the extended period of time would show a much larger AAHU gain. For emergent wetlands, the AAHUs would increase by 8.92 and 11.42 AAHUs, respectively for the MDFP and MDFP (cumulative) conditions over future without-project conditions. A majority of this increase is a direct result of the creation and maintenance of higher quality wetlands, especially in the Corinth Wetland area

of the MDFP. For grasslands, there are losses of AAHUs for both the MDFP and MDFP (cumulative) projects mainly because of conversion of grasslands to bottomland hardwood, aquatic riverine and wetland habitat types in the Mainstem group. Since these other habitat types within the project area have more value for the desired habitat, this is a good improvement. Aquatic riverine shows a 124.95 and 120.69 AAHU increase, respectively for the MDFP and MDFP (cumulative) project over future without-project conditions directly because of restoration of meanders to the Trinity River in the Floodway. There is a little increase in open water AAHUs (9.87 AAHUs) over future without-project condition, generally in the IDS group as sump improvements are made and additional sumps constructed, for both the MDFP and MDFP (cumulative) over the future without-project condition.

In summary, the River Relocation and Corinth Wetlands have positive outputs of desired habitat types of bottomland hardwood, emergent wetland, and aquatic riverine. The River Relocation and Corinth Wetlands contribute to the planning objective developed for ecosystem restoration. Together they increase habitat quality by approximately 139 AAHU (under MDFP alone) in the project area for the desired habitat types over the 50-year period of analysis. In addition to improvements to habitat in the study area, the River Relocation and the Corinth Wetlands align with Corps policies for ecosystem restoration, and their outputs align with National and Regional Significance as described below.

Corps Policies for Ecosystem Restoration

The River Relocation and the Corinth Wetlands also align with the intent of Corps policy guidance for ecosystem restoration projects. The River Relocation and Corinth Wetlands align with the following policy documents:

- Engineering Pamphlet 1165-2-1 (30 July 1999) *Policy Digest*
- Engineering Regulation (ER) 1165-2-501 (30 September 1999) *Civil Works Ecosystem Restoration Policy*
- EP 1165-2-502 (30 September 1999) *Ecosystem Restoration – Supporting Policy Information*
- ER 1105-2-100 (22 April 2000) *Planning Guidance Notebook*

These policies essentially describe the nature of Corps involvement in ecosystem restoration related problems and what types of activities the Corps is involved in, for example:

- …ecosystem restoration activities that involve modification of hydrology or aquatic substrates are most likely to be appropriate for Corp initiatives…
- …The intent of restoration is to partially or fully reestablish the attributes of a naturalistic, functioning, and self-regulating system…
- …Those restoration opportunities that are associated with wetlands, riparian and other floodplain and aquatic systems are likely to be most appropriate for Corps involvement…
- …Civil Works ecosystem restoration initiatives attempt to accomplish a return of natural areas or ecosystems to a close approximation of their conditions prior to disturbance, or to less degraded, more natural conditions…
- …The objective of ecosystem restoration is to restore degraded ecosystem structure, function, and dynamic processes to a less degraded, more natural condition. Restored ecosystems should mimic, as closely as possible, conditions which would occur in the area in the absence of human changes to the landscape and hydrology…

Additionally, it is understood that Corps ecosystem restoration activities are appropriate where habitat degradation is the direct result of Corps actions, such as contributing to the relocation and straitening of the Trinity River and the construction of the Dallas Floodway Project for flood risk purposes.

National and Regional Significance

National Significance is discussed here to show the River Relocation and the Corinth Wetlands alignment with National Significance criteria. In 1983, the U.S. Water Resources Council published the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (P&G). To be considered in plan formulation and evaluation, P&G requires that environmental resources be "significant', with significant being defined as those resources or attributes in the study area that are institutionally, publicly, or technically recognized as important based on non-monetary values. The outputs of the River Relocation and the Corinth Wetlands are Nationally and Regionally significant as described in the following paragraphs.

Significance based on institutional recognition means that the importance of an environmental resource is acknowledged in the laws, adopted plans, and other policy statements of public agencies, tribes or private groups. The Trinity River has always represented both the greatest challenge and the greatest opportunity to define the City of Dallas. The Trinity River has posed a physical barrier within the community, separating the City of Dallas (areas behind the East Levee and the West Levee). In 1994, the City of Dallas (in conjunction with regional stakeholders) began looking at ways to outline a long-range vision for the entire Trinity River Corridor: to reclaim the Trinity River as a great natural resource, create a great public domain, and achieve a model of environmental stewardship. The City of Dallas' goals are outlined in the report entitled, *The Balanced Vision Plan for the Trinity River Corridor, Dallas, Texas,* dated December 2003, and amended in March 2004. The River Relocation and the Corinth Wetlands are part of the plan outlined in the BVP, and the adopted plan was developed and coordinated by the City of Dallas and the City Council representing the neighborhoods in the immediate area.

Significance based on public recognition means that some segment of the general public recognizes the importance of an environmental resource. For environmental restoration projects, willingness to cost share or evidence of public support are indicators of public recognition significance. Several times over the past 25 years, voters in the City of Dallas have approved and the City of Dallas has subsequently authorized bond program investments in the Trinity River Corridor, which per above are indicators of publicly recognition of a resources significance. These include: (1) an $8,500,000 bond program in 1989; (2) a $246,000,000 bond program in 1998; (3) a $219,017,612 bond program in 2006; and (4) a $6,418,400 bond program in 2012. These bond programs included funding for activities associated with O&M activities within the Dallas Floodway and DFE Project areas; interior drainage studies and improvements to sumps and pump stations within the Dallas Floodway; cost shared study funds for the Dallas Floodway Feasibility Report; cost share construction funds for elements of the DFE Project; and implementation funds for some elements of the BVP.

Significance based on technical recognition means that the importance of an environmental resource is based on scientific or technical knowledge or judgment of critical resource characteristics. Restoration projects should be related to environmental resources that are considered significant within an identified watershed or larger context. The following describes how the River Relocation and the Corinth Wetlands meets the technical recognition criteria for significance.

- It has been well documented that nationally large, functioning river ecosystems are listed as endangered (Noss *et al.* 1995) with an 85-90% decline since European settlement. This is also true within the State of Texas (Texas Parks and Wildlife Magazine 2004). The River Relocation

and the Corinth Wetlands would restore to the extent possible, natural structure, function, and dynamic processes for a better performing river ecosystem. Aquatic riverine habitat outputs shows a 124.95 and 120.69 AAHUs increase, respectively for the MDFP and MDFP (cumulative) project over future without-project conditions directly as a result of restoration of meanders in the Trinity River Mainstem using fluvial geomorphologic principles. For emergent wetlands, the AAHUs increase by 8.92 and 11.42 AAHUs, respectively for the MDFP and MDFP (cumulative) conditions over future without-project conditions. A majority of this increase is a direct result of the creation and maintenance of higher quality wetlands, especially in the Corinth Wetland area of the MDFP. When combined with the Corinth Wetlands, and other wetland projects, the channel realignment design will significantly improve floodplain habitat and connectivity.

- The River Relocation and the Corinth Wetlands would restore bottomland hardwood habitat, which is a declining resource in the state of Texas. Within Texas, it is estimated that more than 60% of the historical bottomland hardwoods and bottomland-forested wetlands have been lost due to reservoir construction and operation, agricultural conversion, timber production, channelization and urban and industrial development (Texas Center for Policy Studies 1995). The River Relocation and the Corinth Wetlands includes construction of bottomland hardwood habitat, a resource that has been declining in the area due to previously constructed large flood control projects and reservoir systems. Bottomland Hardwood habitat shows a gain of 4.81 AAHUs for the MDFP and a lesser gain of 2.20 AAHUs for the MDFP (cumulative) conditions. Again, this doesn't seem like much gain, but the reason is due to the establishment and maturation process of bottomland hardwood species. If a longer period of analysis were used, to be reflective of the actual time that it takes bottomland hardwoods to reach maturity and maximize their habitat value, and AAHU values would show a much larger AAHU gain.

3.6.2 Tentatively Selected Plan – Ecosystem Restoration

Major BVP environmental restoration and management features that align with the overall National Ecosystem Restoration Objective by increasing the net quantity and/or quality of desired ecosystem resources and that align with National Significance are considered for inclusion in the Recommended Plan for the MDFP. The River Relocation and the Corinth Wetlands result in an increase in net quality and quantity of desire riverine ecosystem outputs. The River Relocation and Corinth Wetlands have positive outputs of desired habitat types of bottomland hardwood, emergent wetland, and aquatic riverine. The River Relocation and Corinth Wetlands contribute to the planning objective developed for ecosystem restoration. Together they increase habitat quality by approximately 139 AAHU in the project area for the desired habitat types over the 50-year period of analysis. In addition to improvements to habitat in the study area, the River Relocation and the Corinth Wetlands align with Corps policies for ecosystem restoration, and their outputs align with National and Regional Significance as described in the previous section.

It is important to note, the River Relocation is also required to implement several of the BVP features, and supports the recreation objective for the City of Dallas. The River Relocation presents the greatest risk to the functioning of the levee system due to the potential to increase seepage under the levees, which could result in levee safety risk. This risk is mitigated with the installation of cut-off walls, but it still presents engineering challenges and it is recommended the design for this feature be completed by the Corps. For these reasons combined with the contributions to the Corps objective for ecosystem restoration, the River Relocation and the Corinth Wetlands are included in the MDFP.

3.7 PLAN FORMULATION SUMMARY

Tables 3-31 to 3-33 are screening matrices that summarize the plan formulation results and how the items recommended in the MDFP contribute to the planning objectives. Based on the plan formulation and measuring the BVP and IDP features and their contributions to the planning objectives during the plan formulation process, the Corps identified the following features for potential inclusion for the recommended MDFP. They are listed here as a combination of the Tentatively Selected Plans from each formulation section including the Trinity River flooding, interior drainage flooding and the ecosystem restoration. Collectively, these plans produced a Recommended Plan for the MDFP; however, the plans required additional screening as described in Section 3.8.

- NED Plan (the 277,000 levee raise with AT&SF Railroad Bridge modification and EAP improvements);
- Levee Side Slope Flattening to 4H:1V (Betterment 100% locally funded);
- the IDP Phase I (Able, Baker, and Hampton Pump Stations, and the Nobles Branch sump improvements);
- the IDP Phase II (Charlie, Pavaho, Delta, and New Trinity Portland Pump Stations);
- River Relocation; and
- Corinth Wetlands.

The project features identified above are estimated to cost $713,500,000. This cost exceeds the Section 902 of WRDA 1986 cost limit for Section 5141 of WRDA 2007. Therefore, there were two options for moving forward. The Corps could recommend the project to Congress for additional authorization or formulate a project that still meets the objectives of the study and stays within the Section 902 cost limit. The Corps, in coordination with the City of Dallas, decided to identify a project that is within the Section 5141 cost limit; therefore additional screening was required as described in Section 3.8.

3.7.1 Consideration of Recreation and other items in the BVP

The BVP includes several recreational features which are above and beyond what the Corps would generally participate. These features include the West Dallas and Urban Lakes, flex fields, and associated recreational facilities such as restrooms, parking lots, roads, trails, amphitheaters, etc. The Corps traditionally participates in more low impact (passive) recreation as part of a FRM project unless it is associated with a reservoir project. Therefore, the Corps is not including recommendations for any recreation features in the MDFP. However, these recreation features were included in the Comprehensive Analysis, along with the Natural Lake, as remaining BVP features. The City of Dallas has submitted a Section 408 request to construct these features.

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Table 3-31. Decision Matrix for the Modified Dallas Floodway Project for Objective 1

Category	*Description*	*Modified Dallas Floodway Project*	*Notes*	***FRM – Trinity River Flooding***					
				Decision Criteria 1- Net benefits ($000)	*Decision Criteria 2 – Incremental % Reduction in Loss-of-Life Estimates (East Levee/West Levee)*		*Decision Criteria 3 – CSSL ($000)*	*Decision Criteria 4 – Net Present Value*	*Decision Criteria 5 – Qualitative Purposes*	*Contribution to Objective 1*
Structural										
Individual Measures as Alternatives										
AT&SF	Removal of Wood Bridge Segment	✓	Justified as first-added increment	$607						
	Removal of Concrete Bridge Segment									
	Removal of Embankment Segments									
Levees	Raise to 260,000 cfs Flood Height (3H:1V side slopes)		Raising the low spots on the East and West Levee with earthen fill	$340	-52.0%	-18.9%	-			• Residual risk is reduced from $5,551,000 to $3,817,000. Flood reduction benefits over a 50-year period are $1,236,000 • Estimated reduction in probability and Loss-of-Life is over 50% for both the East and West Levees • Annualized life-safety risk is efficiently reduced • City of Dallas betterment of 4H:1V addresses residual risk for levee side slope failures; mowing safety; and efficiencies during construction • EAP Improvements reduce life-safety risk
Levees	Raise to 265,000 cfs Flood Height (3H:1V side slopes)			$726	-	-				
Levees	Raise to 269,000 cfs Flood Height (3H:1V side slopes)			$989	-	-				
Levee	Raise to 273,000 cfs Flood Height (3H:1V side slopes)			$981	-	-				
Levees	Raise to 277,000 cfs Flood Height (3H:1V side slopes)	✓		$1,179	-30.9%	-49.7%	$920	N/A	N/A	
Levees	Raise to 289,000 cfs Flood Height (3H:1V side slopes)			$1,129	-	-				
Levees	Raise to 302,000 cfs Flood Height (3H:1V side slopes)			N/A	-28.7%	-23.9%	-			
Levees	Raise to 260,000 cfs Flood Height (4H:1V side slopes)			$319	-	-				
Levees	Raise to 265,000 cfs Flood Height (4H:1V side slopes)			$697	-	-				
Levees	Raise to 269,000 cfs Flood Height (4H:1V side slopes)			$881	-	-				
Levees	Raise to 273,000 cfs Flood Height (4H:1V side slopes)			$675	-	-				
Levees	Raise to 277,000 cfs Flood Height (4H:1V side slopes)	✓		$523	N/A	N/A	N/A	Not economically advantageous over fix-as-fails (almost 2:1)	• Levee Slope Failure Remains a Performance issues with the City of Dallas • Mowing Safety • Efficiencies During Construction • City of Dallas Betterment at 100% local cost	

Category	*Description*	*Modified Dallas Floodway Project*	*Notes*	***FRM – Trinity River Flooding***						
				Decision Criteria 1- Net benefits ($000)	*Decision Criteria 2 – Incremental % Reduction in Loss-of-Life Estimates (East Levee/West Levee)*		*Decision Criteria 3 – CSSL ($000)*	*Decision Criteria 4 – Net Present Value*	*Decision Criteria 5 – Qualitative Purposes*	*Contribution to Objective 1 – con't*
Levees	Raise to 289,000 cfs Flood Height (4H:1V side slopes)		Raising the low spots on the East and West Levee with earthen fill	N/A	-	-				• Residual risk is reduced from $5,551,000 to $3,817,000. Flood reduction benefits over a 50-year period are $1,236,000 • Estimated reduction in probability and Loss-of-Life is over 50% for both the East and West Levees • Annualized life-safety risk is efficiently reduced • City of Dallas betterment of 4H:1V addresses residual risk for levee side slope failures; mowing safety; and efficiencies during construction • EAP Improvements reduce life-safety risk
Levees	Armoring to 255,000 cfs Flood Height		Armor the low spots with Articulating Concrete Block	$215	-	-				
Levees	Armoring to 260,000 cfs Flood Height			$428	-46.9%	-18.9%	$1,500	-		
Levees	Armoring to 265,000 cfs Flood Height			$474	-	-				
Levees	Armoring to 269,000 cfs Flood Height			($585)	-	-				
Levees	Armoring to 273,000 cfs Flood Height			($1,295)	-	-				
Levees	Armoring to 277,000 cfs Flood Height			(1,451)	-0.1%	-37.4%	-			
Levees	Armoring to 289,000 cfs Flood Height			($6,121)	-	-				
Levees	Armoring to 302,000 cfs Flood Height			($8,475)	-70.2%	-66.5%	$31,700	-		
Levees	Seepage Cut-off Walls			($1,043)	-93.2%	N/A	>1,000,000	-		
Combined Measures as Alternatives for Life Safety Considerations										
Levees	NED Plan + Controlled Overtopping			N/A	N/A		>$1,500	-		
Levees	NED Plan + Cut-off Walls			$145			>1,000,000	-		
Non-Structural										
EAP	Floodplain Inundation Maps	✓		N/A	Not measurable		N/A	N/A	High Risk Areas targeted first to improve evacuation	
Rockefeller Boulevard	Permanent Localized Buyout (500-year floodplain)			($26.7)	-					

Note: "-" indicates the measure/alternative was eliminated and didn't continue to be evaluated for the decision criteria.

Table 3-32. Decision Matrix for the Modified Dallas Floodway Project for Objective 2

Category	*Description*	*Modified Dallas Floodway Project*	***FRM – Interior Drainage Flooding***				
			Eliminated in Initial Screening (Reasons for Elimination: High Cost [C], Adverse Social Impacts [S], Technical Viability [T])	*Eliminated in Second Screening (Reasons for Elimination: High Cost [C], Adverse Social Impacts [S], Technical Viability [T])*	*Decision Criteria 6 – Reduce number of structures affected by the 100-year, 24-hour storm event*	*Decision Criteria 7 - Qualitative safety concerns with the East and West Levee Interior Drainage System.*	*Contribution to Objective 2*
Structural/Non-Structural Measures							
Interior Drainage	Remove Structures in the Floodplain (Non-Structural)		C,S	-			
Interior Drainage	Increase Sump Storage Capacity		C,S	-			
Interior Drainage	Alter Sump Inflow Hydrographs (Detention)		C,S	-			
Interior Drainage	Increase Pumping Capacity		Carried Forward, see Alternatives Considered in IDP				
Interior Drainage	Construct New Pressure Sewers		T	-			
Interior Drainage	Improve Conveyance between Sump Ponds		Carried Forward, see Alternatives Considered in IDP				
Interior Drainage	Gravity Sluice Options		Carried Forward, see Alternatives Considered in IDP				
Alternatives Considered in the IDP							
East Levee Interior Drainage System							
HB-1	• Construct New 500,000-gpm Pump Station and Outfall • Rehabilitate Existing Pump Stations • Install Three, 60-inch Culverts beneath Empire Central Drive (Nobles Branch Sump) • Demolish the Old Hampton Pump Station	✓		Carried Forward Decision Criteria 6	48%	N/A	• Overall 83% Reduction in structures affected behind the East Levee
BB-1	• Construct New 700,000-gpm Pump Station and Outfall (Baker No. 3 Pump Station) • Minor Improvements to the Existing Baker Pump Station • Minor Improvements to the Hampton-Oak Lawn Sump	✓		Carried Forward Decision Criteria 6	96%	N/A	
AB-1	• Construct New 876,000-gpm Pump Station and Outfall (Able No. 3 Pump Station)	✓		Carried Forward Decision Criteria 6	100%	N/A	
West Levee Interior Drainage System							
DB-1A	• Demolish Existing Delta Pump Station • Construct New 250,000-gpm Pump Station at Delta • Install Two, 10-foot by 6-foot Culverts under Westmoreland Avenue • Install One, 6-foot by 4-foot Culvert at the Ledbetter Dike Control Structure			T	-		

Category	*Description*	*Modified Dallas Floodway Project*	***FRM – Interior Drainage Flooding***				
			Eliminated in Initial Screening (Reasons for Elimination: High Cost [C], Adverse Social Impacts [S], Technical Viability [T])	*Eliminated in Second Screening (Reasons for Elimination: High Cost [C], Adverse Social Impacts [S], Technical Viability [T])*	*Decision Criteria 6 – Reduce number of structures affected by the 100-year, 24-hour storm event*	*Decision Criteria 7 - Qualitative safety concerns with the East and West Levee Interior Drainage System.*	*Contribution to Objective 2*
DB-1B	• Rehabilitate Existing Delta Pump Station • Construct New 166,000-gpm Pump Station at Delta • Install Two, 10-foot by 6-foot Culverts under Westmoreland Avenue • Install One, 6-foot by 4-foot Culvert at the Ledbetter Dike Control Structure			T	-		•
DB-2	• Construct New 150,000-gpm Pump Station in Trinity-Portland Sump			T	-		
DB-3	• Demolish Existing Delta Pump Station • Construct New 400,000-gpm Pump Station at Delta • Install One, 6-square foot Culvert between Trinity-Portland and Eagle Ford Sumps • Install Three, 10-foot by 6-foot Culverts under Westmoreland Avenue • Install One, 6-foot by 4-foot Culvert at the Ledbetter Dike Control Structure			T	-		
DB-4	• Construct New 250,000-gpm Pump Station in Trinity-Portland Sump • Rehabilitate Existing Delta Pump Station Install One, 6-square foot Culvert between Trinity-Portland and Eagle Ford Sumps	✓		Carried Forward Decision Criteria 6	50%	N/A	
PB-1	• Demolish Existing Pavaho Pump Station Construct New 500,000-gpm Pump Station at Pavaho			T	-		
PB-2	• Demolish Existing Pavaho Pump Station • Construct New 375,000-gpm Pump Station at Pavaho • Install Two, 10-foot by 6-foot Culverts under Sylvan Avenue • Install One, 10-foot by 8-foot Culvert under Canada Drive			T	-		• Overall 92% Reduction in structures affected behind the West Levee
PB-3	• Perform Minor Improvements to the Existing Pavaho Pump Station • Construct New 381,000-gpm Pump Station at Pavaho	✓		Carried Forward Decision Criteria 6	98%	N/A	
EF-1	• Add Seven, 4.5-square foot Gravity Sluices Adjacent to Existing Gravity Sluices			T	-		
EF-2	• Demolish Existing Gravity Sluices • Install Two, 10-square foot Gravity Sluices			T	-		
EF-3	• Add One, 10-foot by 12-foot Gravity Sluice Adjacent to Existing Gravity Sluices			T	-		
EF-4	• Retain Existing Gravity Sluices • Construct New 100,000-gpm Pumping Plant			T	-		
EF-5	• Demolish Existing Gravity Sluices • Construct New 150,000-gpm Pumping Plant			T	-		

Category	*Description*	*Modified Dallas Floodway Project*	***FRM – Interior Drainage Flooding***				
			Eliminated in Initial Screening (Reasons for Elimination: High Cost [C], Adverse Social Impacts [S], Technical Viability [T])	*Eliminated in Second Screening (Reasons for Elimination: High Cost [C], Adverse Social Impacts [S], Technical Viability [T])*	*Decision Criteria 6 – Reduce number of structures affected by the 100-year, 24-hour storm event*	*Decision Criteria 7 - Qualitative safety concerns with the East and West Levee Interior Drainage System.*	*Contribution to Objective 2*
CB-1	• Rehabilitate Existing Charlie Pump Station • Install Two, 10-square foot Gravity Sluices through the West Levee			T	-		
CB-2A	• Demolish Existing Charlie Pump Station • Construct New 225,000-gpm Pump Station	✓		Carried Forward Decision Criteria 6	0%	Charlie Pump Station itself is susceptible to stormwater flooding from the 100-year, 24-hour event, and a new pumping station at a slightly higher elevation is recommended	
CB-2B	• Rehabilitate Existing Charlie Pump Station • Construct New 145,000-gpm Pump Station adjacent to Charlie Pump Station			T	-		

Notes: HB = Hampton Basin, BB = Baker Basin, AB = Able Basin, DB = Delta Basin, PB = Pavaho Basin, CB = Charlie Basin, PB-3, AB-1, and BB-1 were analyzed in EAs prepared under Section 408; "-" indicates the measure/alternative was eliminated and didn't continue to be evaluated for the decision criteria.
Sources: City of Dallas 2006, 2009.

Table 3-33. Decision Matrix for the Modified Dallas Floodway Project for Objective 3

Category	*Description*	*Modified Dallas Floodway Project*	*Notes*	*Initial Screening*	*Decision Criteria 8 – Net Increase in quantity and/or quality of desired ecosystem resources*	*Contribution to Objective 3*
Major BVP Feature						
Environmental Feature	River Relocation	✓	8-miles of Trinity River within the Floodway modified for habitat improvements features		Aquatic riverine habitat outputs show approximately 124.95 and 120.69 AAHU increase, respectively for the MDFP and MDFP (cumulative) project over without-project conditions directly because of restoration of meanders in the Trinity River. Bottomland hardwood habitat shows a gain of 4.81 AAHUs for the MDFP and a lesser gain of 2.20 AAHUs for the MDFP (cumulative) conditions. This does not seem like much gain, but the reason is due to the establishment and maturation process of bottomland hardwood species. If a longer period of analysis were used, to be reflective of the actual time that it takes bottomland hardwoods to reach maturity and maximize their habitat value, and AAHU values would show a much larger AAHU gain. When combined with the Corinth Wetlands, and other wetland projects, the channel realignment design will significantly improve floodplain habitat and connectivity.	The River Relocation and the Corinth Wetlands together increase habitat quality by approximately 139 AAHU (under MDFP alone) in the project area for the desired habitat types (bottomland hardwood, emergent wetland, and aquatic riverine) over the 50-year period of analysis. In addition to improvements to habitat in the study area, the River Relocation and the Corinth Wetlands align with Corps policies for ecosystem restoration, and their outputs align with National and Regional Significance as described in the main report.
Environmental Feature	Corinth Wetlands	✓	Approximately 85 acres of wetland creation adjacent to the modified River in the Floodway (SE segment)		For emergent wetlands, the AAHUs increase by 8.92 and 11.42 AAHUs, respectively for the MDFP and MDFP (cumulative) conditions over future without-project conditions. A majority of this increase is a direct result of the creation and maintenance of higher quality wetlands, especially in the Corinth Wetland area of the MDFP.	
Environmental Feature	Natural Lake		Approximately 57-acre Lake with wetland features	The overlap with Trinity Parkway as a borrow source renders this difficult to implement for them as a single and complete project. It is also in close proximity to recreation features.	-	
Environmental Feature	Other Wetlands in the BVP		Various wetlands throughout the Floodway	Potential for including these in the ecosystem restoration component is possible, but only in the grading of major features; they are too close in proximity to recreation features to consider for ecosystem restoration.	-	

Note: "-" indicates the measure/alternative was eliminated and didn't continue to be evaluated for the decision criteria.

3.8 ADDITIONAL SCREENING FOR THE MODIFIED DALLAS FLOODWAY PROJECT

Early in the study process it was found that the BVP and IDP had experienced significant cost growth since the authorization. The project was authorized in 2007 at $459,000,000 and the current cost estimate for the entire BVP and IDP (including original BVP FRM features) is estimated at $1,400,000,000. There are multiple reasons for these cost growths. These include: (1) the project was authorized based on the City of Dallas' conceptual design prior to a feasibility report being completed so the cost estimates were not developed utilizing Corps standards; (2) inflation from 2003 to 2007 was not accounted for in the WRDA 2007 authorization; and (3) additional feasibility design confirmed major increases in most project features.

Through the formulation process of identifying the NED Plan for FRM and eliminating recreation from consideration from cost share, the cost shareable total of the BVP and IDP was brought down to $713,500,000. These cost shareable features were found technically sound and environmentally acceptable and within Corps traditional mission areas (cost shareable) as described above in the formulation sections. The authorized project cost of $459,000,000 brought up to current price levels is $521,170,000. The cost estimate of $713,500,000 is well over this price for all of the features that are technically sound and environmentally acceptable. In accordance with guidance provided in the memorandum entitled "Civil Works Delegated Authority for Project Cost Management," dated May 29, 2013, the Corps and the City of Dallas decided to descope Corps participation in the project to fit within the existing 902 limit.

In accordance with the Section 5141 and the IG, the City of Dallas had the ability to advance features of the project prior to execution of the PPA. The City of Dallas decided to request and receive approval through the Section 408 process to construct Able, Baker and Pavaho Pump Stations to address immediate interior drainage flooding concerns. Pavaho is currently operational and Baker and Able are under construction. The City of Dallas determined it would rather stay within the Section 902 limit and not request credit for the pump stations they are currently constructing, thus removing them from the total project cost. Removing Pavaho ($32,500,000) and Able ($120,200,000) Pump Stations from the MDFP makes the total cost shareable project $560,839,000. While this is over $521,170,000, it was within the Section 902 limit of the project and still considered technically sound and environmentally acceptable.

Table 3-34 presents the revised annualized habitat units in the study area between existing conditions, future without-project conditions, and the MDFP and the MDFP (with cumulative projects) over the 50-year period of analysis to account for the removal of Pavaho and Able from the MDFP in the additional screening process. Bottomland hardwood habitat shows a gain of 3.19 AAHUs for the MDFP and a lesser gain of 1.54 AAHUs for the MDFP (cumulative) conditions. For emergent wetlands, the AAHUs would increase by 11.04 and 13.54 AAHUs, respectively for the MDFP and MDFP (cumulative) conditions over future without-project conditions. Aquatic riverine shows a 128.94 and 124.21 AAHU increase, respectively for the MDFP and MDFP (cumulative) conditions over future without-project conditions. There is a little increase in open water AAHUs (0.01 AAHUs) over future without-project conditions for both the MDFP and MDFP (cumulative) conditions.

In summary, the River Relocation and Corinth Wetlands still result in a lift of functional habitat units over the period of analysis compared to future without-project conditions. The increase in habitat quality is approximately 143 AAHUs under MDFP alone and 139 under MDFP (cumulative) conditions for the desired habitat types over the 50-year period of analysis. The River Relocation and the Corinth Wetlands also still align with Corps policies for ecosystem restoration, and their outputs align with National and Regional Significance as described in Section 3.6.1.1. There was a small reduction in AAHU for the bottomland hardwood habitat type for the MDFP and MDFP cumulative with revised MDFP; however, there is still a positive gain in AAHU for bottomland hardwood habitat.

Table 3-34. Estimated Changes to Average Annual Habitat Units within the Study Area under the Recommended Modified Dallas Floodway Project

Habitat Type	*Average Annual Habitat Units*				
	Future Without-Project Conditions	*MDFP*	*Change*[1]	*MDFP (Cumulative)*	*Change*[1]
Bottomland Hardwood	273.35	276.54	3.19	274.89	1.54
Emergent Wetland	68.02	79.06	11.04	81.56	13.54
Grassland	1,559.56	1,299.86	-259.7	1,249.40	-310.16
Aquatic Riverine	235.61	364.55	128.94	359.82	124.21
Open Water	96.92	96.93	0.01	96.93	0.01
Total	**2,233.46**	**2,116.94**	**-116.52**	**2,062.6**	**-170.86**

Note: [1] "Change" refers to the difference between the MDFP alone and under cumulative conditions at year 50 as compared to the future without-project condition at year 50.

3.9 THE RECOMMENDED PLAN FOR THE MODIFIED DALLAS FLOODWAY PROJECT

The Recommended Plan for the MDFP includes the NED Plan (the 277,000 levee raise with AT&SF Railroad Bridge modification and EAP improvements), levee side slope flattening to 4H:1V, the IDP Phase I (Hampton, and Baker Pump Stations, and the Nobles Branch sump improvements), the IDP Phase II (Charlie, Delta and New Trinity Portland), the proposed River Relocation, and the Corinth Wetlands. The Able and Pavaho IDP features were processed under Section 408 in advance of completion of this feasibility report, and the City of Dallas does not wish to pursue credit for these features. Section 4013 of the WRRDA of 2014 (Public Law 113-121), provides a technical correction to Section 5141(a)(2) of the WRDA 2007. Section 5141 was amended by inserting "and the Interior Levee Drainage Study Phase-II report, Dallas, Texas, dated January 2009," after "September 2006." Thus, the WRRDA authorization adds the West Levee IDP to the Section 5141 of WRDA 2007 authorization. The plan formulation process of the MDFP is summarized in Tables 3-31 through 3-33. Table 3-35 summarizes how the features in the Recommended Plan meet the Corps planning objectives.

Table 3-35. Modified Dallas Floodway Project Recommended Plan and Alignment with Corps Planning Objectives

Objective 1	*Recommended Plan Feature*	*Contribution*
Ensure the reliability and integrity of the current infrastructure and improve the functioning to further reduce residual flood risk to property while promoting life safety for the Dallas Floodway Project over a 50-year period of analysis.	NED Plan (the 277,000 levee raise with AT&SF Railroad Bridge modification and EAP improvements).	Residual risk is reduced from $5,551,000 to $3,817,000. Flood reduction benefits over a 50-year period are $1,236,000. Estimated reduction in probability and Loss-of-Life is over 50% for both the East and West Levees. Annualized life-safety risk is efficiently reduced.
	EAP Improvements (Flood Inundation Maps).	The high risk areas are areas that flood first, deepest and have residents with special needs. Emergency action personnel would target these structures first.
	Levee Side Slope Flattening to 4H:1V.	The present method of maintenance is more economical; however, considering mowing hazards, and construction efficiencies, the 4H:1V side slopes are being pursued by the City of Dallas as a betterment.
Objective 2	*Recommended Plan Feature*	*Contribution*
Reduce the risk of flooding due to interior drainage.	East Levee IDP Phase I	The IDP would result in an 83% reduction in potentially flooded structures behind the East Levee in the predicted 100-year, 24-hour storm event.
	West Levee IDP Phase II	The IDP would result in a 92% reduction of potentially affected structures behind the West Levee in the predicted 100-year, 24-hour storm event.
Objective 3	*Recommended Plan Feature*	*Contribution*
Restore to the extent possible the aquatic and riparian ecosystem of the Trinity River within the boundaries of the Dallas Floodway Project over a 50-year period of analysis.	River Relocation and Corinth Wetlands	The River Relocation and Corinth Wetlands increases habitat quality by approximately 143 AAHUs in the project area for the desired habitat types over the 50-year period of analysis.

The BVP and IDP have several features that are not part of the Recommended Plan for implementation under Section 5141 of WRDA 2007, but can be constructed through the Section 408 permit process under the Rivers and Harbors Appropriation Act of 1899, as amended. The City of Dallas will be responsible for the construction of remaining features of the BVP and IDP and their associated cost. The City of Dallas will provide separate Section 408 approval submittals for Corps review that can reference the Comprehensive Analysis evaluation presented in this feasibility report. Table 3-36 presents the features of the City of Dallas' BVP and IDP and the MDFP recommended under Section 5141 of WRDA 2007, as amended.

Table 3-36. BVP and IDP and the Modified Dallas Floodway Project

Category	*Description*	*WRDA*[1]	*Alternative 2*	
			MDFP	*BVP/IDP*[2]
BVP Flood Risk Management				
Levees	Raise to 277,000 cfs Flood Height	✓	✓	
AT&SF	Removal of Wood Bridge Segment	✓	✓	
	Removal of Concrete Bridge Segment	✓	✓	
	Removal of Embankment Segments	✓	✓	
Levee Flattening	Flattening the Riverside Levee Side Slopes to 4H:1V[3]	✓	✓	
Cut-off Wall	Extend Cut-off Wall along the East Levee[4]	✓	✓	
Nonstructural	Emergency Action Plan Improvements	✓	✓	
	Install piezometers in the Floodway[4]	✓	✓	
BVP Ecosystem and Recreation				
Lakes	West Dallas Lake	✓		✓
	Urban Lake	✓		✓
	Natural Lake	✓		✓
River	Realignment and Modification	✓	✓	
Wetlands	Marshlands	✓		✓
	Corinth Wetlands	✓	✓	
Athletic Facilities	Potential Flex Fields	✓		✓
	Playgrounds	✓		✓
	River Access Points	✓		✓
General Features	Parking and Public Roads	✓		✓
	Lighting	✓		✓
	Vehicular Access	✓		✓
	Pedestrian Amenities	✓		✓
	Forested Ponds	✓		✓
	Restrooms	✓		✓
Interior Drainage Outfall Extensions	Extend Pump Station Outfalls	✓	✓	
	Extend Pressure Sewer Outfalls	✓	✓	
Able Sump Ponds	Recreation and Ecosystem Enhancements	✓		✓

Category	*Description*	*WRDA*[1]	*Alternative 2*	
			MDFP	*BVP/IDP*[2]
IDP Flood Risk Management				
East Levee	Demolish Old Hampton Pump Station	✓	✓	
	Construct New Hampton Pump Station	✓	✓	
	Nobles Branch Sump Improvements	✓	✓	
	Construct New Baker Pump Station	✓	✓[5]	
	Construct New Able Pump Station[6]	✓		
West Levee	Demolish Old Charlie Pump Station	✓	✓	
	Construct New Charlie Pump Station	✓	✓	
	Rehabilitate Existing Delta Pump Station	✓	✓	
	Construct New Trinity-Portland Pumping Plant	✓	✓	
	Construct New Pavaho Pump Station[6]	✓		
	Eagle Ford and Trinity-Portland Sump Improvements	✓		✓
	Pavaho and Delta Sump Improvements	✓		✓

Notes: [1] Includes Section 5141 of the WRDA 2007, as amended by WRRDA of 2014.
[2] Remaining non-Federal BVP elements to be completed by the City of Dallas under a future Section 408 submittal.
[3] Included in the MDFP, and entirely paid for by the City of Dallas as a betterment.
[4] Included in the MDFP as a risk mitigation feature of the River Relocation.
[5] The Baker Pump Station is part of the MDFP but was analyzed for NEPA compliance separately (Corps 2012).
[6] Able and Pavaho are not part of the MDFP and were processed under Section 408.

3.10 TECHNICALLY SOUND AND ENVIRONMENTALLY ACCEPTABLE

The features that met the objectives were considered technically sound and could be considered for the Recommended Plan for the MDFP from an engineering perspective. Other criteria for technically sound included adequate feasibility-level engineering and design, including a risk analysis. The design completed for the MDFP during this phase is considered technically sound for the current stage of the projects and will provide a sound basis for future development of detailed design during the PED phase. This determination is based on the fact that the MDFP meets the objectives of the study. The key objectives in this determination are Objectives 1, 2 and 3.

The first objective of the study was to ensure the reliability and integrity of the current infrastructure and to further reduce residual flood risk to property. While there would be slight increases in water surface elevations downstream, it was determined that these impacts are insignificant and the project is acceptable from a hydrologic and hydraulic perspective. Furthermore, through the risk assessment process it was determined that the MDFP did not impact the geotechnical conditions of the Floodway, but instead would have beneficial impacts by further reducing the risk of failure to the levee system from seepage. Finally, the MDFP will function with other proposed features within the Floodway footprint. Because the proposed MDFP would improve the functioning of the Floodway by further reducing flood risk and property damage when the levees are raised and the AT&SF Railroad Bridge is modified, it is considered technically sound under Objective 1.

The second objective of the study was to reduce the risk of flooding from interior drainage. The MDFP proposes improvements to Hampton, Baker, Delta, and Charlie Pump Stations and construction of the new Trinity Portland Pump Station to reduce the risk of flooding from interior drainage. By reducing the number of structures affected by the 1% flood event, the MDFP meets Objective 2. In addition, the IDP

components do not impact the functioning of the Floodway from a hydrologic and hydraulic or geotechnical perspective and will function with other project components. Therefore, the MDFP is considered technically sound when considering Objective 2.

The third objective of the study was to restore the degraded aquatic and riparian ecosystem within the Dallas Floodway study area. The MDFP restores the aquatic and riparian ecosystems of the Trinity River and the adjacent floodplain. At the same time, due to mitigation measures such as cutoff walls, the MDFP improves the functioning of the Floodway from a geotechnical perspective. As part of the larger Comprehensive Analysis it does not affect the hydrology and hydraulics and it functions with other proposed projects within the Floodway. Therefore, the MDFP is considered technically sound when considering Objective 3.

Making feasibility-level technically sound determinations of multiple projects in various stages of design and construction carries with it some level of risk. The key risks identified in the Comprehensive Analysis are related to designs provided for the River Relocation, the BVP Lakes and grading plans, bridge pier modifications, earthen berms separating the River Relocation and the BVP Lakes, the clay liner and lake drainage system associated with the BVP Lakes, River Relocation erosion control, and the Trinity Parkway Geotechnical Report. The risks are related to ensuring levee system integrity, level of design detail and integration of multiple projects across the Floodway. Risks were determined manageable at this stage given continued coordination and integration of design throughout the PED phase.

The proposed MDFP is environmentally acceptable at this point in the planning process. The final determination on environmentally acceptable will be made when the ROD is finalized.

3.11 COMPREHENSIVE ANALYSIS

Following the identification of the MDFP, the Corps performed the Comprehensive Analysis. Overall, the goal of the Comprehensive Analysis was to ensure the projects affecting the MDFP met Corps engineering and safety standards. The criteria for the Comprehensive Analysis are listed in Table 3-37. The objective and the decision criteria were developed to achieve the overall goal and allow for other local and Federal entities to submit their Section 408 submittal packages for Corps approval once the Comprehensive Analysis was complete. While this was not considered a Section 408 review, it will be helpful for reviewing future Section 408 packages that are submitted for review. The Comprehensive Analysis modeled features collectively and not on an individual basis. Projects were analyzed at an individual level under the Corps Section 408 review process.

Table 3-37. Water Related Objectives and Decision Criteria

<table>
<tr><th>Objective 4</th><th>Measurement 8</th><th>Decision Criteria 9</th></tr>
<tr><td rowspan="3">Ensure local projects do not impact the functioning or integrity of the Dallas Floodway System.</td><td>Local features were reviewed against Corps engineering and safety standards and for compatibility with the MDFP with the primary purpose of FRM.</td><td rowspan="3">Upon completion of the Comprehensive Analysis, local interests were provided input and allowed to submit a Section 408 package for review. However, this should not be construed as Section 408 approval under Policy and Procedural Guidance for 33 U.S. Code 408.</td></tr>
<tr><td>Measurement 8a</td></tr>
<tr><td>Engineering and safety standards for the review include:
Hydraulic neutrality (ROD criteria);
Compliance with Engineer Regulations, Manuals and Technical Letters;
No increase in risk through a risk analysis; and
Completion of the EIS for the entire BVP and IDP.</td></tr>
</table>

3.11.1 Trinity Parkway & Other Local Features

The Trinity Parkway is a proposed 9-mile toll road that would extend from the State Highway (SH) 183/IH-35E juncture to US-175/Spur 310. Several route alternatives are currently being evaluated as part of the Federal Highway Administration (FHWA) NEPA process (a separate and stand-alone EIS). The FHWA is the lead Federal agency for the Trinity Parkway EIS, with the Texas Department of Transportation and the North Texas Tollway Authority (NTTA) as joint lead agencies. The Trinity Parkway would be a tolled route around downtown Dallas, and would assist in managing traffic congestions on IH-30 and IH-35E. As this project has the potential to affect the form and function of the Dallas Floodway Project, the Corps was a cooperating agency in the development of the FHWA Trinity Parkway EIS. The Corps intends to cooperate with the FHWA in considering the FHWA-preferred Trinity Parkway alignment alternative in the Comprehensive Analysis to determine if together they would be hydraulically, geotechnically, and structurally compatible with the MDFP and the other local features.

The other local features evaluated in the Comprehensive Analysis include the Trinity River Standing Wave, Santa Fe Trestle Trail, Pavaho Wetlands, Dallas Horseshoe Project, Sylvan Avenue Bridge, Jefferson Bridge, Dallas Water Utilities Waterlines, Continental Bridge, and the East Bank/West Bank Interceptor Line. Some projects have received “approval” under Section 408 and are in various stages of design and construction. Table 3-38 presents the status of the ongoing Section 408 reviews.

Table 3-38. Local Features Included in the Comprehensive Analysis

Ongoing Section 408 Project Status			
Figure F-2 Key[1]	**Project Name**	**Section 408 Approval Received**	**Section 408 Undergoing Evaluation**
7	Margaret Hunt Hill Bridge	X	
10	Pavaho Pumping Plant	X	
12	Santa Fe Trestle Trail	X	
13	Sylvan Bridge	X	
17	Trinity River Standing Wave (Dallas Wave)	X	
A	Baker Pumping Plant	X[2]	
D	Continental Pedestrian Bridge	X	
F	EF2 Wastewater Interceptor Line and Laterals (Tunnel 1)	X	
	EF2 Wastewater Interceptor Line and Laterals (Tunnel 2)	X	
G	Horseshoe Project (IH-30, IH-35)	X	
J	Jefferson-Memorial Bridge		X
O	Pavaho Wetlands	X	
R	SH-183 Bridge	X	
U	Trinity Parkway		X[2]
V	Able Pumping Plant	X	
	Remaining BVP Features		X[2]

Notes: [1] Adapted from the Environmental Impact Statement Cumulative Projects list for consistency. [2] Requires Corps HQ level approval; the Section 408 for Trinity Parkway and Remaining BVP Features are currently under evaluation at the District.

3.11.2 Dallas Floodway Project EIS

In accordance with the NEPA of 1969, and EIS was prepared for the entire BVP and IDP (including the features in the MDFP). The EIS describes the potential comprehensive environmental consequences resulting from the application of proposed FRM elements, ecosystem restoration features, recreation enhancement features, interior drainage plan improvements, and other proposed projects in or near the Dallas Floodway Project. The BVP and IDP were developed for both a with- and without- Trinity Parkway condition. The following lists the alternatives considered in the EIS. Variations of the City of Dallas' BVP and IDP were considered and are described in greater detail in the EIS in Chapter 2. The remainder of this section focuses on the engineer and safety standard review, and the other resource impacts are described in the EIS.

- Alternative 1 – No-Action Alternative; and
- Alternative 2 – There are two variations in design of Alternative 2: (1) MDFP and Remaining BVP Features Design with the Trinity Parkway in the Future Condition; and (2) without the Trinity Parkway in the Future Condition.

3.11.3 Comprehensive Analysis Assumptions

The following assumptions were used in the evaluation of projects in the Comprehensive Analysis:

- The future without-project condition (synonymous with No Action) is the description that is expected to prevail if the BVP and IDP are not implemented, including the MDFP.

- The Trinity Parkway evaluation compared to the existing condition is contained in the Trinity Parkway Section 408 package.
- For the environmental impacts, the future without-project condition assumes the Trinity Parkway and other local features are implemented. The environmental evaluation needed to account for environmental impacts associated with the construction of the Trinity Parkway in order to get an accurate baseline to evaluate impacts for the BVP and IDP features in the EIS.
- The following describes the hydrologic and hydraulic modeling effort for the Comprehensive Analysis. After completion of the NED planning effort, the HEC-RAS model was updated to include projects given approval under Section 408. The BVP and IDP were added to this model and represents the BVP and IDP for the design without Trinity Parkway in the future condition. Then the Trinity Parkway was added to the model and represents the design with Trinity Parkway in the future condition.

3.11.4 Description of BVP and IDP Alternatives

Appendix L (Figures L-19 through L-22) contains a set of figures of the two variations of Alternative 2. Also, Appendix D (Civil and Structural Design) contains design information on the BVP and IDP. The EIS evaluates a No-Action Alternative and two variations and the BVP, one that assumes the Trinity Parkway in the future condition and one without the Trinity Parkway in the future condition. Several reports, documents and drawings were used to present and analyze the alternatives described below. Sources for design are provided in Appendix D (Civil and Structural Design), Section 6. For the FRM levee component of the BVP, the feasibility-level design was provided by the Corps.

3.11.4.1 The No-Action Alternative (Alternative 1)

The No-Action Alternative is an alternative that assumes the BVP and IDP are not implemented. An analysis of the No-Action Alternative is included to identify the existing baseline conditions against which potential impacts can be evaluated. The analysis and subsequent presentation of the future without-project condition will help the decision maker decide between alternatives.

3.11.4.2 BVP and IDP with the Trinity Parkway in the Future Condition

This condition assumes the BVP and IDP are implemented with the Trinity Parkway Alternative 3C (East Levee alignment) identified in the Trinity Parkway Final EIS. The Trinity Parkway proposed action includes excavation of fill material for support and berm building. To maximize construction efficiency, the NTTA, the City of Dallas, and the Corps would coordinate to determine if the Trinity Parkway can use fill material at the BVP Lakes sites for construction purposes. This would reduce the excavation needs of the BVP as the Trinity Parkway would excavate a portion of the BVP Lakes for its use. The excavation efforts by the Trinity Parkway would result in dual purpose for the Trinity Parkway and the BVP Lakes. All wetland mitigation associated with impacts from construction of the Trinity Parkway would occur outside of the Floodway in a mitigation bank.

BVP Lakes

The BVP includes creation of three lakes within the Floodway, the Natural Lake, Urban Lake, and West Dallas Lake. The combined length of the Urban and Natural Lakes is approximately two miles long, ranging between 400 and 800 feet wide. The Urban and Natural Lakes are located at the downstream end of the levee system along the East Levee. The Urban Lake includes recreation features on the perimeter of the lake such as the promenade, skate park, water maze, and white water course. The West Dallas Lake is approximately 1.5 miles long, is 600 to 700 feet wide and located further upstream near the confluence along the West Levee. A clay liner 18 – 30 inches thick will be applied to the bottom of the BVP Lakes to

help prevent seepage. The BVP Lakes are designed to withstand the SPF event. The BVP Lakes were also designed to include a water management system with water rights in mind. The three lakes are separated from the Trinity River by fairly narrow earthen berms to ensure proper separation from a hydraulic and geotechnical standpoint. A portion of treated effluent from the CWWTP will be used as a water source for the Urban and Natural Lakes via a pipeline extending from the treatment plant upstream to Natural Lake.

River Relocation

The River Relocation project begins at the confluence, extending downstream approximately 8 miles, merging with the existing river channel near Corinth Avenue. The channel bottom will remain at least 50 feet wide and will be widened in certain regions to improve transitions with elements of the floodplain. The designed channel will also enable low-flow on the floodplain bench elevation at normal depth for flows of 500 cfs and floodplain bench slopes and landscape terrace sides slopes at 20H:1V or flatter. Channel bank side slopes between floodplain benches and channel inverts or between floodplain benches and top of bank will be a maximum of 3H:1V side slopes on the outside and 4H:1V on the insides of meander bends. The channel slopes will have bank treatments to prevent lateral migration and erosion. The channel profile design was intended to approximately preserve the existing average slope and rely on natural geomorphic processes to produce a diverse longitudinal profile over time. Constructed pools were also added to the cross sections and profiles to improve the initial ecological impact and the fish and wildlife habitat diversity. Pools are located in meander bends with preliminary pool design depths averaging depths of approximately 2.6 feet and pool lengths of approximately 375 feet. The Oxbow Lake is located at the downstream end of the study area. The oxbow will only be connected to the Trinity River at flows above 5,740 cfs. The Oxbow Lake is associated with the Corinth Wetlands restoration effort.

Wetlands (Corinth and Marshlands)

Wetlands of varying depths and types are designed across the Floodway including along the shoreline of the BVP Lakes and within the floodplain. Other wetland features include the Corinth Wetlands. The Corinth Wetlands extend from Oxbow Lake (a feature of the River Relocation) as part of the BVP, downstream between the relocated Trinity River and the West Levee. There is a boardwalk that borders the wetlands along the West Levee toe that is designed for viewing of the features of the Corinth Wetlands.

There is an area identified as Hampton Wetlands in the BVP. The Hampton Wetlands are not part of the BVP because they are proposed as a hydraulic mitigation feature for the Trinity Parkway. Since they are listed in the BVP it was important to note this area in the description of the overall BVP here. It was determined they will no longer be managed as wetlands. Mitigation for environmental features impacted by the Trinity Parkway is expected to be conducted at a mitigation bank outside the Floodway.

Athletic Facilities

The BVP proposes a substantial amount of managed playing fields, consisting of approximately 115 acres of playing fields for soccer, softball, and groomed “flex” fields for multiple sport usages. Event and concession facilities and amphitheaters are also proposed as part of the BVP. The hub of the active recreation program would be the West Dallas Recreation Fields, an approximately 78-acre area designed to accommodate up to 17 regulation-size soccer fields, adaptable for lacrosse, field hockey, rugby, cricket, ultimate frisbee, football, and other field sports. This area would also feature two playgrounds. Generally, these areas would be sited at an elevation (25-year to 50-year) to reduce the frequency of maintenance. Water recreation is a major component of the BVP. Water access would be provided in multiple locations.

General Features

General features include parking and public roads, lighting, vehicular access, pedestrian amenities, restrooms, etc. Over 14 miles of roads are proposed. The roads would consist of two lanes, paved in concrete of sufficient thickness to support heavy construction and maintenance vehicles. Approximately 1,900 parking spaces divided between 12 paved lots were identified. Approximately 500 supplementary roadside parking spaces (parallel) are also proposed along roads. To serve major events and gatherings, an additional 6,200 overflow parking spaces are proposed in two separate meadow areas, the majority near the potential West Dallas Amphitheater. The BVP proposes several motorized and non-motorized access points to maximize flexibility, connections, and continuity of access into the Floodway by all users. Access points would provide easy access and linkages to neighborhood parks, facilities and city-wide and region-wide trail systems. Upon implementation, people would be able to access recreational features at numerous points via foot, bike, automobile and public transit.

A system of primary and secondary trails totaling approximately 30 miles in length is proposed to run through the Floodway, meandering between the Oak Cliff and the downtown sides and crossing the Trinity River at five key points. The primary trail would provide access for all non-motorized users including pedestrians, cyclists, skaters, and wheelchair users. The primary trail would be 20 feet wide at its narrowest, expanding up to 25 feet in places and/or in stretches and becoming divided into 10-foot lanes separated with a planted median. This trail would also serve as a maintenance and emergency access road as a supplement to the roads. An equestrian trail totaling approximately eight miles would be a single-user bidirectional trail except in constrained areas, trail junctions, bridges, and underpasses.

Due to the potential impact of flood events on restroom structures, the BVP proposes that restrooms consist of mobile or removable units, attached to permanent water and sewer utility lines. Both potable water and sewer pipes would be disconnected in preparation for removal of the units to higher ground prior to flood events. The structures would be at a 2-year flood elevation or higher.

Constructed Forested Ponds are proposed to bring shade and cooling to the heart of the Floodway, especially alongside the edge of the Urban Lake Promenade. They also would function as biofiltration areas capable of absorbing lake nutrients. These constructed wetland ponds would feature native bottomland hardwoods and other water-tolerant herbaceous plants capable of high rates of biofiltration.

Interior Drainage Plan (East and West Levee)

The IDP consists of proposed improvements to the existing EWLIDS. The IDP improvements aim to provide stormwater FRM served by the EWLIDS from the 100-year storm event. Table 3-39 lists the features of the EWLIDS included in the Comprehensive Analysis. The Able, Baker and Pavaho IDP features were processed under Section 408 in advance of completion of this feasibility report. The City of Dallas does not wish to pursue credit for the Pavaho and Able IDP features.

Table 3-39. Summary of Interior Drainage Plan Improvements

Category	*Descriptive Action*
East Levee	Demolish Old Hampton Pump Station
	Construct New Hampton Pump Station
	Nobles Branch Sump Improvements
	Construct New Baker Pump Station
	Construct New Able Pump Station
West Levee	Demolish Old Charlie Pump Station
	Construct New Charlie Pump Station
	Rehabilitate Existing Delta Pump Station
	Construct New Trinity-Portland Pumping Plant
	Construct New Pavaho Pump Station
	Eagle Ford and Trinity-Portland Sump Improvements
	Pavaho and Delta Sump Improvements

3.11.4.3 BVP and IDP without the Trinity Parkway in the Future Condition

While the Trinity Parkway is currently a "reasonably foreseeable" project, there is a possibility that it may never be constructed or the BVP and IDP could be constructed before the Trinity Parkway. The BVP and IDP could be implemented as a stand-alone project, but the Trinity Parkway could potentially be constructed within the Trinity River Corridor at a later date so long as FHWA updated their Final EIS accordingly. Because it is assumed that the Trinity Parkway is not in-place, certain BVP features would be different under this scenario. In addition, there would be additional cost for disposal of excess material off-site to build the BVP features. There would be no change to the NED (levee) component of the BVP or IDP improvements for this design.

Table 3-40 summarizes some of the notable changes to BVP features without the Trinity Parkway. These modifications are a result of the new Floodway feature geometry, reflecting the absence of the Trinity Parkway.

Table 3-40. Comparison of Notable BVP Features with and without Trinity Parkway

Feature	*With Trinity Parkway*	*Without Trinity Parkway*	*Change*
Dedicated Bike Path	0 mile	3.4 miles	+ 3.4 miles
Flex Fields	77.8 acres	88.1 acres	+ 10.3 acres
Meadow	1,152.1 acres	1,121.6 acres	- 30.5 acres
Park Road	13.7 miles	15.8 miles	+ 2.1 miles
Planter Boxes (raised vegetation)	4.9 acres	14.7 acres	+ 9.8 acres
Secondary Pedestrian Path	17.5 miles	16.9 miles	- 0.6 mile
Wetlands	176.6 acres	178.4 acres	+ 1.8 acres

3.11.4.4 Engineer and Safety Standard Review Criteria

The feasibility-level design documentation listed in Section 6 of Appendix D (Civil and Structural Design) was provided by the City of Dallas on the BVP and IDP and was the basis for the review in the Comprehensive Analysis along with the design of the local features. Section 408 project design documentation was provided by their respective project proponents for the Comprehensive Analysis. Feasibility-level design of the NED Plan and the 4H:1V levee side slopes was developed by the Corps.

The following sections discuss the Corps engineer and safety standard review of the engineering analysis and designs prepared by the City of Dallas and their contractors as well as other Section 408 projects.

The engineer and safety standards review was based on project constructability, functionality, risk, hydraulic neutrality, compliance with Corps engineering standards at the feasibility level of design. The evaluation also includes a Comprehensive Analysis for all projects in the Dallas Floodway Project from a system-wide approach. It also determines potential conflicts in the integration of the multiple local features (Section 408 projects) and the BVP and IDP.

Hydrology and Hydraulics Analysis

In the determination of hydraulic neutrality a process of plan comparison in the Hydrology and Hydraulics analysis was used to evaluate if the 1988 Upper Trinity River EIS ROD Hydrology and Hydraulics criteria (ROD criteria) were met. The ROD criteria was originally developed for the purpose of limiting potential increases in flood risk in the TRC due to floodplain developments and has been applied to the Corps Section 404 regulatory process in the Upper TRC since 1988. While the Corps is not constrained by this regulatory process for development of projects that are consistent with Corps mission objectives, it was expected that the study would identify a project that would be a combination of Corps mission objectives (FRM, ecosystem restoration, and recreation, etc.), projects by local interests, and other agencies such as the FHWA. These local interest projects on the Trinity River and tributaries have historically been subject to the ROD criteria and all the local features described herein were evaluated as stand-alone projects using the ROD criteria. Therefore, it was deemed appropriate for the Corps to use the ROD criteria to evaluate these combinations of project components that have varying and sometimes competing hydrologic and hydraulic impacts. This evaluation process was consistent with the original intent of the ROD criteria and ensures that projects that may have significant FRM, ecosystem restoration, and recreation benefits for the City of Dallas are designed in such a way that minimizes any potential negative flood risk impacts beyond the limits of the Dallas Floodway Project. The hydraulic modeling results of the Comprehensive Analysis were evaluated on four points from the ROD criteria. These four points are: water surface rise due to the project for the 1% AEP and SPF flood events and valley storage loss for the 1% AEP and SPF flood events.

Geotechnical

Comprehensive Analysis criteria, for geotechnical purposes, includes compliance with Corps criteria as provided in the Corps Engineer Regulations, Engineer Manuals, and Engineer Technical Letters. Additional criteria includes the Risk Management Center's reports, "*Risk Assessment Trinity River Corridor Dallas Floodway near Dallas, Texas,"* September 7, 2012, "*Risk Assessment of Proposed Remediation Methods, Trinity River Corridor Dallas Floodway,"* November 2, 2012, and "*Study of the Impact on Risk of the Proposed Balanced Vision Plan and Trinity Parkway, Trinity River Corridor Dallas Floodway,"* June 26, 2013. Fort Worth District Pamphlet 1150-2-1, and "*Preliminary Design Information, Guidelines, and Criteria, Geotechnical Design – City of Dallas Levees*," dated June 6, 2012. The memorandum was developed by the Corps and the City of Dallas' contractor, HNTB.

Civil and Structural Design

The review consisted of determining whether the feature was constructible and positively interfaces with adjacent existing or the MDFP features. The feature was designed to meet minimum Corps and all other relevant design criteria. This includes Fort Worth District Pamphlet 1150-2-1, which describes "Criteria for Construction within the Limits of Existing Federal Flood Protection Projects." A feature needs to be consistent with standard engineering practice. In the event the review identified criteria were not met, a

risk-informed decision was made whether further feasibility-level design was required or whether the design could be considered acceptable and issues remedied in future design phases. Potential issues in lack of detail in design or potential conflicts in designed features were identified. Design conflicts were provided to the Section 408 proponent for consideration in the development of their Section 408 approval package for review by the Corps following the Comprehensive Analysis.

Risk Analysis

A risk assessment was performed on the major BVP features including the BVP Lakes, and the River Relocation and the Trinity Parkway Alternative 3C on the East Levee. The risk assessment was performed to quantify and evaluate risks posed by the East and West Levees associated with Trinity River flooding considering the major features of the BVP and the Trinity Parkway. The risk assessment was conducted using ER 1110-2-1156, Safety of Dams - Policy and Procedures as a guideline for the Dallas Floodway Project.

3.11.5 Results

The following summarizes the results of the Comprehensive Analysis. Additional detail can be found in the technical appendices of this report. The environmental impacts are discussed in the EIS.

No-Action Alternative

Hydrology and Hydraulics

A HEC-RAS model was developed to represent a future without-project condition. This model includes all of the projects included in the existing conditions model as well as additional local features that were reasonably foreseeable as part of future conditions. The results of this model serve as the base line for comparison to the "with-project" models for determination of "hydraulic neutrality" by evaluation of the overall project with regard to the ROD criteria.

The comparison of the existing condition and the future without-project condition has indicated very small changes to the water surface profiles for both the 100-year (1% AEP) and SPF flood events. This was expected since most of the permitted projects were not located in the floodplain or were designed to ensure that the project meets the requirements of the ROD criteria. A valley storage comparison was computed for the future without-project condition compared to the existing condition. The valley storage change for the future without-project is -0.11% for the 1% AEP flood event and -0.45% for the SPF compared to the existing conditions. Not all of the projects included in the future without-project condition model have advanced to a level of development to include design to mitigate for any potential negative floodplain impacts. The future without-project condition was consistent with the current conditions for the geotechnical, civil and structural engineering analysis.

BVP and IDP with the Trinity Parkway in the Future Condition

This design includes the BVP and IDP with the Trinity Parkway preferred 3C Alternative in place. The BVP and IDP consist of the following three actions:

- FRM Component of the BVP;
- BVP Ecosystem Restoration and Recreation Features; and
- IDP Improvements.

Hydrology & Hydraulics

The results of the future without-project condition model serve as the base line for comparison to the "with-project" models for determination of "hydraulic neutrality" for evaluation of the overall project with regard to the ROD criteria. Hydraulic analysis results for the three listed actions in this alternative are as follows.

The with-project NED Plan HEC-RAS model was developed by creating a NED Plan model that encompasses all of the project features of the future without-project condition model with the added NED Plan features. The added features include: (1) the proposed AT&SF Railroad Bridge modification; (2) the levee raise to 277,000 cfs with 3H:1V side slopes on both levees; and (3) the excavated borrow areas within the Floodway needed for the levee raise construction. The 4H:1V side slopes were added to the hydraulic model under the BVP ecosystem restoration and recreation features. The hydraulic modeling results indicate that the AT&SF Railroad Bridge modification causes a loss of valley storage within the Dallas Floodway Project for the 100-year and the SPF flood events. This is caused by a lowering of the water surface due to portions of the bridge being removed. Valley storage is defined as the water volume that occupies the floodplain during passage of the flood event and is measured at the peak of the flood event. When floodplain modifications are made that reduce the peak water surface elevation of the flood event, then a valley storage loss occurs. This in turn may result in a higher peakflow for the same flood event downstream and without compensating downstream floodplain modifications may result in higher peak water surface elevations which may result in a higher flood risk downstream. Refer to Appendix A (Hydrology and Hydraulics), pages A-92 through A-95 for a more detailed discussion of valley storage impacts and computation methodology.

The hydraulic modeling results of the BVP and IDP with the Trinity Parkway in the future condition were evaluated on four points from the ROD criteria. These four points are: water surface rise due to the project for the 1% AEP and SPF flood events and valley storage loss for the 1% AEP and SPF flood events. The results showed that there were no water surface rises due to the project for the SPF flood event but there were some localized areas where a water surface rise occurs for the 1% AEP flood event. These rises occur on the Trinity River main stem where both levees provide risk reduction with levee crest elevations approximately 10 feet above the 1% AEP. No water surface rise occurs for the SPF flood event and the 1% AEP flood event for areas upstream of the project, so there would be no increase in flood risk for these areas for either flood event. However, since water surface rises occur for the 1% AEP flood event, this plan fails to meet the requirements of the ROD criteria as a stand-alone project.

The loss of valley storage was computed at more than 6% for the SPF and approximately 2.1% for the 1% AEP compared to the future without-project condition. Since the project results in a valley storage loss for both flood events, the project as currently designed does not meet the ROD criteria for the 1% AEP or SPF event. The unsteady modeling results showed that the decrease in valley storage resulted in a small (less than 1%) increase in peak flow downstream of the Trinity Parkway of 600 cfs for the 1% AEP and 2,200 cfs for the SPF event. This increase in peak discharge resulted in an increase in water surface of about 0.1 feet in the reach downstream of the Dallas Floodway Project. While technically this would be regarded as a potential increase in flood risk, it was considered insignificant with consideration for actual damages that could be realized. The immediate areas downstream of the Dallas Floodway Project were assumed to be protected by the DFE Project levees, and downstream of the DFE Project, there are very few structures subject to flooding by the SPF or 1% AEP flood event.

Geotechnical

The NED Plan was developed by the Corps and is considered in accordance with engineering and safety standards from a geotechnical standpoint. The BVP and IDP at feasibility-level design is sufficient at this stage, and any issues with the current design can be remedied in PED and future design submittals. The seepage and stability analyses will need to be updated in future design to include the use of unsteady flow in lieu of the steady state analyses (if appropriate). Deterministic criteria will be confirmed during PED phase when designing BVP and IDP features.

The Trinity Parkway HNTB Supplemental Geotechnical Report, submitted as a Technical Memorandum dated June 10, 2013, generally addresses the outstanding review comments with respect to data quality issues, and also asserts that a revised geotechnical report (with data "clean-up") will be provided with the 65% design Section 408 package.

Civil and Structural Design

There are several key design issues identified in the BVP and IDP that need to be mitigated in future design: grading plans, bridge pier modifications, earthen berms, clay liner and lake drainage system associated with the BVP Lakes, and River Relocation erosion control.

The BVP grading plans require design to remedy low spots and some inconsistencies with other features (including other BVP, IDP, and local features) within the Dallas Floodway Project. This can be fixed in future design by properly grading to drain and positively interfacing all features within the Floodway.

Bridge pier modifications are necessary for the construction of the BVP Lakes and River Relocation to ensure proper scour and erosion protection around the bridges. The cost of the River Relocation includes the bridges affected by the River Relocation. The new Margaret Hunt Hill Bridge, IH-30/IH-35 and the Jefferson Bridge were assumed to accommodate the River Relocation in the future condition outside the scope and cost of the River Relocation feature of the BVP.

The three lakes of the BVP all have earthen berms, clay liners, and a lake drain system. The earthen berms, separating the lakes from the Trinity River, need to satisfy Corps criteria. In future design, the earthen berms will be evaluated with Corps criteria. This includes the evaluation of the various utilities and the lake drainage system penetrating the berms. The earthen berms also need to be evaluated for erosion due to storm events with water surface elevations that exceed the height of the earthen berms and protected accordingly. Both the berms and the lining system for the lake must be of suitable material. To date, there has not been any detailed evaluation to determine specific requirements and the quantity of material available within the Floodway. The lake drainage system may conflict with some utility relocations within the Floodway, specifically the pressure sewers. The lake drainage system is currently planned to be gravity flow. This would require drains to have a necessary pressure head differential between the top of lake and outfall structure to achieve flows for drainage.

Finally, River Relocation erosion control needs further evaluation in future design stages. River banks opposite discharge points need increased erosion protection to avoid blow outs, adverse effects to other features within the Floodway including bridge piers, and to limit river migration. An erosion protection plan to include all predicted shear stresses and velocities at high volume areas and confluences of discharge needs to be developed in future design phases to ensure appropriate protection schemes are implemented.

The Trinity Parkway design includes the realignment of a portion of the Trinity River that is not a BVP design feature. This current realignment strategy is to accommodate the footprint of the Trinity Parkway.

This strategy may have to be expanded in scope to incorporate larger lengths of the Trinity River in order to allow for proper design and construction of borrow pits in the proposed footprints of the BVP features, Urban and Natural Lakes. In addition, the Parkway may have to include portions of BVP Lake features, such as earthen berms and clay lining material to achieve Section 408 approval. The revised designs would then also have to accommodate any new utility relocation, drainage accommodation, or grading features.

Future detailed design submittals for both the BVP and Trinity Parkway will have to be reviewed and evaluated for compliance with Corps design criteria. A high level of coordination between the City of Dallas, Corps, and the Trinity Parkway design team will be required to ensure these features are properly designed and constructed.

The design evaluation of the IDP was based on the interface of the IDP with the BVP, Trinity Parkway and the plans to flatten all slopes to 4H:1V. The proposed pump stations increase discharge into existing channels and may require the expansion of the channel and/or additional scour protection. Flow capacities for the outfall channels need to be coordinated between the BVP and IDP during future design. Provided the pump stations are designed in coordination with the NED Plan, Trinity Parkway, BVP and levee side slope flattening plans, these features can proceed to the next design phase.

Risk Analysis

Seepage pathways are shortened by the River Relocation and the risk for heave (PFM #8) increases in the following locations: (1) West Levee, Station 3+00 to 29+00; (2) East Levee, Station 285+00 to 442+00; and (3) East Levee, Continental Avenue to Station 285+00. The City of Dallas has completed construction of seepage cut-off walls as a part of their 100-year certification effort in these locations except the section on the East Levee from Continental Avenue to Station 285+00. The existing cut-off walls the City of Dallas has constructed on the East Levee at Station 285+00 will be extended downstream to approximately Continental Avenue (approximately Station 170+00) to mitigate for the increase in risk (underseepage) due to the River Relocation.

There is some concern as to how close the three proposed BVP Lakes are to the levees. The risk assessment concluded that placement of the proposed lakes detailed in the BVP will not impact the levee system because the excavation will not advance deep enough to penetrate the basal sand lenses that could cause seepage issues. The clay liner also helps address the seepage concerns.

<u>BVP and IDP without the Trinity Parkway in the Future Condition</u>

This design assumes the BVP and IDP are implemented without the Trinity Parkway Alternative 3C. The BVP and IDP consist of the following three actions:

- FRM Component of the BVP;
- BVP Ecosystem Restoration and Recreation Features; and
- IDP Improvements.

Hydrology and Hydraulics

The BVP and IDP without the Trinity Parkway HEC-RAS hydraulic model includes a determination regarding the hydraulic neutrality with reference to the ROD criteria. The criteria are evaluated on water surface rise due to the project for the 1% AEP and SPF flood events and valley storage loss for the 1% AEP and SPF flood events. There were no water surface rises due to the project for the SPF flood event but there was a short reach where a water surface rise occurs for the 1% AEP flood event, which occurs just downstream of the IH-30 Bridge. This rise occurs within the Floodway on the Trinity River main

stem where both levees provide risk reduction from flooding for the 1% AEP flood event to the City of Dallas. No rises were indicated upstream of the Elm Fork and West Fork confluence. This analysis indicates that since no water surface rise occurs for the SPF flood event and the 1% AEP flood event for areas upstream of the project, there would be no increase in flood risk for these areas for either flood event. However, since water surface rises occur for the 1% AEP flood event, this plan fails to meet the requirements of the ROD criteria.

The loss of valley storage for the BVP in the without Trinity Parkway in the future condition was estimated at -5.1% for the SPF and -0.80% for the 1% AEP compared to the future without-project condition. This means that the project results in a valley storage loss for both flood events. The project as currently designed does not meet the ROD criteria because no valley storage loss is allowed for the 1% AEP and no loss greater than 5% is allowed for the SPF. However, the downstream impacts are expected to be negligible, similar to what was discussed for the with Trinity Parkway version of the design. The immediate areas downstream of the Dallas Floodway Project are protected by the DFE Project levees, and downstream of the DFE Project, there are few structures subject to flooding by the SPF or 1% AEP flood event.

Geotechnical, Civil and Structural Design, and Risk Analysis

The conclusions of the BVP and IDP for the design without the Trinity Parkway in the future condition are the same from a geotechnical and risk analysis standpoint. This is because there is still some benching (for the Trinity Parkway embankment) along the East Levee. Evaluation results are also the same from a civil and structural design perspective for the BVP and IDP for the design without the Trinity Parkway in the future condition, except design integration issues are reduced under this design.

3.11.6 Comprehensive Analysis Conclusions

The results of the Comprehensive Analysis shows that both variations of the design of Alternative 2 did not meet the ROD criteria in terms of valley storage and water surface rise; however, the potential negative impacts were insignificant. While additional design refinement efforts may be able to reduce the valley storage losses noted and/or reduce the water surface rises for the 1% AEP flood event within the Dallas Floodway main stem Trinity River, meeting the ROD criteria on every point and at every location is likely not achievable for such a large and complex combination of projects. Further reducing the negative impacts for valley storage loss to some extent may be achievable, but since these estimated impacts were regarded as insignificant, and efforts to further reduce them are not likely to be cost effective at this level of design. At the current level of design for the various project components considered, the level of compliance with regard to meeting the goals of the ROD criteria is estimated to be very nearly optimal from a hydraulic standpoint. As project designs move toward a higher level of detail in the final design stages, continual hydrologic and hydraulic analysis will be performed to ensure the highest reasonable level of compliance with the ROD criteria. Another point to consider is estimation for such small changes is difficult to rely upon for the level of precision in the hydraulic models.

Findings for each of the technical disciplines (Hydrology and Hydraulics, Geotechnical, and Civil and Structural Design) are found in the technical appendices of this report. During the Comprehensive Analysis, local features were reviewed against Corps engineer regulations and safety standards to ensure the projects would not have a significant adverse impact on the system. The findings are based on the level of design development of the individual local features at the time of the Comprehensive Analysis. Upon completion of the Comprehensive Analysis the local interests were provided the results to use as an input into their Section 408 package. Future design work needs to follow Corps guidance and format as

prescribed in Corps design standards or Section 408 requirements. Typical design submittals at the 35%, 65% and 100% level of development will be submitted and approval is required to advance to the next phase. Technical analysis and NEPA documentation are contained in the individual local feature's Section 408 packages and not included in this feasibility report. The local features in the Comprehensive Analysis follow a separate Section 408 review process for approval.

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CHAPTER 4
RECOMMENDED PLAN DESCRIPTION

4.1 RECOMMENDED PLAN FEATURES

The Recommended Plan for the Modified Dallas Floodway Project (MDFP) includes:

- National Economic Development (NED) Plan (the 277,000 cfs levee raise with AT&SF Railroad Bridge modification and Emergency Action Plan (EAP) improvements);
- Levee Side Slope Flattening to 4H:1V (City of Dallas betterment);
- the Interior Drainage Plan (IDP) Phase I (Hampton and Baker Pump Stations, and the Nobles Branch sump improvements);
- the IDP Phase II (Charlie, Delta and New Trinity Portland Pump Stations);
- River Relocation, and
- Corinth Wetlands.

The Recommended Plan assumes the Trinity Parkway is built in the Floodway. The Recommended Plan features are described under the primary Corps mission area proposed for implementation below. Not all features associated with a Balance Vision Plan (BVP) and IDP are proposed in the Recommended Plan and will be pursued as a Section 408 project. Specific features are reflected in the Recommended Plan summaries provided below and in the design and cost estimate accompanying this report (Appendices D and J). Figures L-23 through L-25 of Appendix L are figures of the Recommended Plan.

Feasibility-level design of the NED Plan, AT&SF Railroad Bridge modification, and the levee side slope flattening to 4H:1V was provided by the Corps. Feasibility-level design for the East Levee and West Levee IDP, River Relocation and the Corinth Wetlands was provided by the City of Dallas and their contractors.

4.1.1 Flood Risk Management

4.1.1.1 NED Plan: 277,000 cfs Levee Raise and AT&SF Railroad Bridge Modification

The NED Plan is comprised of a levee raise to meet the 277,000 cfs water surface elevation and modifications to the AT&SF Railroad Bridge at the downstream end of the Dallas Floodway Project. The AT&SF Railroad Bridge modification will include the demolition and removal of 900 linear feet of wooden trestle ballast-deck bridge, demolition and removal of 100 linear feet of wooden trestle open deck bridge, and demolition and removal of 660 linear feet of concrete ballast-deck bridge. Approximately 53,000 cubic yards of earth forming the railroad embankment will be removed and disposed of outside the levee system.

The levee raises will occur in any location where the effective levee crest height is less than that of the 277,000 cfs water surface elevation. The effective levee height of the levee was determined assuming that the existing access road is approximately eight-inches thick based on borings within the crest of the levees. The effective levee height is assumed, therefore to be eight inches below the surveyed levee height at any point along the levees. Table 4-1 depicts the levee stationing that requires levee raises.

Table 4-1. Stationing of East and West Levee Reaches to be Raised

Reach Number	*East Levee and Elm Fork*		*West Levee and West Fork*	
	Begin Station	*End Station*	*Begin Station*	*End Station*
1	79+95	82+63	50+99	52+00
2	99+70	101+41	66+69	69+48
3	117+04	119+12	70+07	71+60
4	153+63	168+03	154+93	211+35
5	168+79	234+87	211+75	233+70
6	246+90	256+05	241+60	243+88
7	256+77	282+80	244+54	268+25
8	283+31	300+28	280+35	306+54
9	300+72	316+90	314+71	316+90
10	328+10	346+92	325+63	327+88
11	347+61	351+96	331+68	332+45
12	442+28	443+05	338+55	340+95
13	474+29	474+87	365+43	367+88
14	476+10	518+76	409+60	416+75
15	520+85	531+33	417+42	419+19
16	531+73	544+43	423+00	429+95
17	546+04	551+22	431+30	443+46
18	551+93	557+08	452+56	454+98
19	559+25	560+68	476+50	478+55
20	-	-	481+40	482+77
21	-	-	486+20	494+87
22	-	-	495+48	499+75
23	-	-	502+51	516+00
24	-	-	517+74	521+09
25	-	-	522+41	536+61
26	-	-	537+65	541+16
27	-	-	544+55	548+46
28	-	-	553+04	555+65
29	-	-	557+45	558+92
Total Length in Linear Feet	**25,740**		**23,529**	

Levee raises will be constructed by first excavating the top eight inches of the levee and disposing the material. The levee will be scarified to a depth of six inches along flat surfaces. Scarification along the slopes for any levee work will need to be constructed by excavating and benching into the levee at a minimum of 10-foot wide steps. For cost estimating purposes, the levee raises were designed to extend from the protected side crest at a 3H:1V slope to the required elevation. The levee crest was assumed to be a minimum of 16 feet before tying into the riverside slope of the levee at a 3H:1V slope. A crushed limestone access road will be placed on top of the levee crest to a depth of eight inches with a Geotextile liner between the levee and the road. Figures 4-1 and 4-2 show a typical levee raise template and the access road template, respectively.

Figure 4-1 3H:1V Levee Raise Template

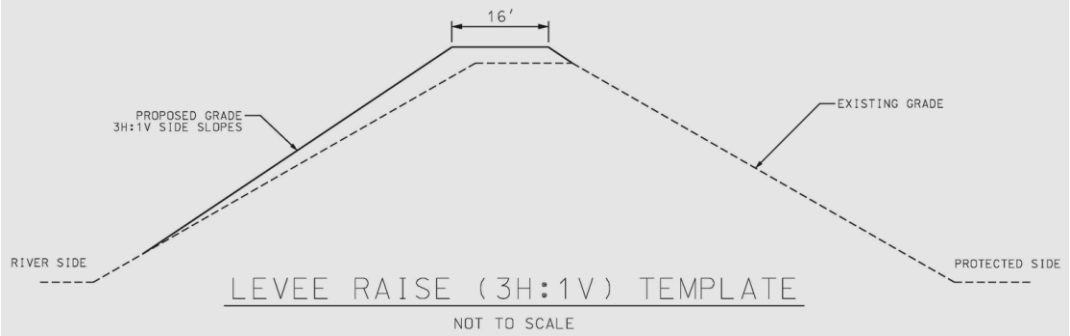
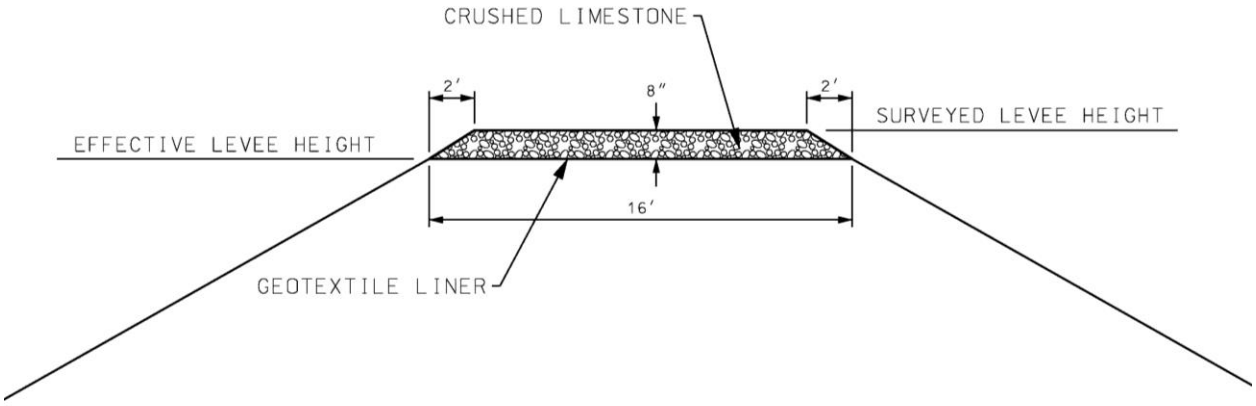


Figure 4-2 New Crushed Limestone Access Road Template



The borrow source for the NED Plan is within the footprint of the proposed West Dallas Lake. An estimated 94,000 cubic yards of material is needed for the construction of the NED Plan. This estimate takes into account compaction. While the Corps is constructing the levee raises and 4H:1V slope flattening, open borrow pits will be evaluated to ensure a clay liner is not required. This will be confirmed during the design phase. This is to ensure the integrity and functioning of the levee system continues throughout the construction phases, until the final design is implemented with a clay liner. Costs for a clay liner in the borrow area as an interim measure is expected to be minimal for the NED Plan and within contingencies if required.

The NED Plan does not require utility relocation. There are three bridge-levee interfaces that require structural bridge sealing plans including Corinth, Union Pacific, and SH-356 on the East Levee. The Houston Street Bridge on the West Levee requires sandbagging at the 277,000 cfs flow.

4.1.1.2 Economic Summary of the NED Plan

In the development of the NED Plan, several base assumptions were used to generate quantities and to determine scope of work. The road surface template developed showed the road surface embedded within the height of the levee. The template assumed that the proposed and existing crushed limestone road surface could be considered part of the effective levee height. It was concluded in final analysis that crushed limestone road cannot be considered part of the overall levee height and was placed on the top of the effective levee instead. The increase in cost of the NED Plan was $3,200,000. Generally, each alternative considered in the NED plan formulation would have a proportional change in cost. The levee raises analyzed in the NED plan formulation were reanalyzed from a cost perspective to determine whether the formulation would change. The plans to match water surface elevations lower than that of the 277,000 cfs NED Plan were not considered because net benefits for the 277,000 cfs NED Plan with an additional $3,200,000 in cost were still greater than the benefits for lower flows. The overall scope and cost of the 289,000 cfs plan, based on knowledge of the 277,000 cfs scope and cost changes, was expected to increase by 60%. If there was a 60% increase in cost of the 289,000 cfs plan, the net benefits would fall below those of the 277,000 cfs plan. Therefore, the 277,000 cfs remains the NED Plan and no additional formulation was required to address the identified increase in quantities for the levee raises. Table 4-2 presents the economic summary of the NED Plan (277,000 cfs levee raise and the AT&SF Railroad Bridge modification) at the current interest rate and Office of Management Budget interest rate.

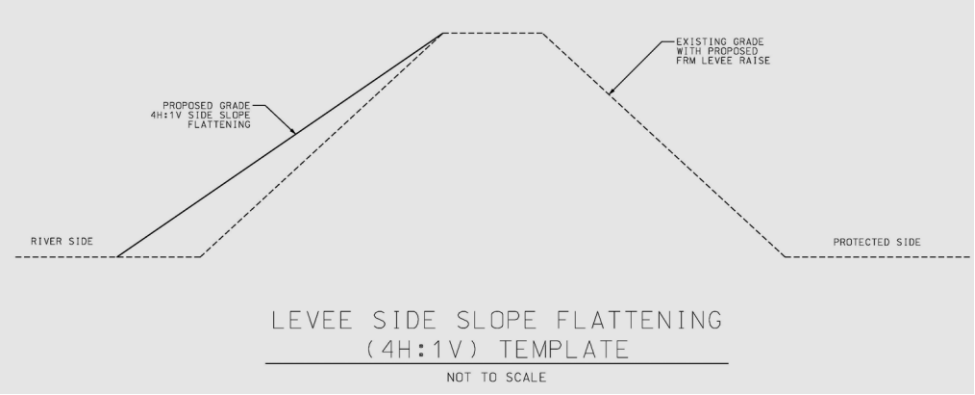
Table 4-2. Economic Summary of the NED Plan
(October 2013 Price Level/3.5% Federal Interest Rate)

	3.5 Percent	***7 Percent***
INVESTMENT		
Construction	$8,042,000	$8,042,000
PED	$901,000	$901,000
Construction Management	$800,000	$800,000
Estimated First Cost	$9,743,000	$9,743,000
Annual Interest Rate	3.5%	7.0%
50-year Period of Analysis (years)	50	50
Construction Period (months)	22	22
Interest During Construction	$315,000	$633,000
Investment Cost	$10,058,000	$10,376,000
Interest	$352,000	$726,000
Amortization	$77,000	$26,000
OMRR&R ($/year)	$30,000	$30,000
TOTAL ANNUAL CHARGES	**$459,000**	**$782,000**
Without Project EAD	$5,511,000	$5,456,000
Residual EAD	$3,817,000	$3,775,000
Flood Reduction Benefits	$1,695,000	$1,681,000
TOTAL BENEFITS	**$1,695,000**	**$1,681,000**
NET BENEFITS	**$1,236,000**	**$900,000**
BENEFIT-COST RATIO	**3.7**	**2.1**

4.1.1.3 Levee Side Slope Flattening

The current side slopes of the levee system range in grade from approximately 2.8H:1V to 4H:1V. Based on the safety hazard of mowing steep side slopes and its inclusion in the BVP, the local sponsor wishes to pursue construction of 4H:1V side slopes on the entire length of the riverward side of the East and West Levees, including the forks, where the existing slopes are steeper than 4H:1V. Currently, the City of Dallas has implemented some sections of this plan along the downstream end of the Dallas Floodway Project. The extents of the existing efforts of side slope flattening are not defined; however, a survey prior to design and construction will delineate the full scope of the side slope flattening project. Quantities for the cost estimate of the side slope flattening were developed using a conservative assumption that the entire length of the levees would require flattening. Figure 4-3 displays the 4H:1V side slope template for the East and West Levee. The side slope flattening includes construction of the access roads to match the new contours of the riverward side of the East and West Levee. The borrow source for the side slope flattening is within the footprint of the proposed West Dallas Lake. An estimated 1,400,000 cubic yards of material is needed for the construction of the 4H:1V side slopes, including the NED Plan levee raise quantities.

Figure 4-3 4H:1V Typical Levee Side Slope Flattening Template



The outfall structures affected by flattening the side slopes include Old Coombs Creek, Coombs Creek, Turtle Creek, Nobles Branch Sump, and Eagle Ford Sump (Table 4-3). The associated costs and quantities for the extension of the outfall structures for these features is solely related to the proposal to flatten all riverward levee side slopes to 4H:1V. The outfall structures affected by a BVP feature, is accounted for in the respective BVP feature cost. For example, the pressure sewer relocation work on the East Levee is primarily affected by the construction of the Urban or Natural Lake. The side slope flattening plan includes demolition of all existing revetment and riprap and replacement with new concrete underneath bridges using Texas Department of Transportation standards. This is to create a uniform 4H:1V surface across the entire levee to improve operations and maintenance efforts.

Table 4-3. Utility Relocations for Side Slope Flattening

Project Objective	*Utility Owner*	*Utilities*
Flood Risk Management	City of Dallas Owned	Storm Pressure – Old Coombs Creek
	City of Dallas Owned	Storm Pressure – Coombs Creek
	City of Dallas Owned	Storm Pressure – Turtle Creek
	City of Dallas Owned	Storm Gravity – Nobles Branch
	City of Dallas Owned	Storm Gravity – Eagle Ford

This feature is included in the Recommended Plan at 100% non-Federal cost, and has a first cost in October 2010 price levels of approximately $39,000,000. The NED Plan levee raises impact approximately 40% of the linear length of the levees. To avoid disturbing the same sections of the levee multiple times and to reduce cost, it is recommended that the flattening of side slopes be constructed concurrent to the NED Plan construction. The levee raises take place in areas indicated in Table 4-1, and the side slopes would be flattened to 4H:1V instead of 3H:1V. The City of Dallas would pay for the increment between the 3H:1V and 4H:1V in the contract cost. The remainder of the levee side slope flattening on the East and West Levee would take place after the initial levee raise and side slope flattening. The project phasing and construction contracts are described in Chapter 5 (Sections 5.2 and 5.8).

4.1.1.4 East Levee Interior Drainage Plan

The East Levee IDP Phase I consists of the construction of new pump stations or improvements to existing pump stations and sumps. This includes the construction of the new Baker 3 Pump Station, and the new Hampton 3 Pump Station, and modifications to the Nobles Branch Sump at Empire Central Drive. The Baker 3 Pump Station is currently under construction, and the new Hampton 3 Pump Station is at a feasibility-level design.

Baker 3 Pump Station is proposed to be constructed upstream of Sylvan Avenue at approximately station 241+00 on the East Levee. Baker 3 Pump Station will replace the Old Baker Pump Station and have a maximum capacity of 700,000 gallons per minute (gpm). The new Hampton 3 Pump Station will be constructed upstream of Hampton Road at approximately station 315+00 along the East Levee. Hampton 3 Pump Station designs will replace Old Hampton Pump Station and have a maximum capacity of 700,000 gpm. The planned improvements of Nobles Branch Sump increase the connectivity of the sump through the construction of two new 60-inch reinforced concrete culverts and the replacement of one existing 60-inch concrete culvert under Empire Central Drive.

4.1.1.5 West Levee Interior Drainage Plan

The West Levee IDP consists of the construction of new pump stations or improvements to existing pump stations and sump areas. The current 35% design proposes the construction of a new Charlie Pump Station and demolition of the existing pump station. The site of the new Charlie Pump Station is downstream from the existing pump station just east of Jefferson Boulevard. The proposed capacity of the Charlie Pump Station is 225,000 gpm. Demolition plans for the existing Charlie Pump Station involve utilizing the existing box culvert through the levee at the pump station for continued gravity drainage use. At Charlie Pump Station, the Trinity River Relocation will move the river significantly towards the West Levee in order to accommodate the proposed Natural Lake footprint. The slopes for Charlie Pump Station need to match the intent of the City of Dallas to flatten all levee side slopes to 4H:1V. It is also recommended that slopes tie back into the levee more gradually to create a smoother mowing surface for maintenance workers.

Trinity Portland Pumping Station would be a new pump station located on the West Levee near Mexicana Drive. The pump station would be fed by the Trinity Portland basin. The proposed pump station is in the 35% design phase. Current plans call for two 125,000 gpm pumps to service this pump station. The proposed design would slightly modify the sump areas around the pump station to provide conveyance to the pump intake. These modifications would not affect the levee template itself. Access roads on the levee crest would be realigned accordingly to accommodate the increase in elevation due to the discharge pipes passing over the levee. The slopes covering the pipes accommodate the proposed 4H:1V slope flattening

goal of the City of Dallas with added articulated concrete block protection occurring over the pipes on the riverside slope.

The Delta Pump Station is located on the West Levee just upstream from Hampton Road. It is on the landward side of the West Levee along a dirt access road. The current Delta Pump Station consists of one main pumping building with an intake and outfall structure passing through the levee. The current capacity of the Delta Pump Station is 40,000 gpm. The proposed project involves the renovation of the pump station and the improvement of the sump and outfall area to prevent further erosion and preserve the integrity of the levee. The pumps will be replaced with pumps of the same capacity and the existing two 4-foot by 4-foot box culverts will remain in place as the discharge structure.

4.1.1.6 Emergency Action Plan Improvements

The City of Dallas has an existing in-depth EAP that identifies elderly populations over 65, special needs households, and other structures that should to be targeted for evacuation during flood events. Floodplain inundation maps are available to the City of Dallas to update their EAP and help them target areas with these populations that are flooded the deepest so that they can be evacuated first. The floodplain inundation maps will be developed in PED phase.

4.1.2 Ecosystem Restoration

4.1.2.1 River Relocation

The River Relocation is proposed for ecosystem restoration in the Recommended Plan. The Corps will participate in vegetation plantings, edge treatments for the river, erosion protection, excavation of the new river channel, and backfill of the existing river channel. The remaining features of the River Relocation are proposed under the Section 408. The existing 7.2 miles of the Trinity River will be relocated between Corinth Street to the confluence of the Elm and West Forks to improve channel diversity and sinuosity. The meanders will add approximately 1,750 linear feet to the existing Trinity River in the Floodway. As part of the River Relocation, an oxbow (Oxbow Lake) will be created upstream from Corinth Street. Oxbow Lake will have a length of approximately 2,400 linear feet. The Oxbow Lake will only be connected to the Trinity River at flows above 5,740 cfs. In order to minimize impacts to state listed threatened and endangered species, some parts of the existing channel will remain intact. The exact areas and extents will be determined during detailed design.

The channel bottom width will remain at least 50 feet wide and will be widened in certain regions to improve transitions with elements of the floodplain park design. The geometry of the designed channel will also enable low-flow on the floodplain bench elevation at normal depth for flows of 500 cfs, floodplain bench slopes and landscape terrace sides slopes at 20H:1V or flatter, for adequate drainage and transitions, and channel bank side slopes between floodplain benches and channel inverts or between floodplain benches and top of bank to be a maximum of 3H:1V side slopes on the outside and 4H:1V on the insides of meander bends. The channel slopes will have bank treatments to prevent lateral migration and erosion. The channel profile design is intended to approximately preserve the existing average slope and rely on natural geomorphic processes to produce a diverse longitudinal profile over time. Constructed pools were also added to the cross sections and profiles to improve the initial ecological impact and the fish and bird habitat diversity.

After excavation of the new channel and backfill of the existing channel, the River Relocation and Oxbow Lake, there could be up to approximately 1.2 million cubic yards of excess material. In order to mitigate the cost of the disposal of this material, the excess can be used for grading to drain the project features and neighboring features of the West Dallas Lake. The features neighboring West Dallas Lake are not a

part of the Recommended Plan; however, providing suitable material for rough grading to meet future BVP goals is recommended.

The relocation of the Trinity River requires relocation or extension of several utilities that either cross the Floodway or drain into the existing Trinity River. Table 4-4 presents the required utility relocations for the River Relocation. The discharges of the new Able Pump Station, Belleview Storm Sewer, Dallas Branch Storm Sewer, and Woodall Rogers Storm Sewer need extensions from their current (or planned) outfalls to accommodate the relocated Trinity River. The initial extension would be provided by the Trinity Parkway.

Table 4-4. Utility Relocations for River Relocation

Project Objective	*Utility Owner*	*Utilities*
Ecosystem Restoration	City of Dallas Owned	Belleview Storm Sewer Outfall
	City of Dallas Owned	Dallas Branch Storm Sewer Outfall
	City of Dallas Owned	Woodall Rogers Sewer Outfall
	City of Dallas Owned	Houston Street Viaduct Water Line
	City of Dallas Owned	Hampton Road/Inwood Water Line
	City of Dallas Owned	Removal of Misc. Pipelines
	City of Dallas Owned	Able Pump Station Outfall
	Franchise (Atmos Energy)	Gas Main – 16 inches North of Houston Street
	Franchise (Atmos Energy)	Gas Main – 30 inches South of Sylvan Street
	Franchise (Oncor)	Underground Electric North of Commerce Street
	Franchise (Oncor)	Underground Electric South of Houston
	Franchise (Oncor)	Aerial 138kV Elec. Transm. North of Continental Street
	Franchise (AT&T)	Underground Telecomm. South of IH-30
	Franchise (Verizon)	Underground Fiber Optics South of Union Pacific
	Franchise (AT&T)	Underground Fiber Optics Between Sylvan and Continental Avenue
	Franchise (Magellan)	Jet Fuel Pipeline – 6 inches West of Westmoreland

Bridge pier modifications are required for Continental, Commerce Street, Houston Street, Jefferson Boulevard, and the existing IH-35E (southbound and northbound) because the relocated Trinity River will affect the existing bridge piers. The design methodology includes encasing the existing surrounding soil before any excavation of the River Relocation takes place.

The existing cut-off walls the City of Dallas has constructed on the East Levee at Station 285+00 will be extended downstream to approximately Continental Avenue (approximately Station 170+00) to mitigate for the increase in risk due to the River Relocation. With implementation of the additional cut-off wall, there is no increase in risk due to the River Relocation. The City of Dallas' cut-off wall and the extension of the cut-off wall on the East Levee from approximately Station 170+00 to Station 285+00 are part of the Recommended Plan as a seepage mitigation measure for the River Relocation. Piezometers will be installed along the East and West Levee for seepage monitoring purposes.

4.1.2.2 Corinth Wetlands

The Corinth Wetlands extend from Oxbow Lake, downstream between the relocated Trinity River and the West Levee. The intent of this feature is to expand the existing wetlands in that area. The Corps will participate in vegetation plantings and excavation of the Corinth Wetlands. The total size of the Corinth Wetlands is approximately 84 acres. All remaining features will be provided by the City of Dallas under Section 408 including a boardwalk that borders the wetlands along the West Levee toe that is designed for

viewing of the features of the Corinth Wetlands. There are multiple landscape and grading plans for this area that all have varying descriptions and details of the amount and type of work to be completed in this area. Some plans show large amounts of landscape work including riparian woodland plantings. The intent is for the area specified in the environmental analysis for Corinth Wetlands to be emergent wetlands; however, in future design some tree plantings could be incorporated into the design. Upon further design, the final vegetation plan needs to be accounted for within the hydraulics and hydrology model for the Floodway.

4.1.2.3 Mitigation Analysis

There are several key laws and regulations that established policy for environmental mitigation requirements for federal actions. These requirements are in addition to the Compensatory Mitigation for Losses of Aquatic Resources (33 CFR §§ 325 and 332), which govern the Corps Regulatory Program. The Council of Environmental Quality regulations for Implementation of NEPA includes mitigation requirements in 40 CFR § 1508.20. The Corps ER 1105-2-100, Planning Guidance, requires that mitigation planning be an integral part of the overall planning process and includes avoiding impacts, if possible; minimizing impacts to extent practicable; rectifying impacts by repair, rehabilitation, or restoring the affected environment; reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and/or compensating for lost non-negligible resources through in-kind mitigation to the extent incrementally justified.

Modified Dallas Floodway Project Environmental Mitigation Analysis Results

The results of the environmental mitigation analysis indicate that for implementation of the MDFP, only grasslands show both habitat acreage and habitat unit losses over the future without-project condition through the 50-year period of analysis. The greatest reduction of habitat value is to grassland habitat. This is not because the habitat value is degrading, but because grassland would be converted to other habitat types upon implementing the River Relocation and Corinth Wetlands. Better function and values for the desired habitat types (considering changes in grassland habitat as a tradeoff for more desirable habitat types) is achieved in the future with-project than the future without-project condition over the 50-year period of analysis. The River Relocation and Corinth Wetlands increases habitat quality by approximately 143 AAHUs in the project area for the desired habitat types. For these reasons, mitigation for the MDFP is not recommended.

While the project moves into the design and implementation phase, the Corps recommends no net loss of bottomland hardwoods and emergent wetlands as construction occurs. No net loss of acres and habitat value will be considered. Unavoidable impacts during construction would be offset through implementation of the Corinth Wetlands and River Relocation with the addition of emergent wetlands and riparian/bottomland hardwood plantings with the River Relocation in the Recommended Plan.

To minimize the impacts to state listed mussel species during construction of the River Relocation, the system, the Corps will coordinate with the USFWS and the Texas Parks and Wildlife Department and the Texas Commission on Environmental Quality and develop an Aquatic Resource Recovery, Relocation, and Monitoring Plan or similar method. The plan will detail how the Corps will minimize impacts to mussel beds and other sensitive aquatic resources during construction. The plan could include measures such as minimizing disturbance to the existing river channel, leaving cut-off of segments of the river channel as mussel refugia, collecting and relocating mussels during dewatering of the river construction areas, and monitoring mussel population and community parameters after project completion. Impact minimization efforts are not expected to increase the total project cost.

USFWS Recommendations

The Corps has reviewed the recommendations provided by the USFWS in their Planning Aid Letter and can incorporate the measures in future design efforts or implement in operation and maintenance as described below. Planning Aid Report measures are listed as follows.

- Widen the riparian woodland corridor along the creeks and their associated tributaries as much as possible;
- Improve the existing riparian corridor and upland forests by thinning portions where it's too dense, and planting mast producing trees and shrubs where they are lacking;
- Provide brush and log piles in all existing habitats to provide cover for small mammals;
- Conduct Hazardous, Toxic, and Radioactive Waste tests where restoration work is proposed;
- Create off-stream wetlands;
- Plant locally available native aquatic plants and shrubs around the water edges;
- Construct proposed waterbodies with shelved floors of variable depths and appropriate substrates for habitat cover and spawning conditions;
- Implement a fish stocking plan, and do not use carp for vegetation control;
- Implement a monitoring program;
- Construct pool, riffle, run sequences where possible;
- Retain canopy cover where possible;
- Create native grasslands where possible;
- Implement a mowing program that promotes tall grass growth, but does not interfere with tall grass nesting birds; and
- Consider Birds of Conservation Concern 2002 during project planning.

In regards to the recommendation under the 4th bullet, the Corps felt there had already been enough background Hazardous, Toxic, and Radioactive Waste testing done within the proposed project that would preclude the need for further testing unless during construction suspect areas are encountered. The USFWS provided two recommended conservation measures in the final Fish and Wildlife Coordination Act Report (see Appendix G). The USFWS identified the potential for the mobilization of sediment and soil contaminants resulting from excavation activities. The USFWS recommended evaluating the fate and transport of contaminants and including measures to avoid or minimize exposure of contaminants by downstream biota. In addition, the USFWS recommended incorporating Best Management Practices to minimize non-point source pollution from adjacent transportation corridors and urban areas. Measures to address these concerns will be incorporated into the final design and construction specifications.

The Corps does not plan to adopt the recommendation for fish stocking (8th bullet) as the diversity of the fish species in the Trinity River and the existing Floodway ponds is already high. In addition, the same fish species are located in both the upstream and downstream river reaches and upon construction completion of the realigned river channel segments these species will repopulate the modified river channel. Finally, baseline aquatic IBI investigations and analysis note that the existing Floodway ponds in the study area have the same diversity of fish species as the river channel, so it is understood that during out of channel flooding events these same fish species will be introduced into the off-channel lakes so no fish stocking should be necessary.

4.2 MONITORING AND ADAPTIVE MANAGEMENT

Section 2039 of WRDA 2007 requires monitoring for all ecosystem restoration projects to: (1) assess project performance; (2) determine achievement of success; (3) determine whether adaptive management (adjustments) are needed. A Monitoring and Adaptive Management Plan for the MDFP was developed. The plan identifies and describes the monitoring and adaptive management activities proposed for the River Relocation and the Corinth Wetlands. This plan will be further developed in the PED phase as specific design details are made available. The plan describes and justifies that monitoring and adaptive management are needed for the MDFP. The plan outlines how the results of the project-specific monitoring program would be used to adaptively manage the project, including specification of conditions that will define project success. A preliminary cost estimate for implementation of the Monitoring and Adaptive Management Plan is $3,447,000. The detailed Monitoring and Adaptive Management Plan is provided in Appendix H of this feasibility report.

4.3 VALUE ENGINEERING

A value engineering workshop was performed October 1 – 5, 2012 using the Corps Value Engineering Job Plan. Forty-four items were identified by the Value Engineering team believed to improve project performance and/or cost effectiveness. Items were accepted, rejected or deferred to future design phases as detailed in the final Value Engineering report. The Value Engineering report recommended the levee raise alternatives be 3H:1V and the effective levee crest width be reduced to 14 feet from 16 feet. The project delivery team adopted the 3H:1V recommendation but not the reduction in levee crest. The reduction in crest width was rejected because it was thought to produce a safety hazard for the City of Dallas personnel that routinely drive equipment on the top of the levee for operation and maintenance purposes. An additional Value Engineering workshop would be performed when the project moves to the next phase of design development.

4.4 RISK ANALYSIS

4.4.1 Project Development Risk

The project delivery team and other members of the Corps (Fort Worth District, RMC, Agency Technical Review team) the City of Dallas and other resource agencies identified various risks related to design and the cost for proposed features in the BVP and IDP throughout the study process. The causes of the potential risks were identified, along with their consequence, likelihood, and uncertainty. Risks with a high or medium overall risk rating that could affect feasibility-level decisions on design and cost estimating include construction phasing, the River Relocation project, grading plans and the integration of the design of the multiple projects proposed in the Floodway including the Trinity Parkway. The risks were determined to be acceptable for a feasibility phase level of design and can be properly managed in design. Cost risks were mitigated with the cost and schedule risk analysis to develop cost contingencies. All project risks were documented in a risk register and will be used as a tool to develop the Project Management Plan for design and construction.

4.4.2 Levee Safety Risk

A risk assessment was performed during the study process as project features were analyzed and developed (Appendix C). The risk assessment identified the potential failure modes to define baseline (current) life-safety risk for the Dallas Floodway Project. A risk assessment was performed to measure the changes in life-safety risk that occur with the measures evaluated for contribution to NED. In a "with-project" condition, the 277,000 cfs levee raise (including the modification to the AT&SF Railroad Bridge) on the East and West Levee, risk of overtopping with a subsequent breach (PFM #2) is reduced but not below the recommended tolerable risk guideline (Figure 4-4). Figure 4-4 shows there is a slight increase in consequences on the West Levee with the 277,000 cfs levee raise. The reduction in probability of overtopping offsets the slight increase in consequences and reduces the overall risk associated with the West Levee raise. Levee armoring and controlled overtopping were evaluated to see if a breach could be prevented following an overtopping, and seepage cut-off walls were evaluated to address the internal erosion failure modes. Levee armoring, controlled overtopping or cut-off walls were not cost efficient means to reduce risk because they were high cost features and did not reduce total risk as discussed in Section 3.4.6.3. Total risk from a FRM planning standpoint could not be lowered beyond the recommended tolerable risk guideline because the overall risk is dominated by PFM #2 (Figure 4-5).

A Comprehensive Analysis phase risk assessment was performed on the major features of the BVP (BVP Lakes and River Relocation) and the Trinity Parkway. The risk assessment noted that where the proposed river meanders move closer to the levees, floodwaters moving through the basal sand layer could cause a seepage issue and proposed a cut-off wall as a mitigation feature. It is expected the BVP Lakes construction would not cause a seepage problem, but more robust remediation measures beyond the proposed clay liner in the lake might need to be implemented (e.g. an additional cut-off wall), pending additional analysis. The risk assessment found the Trinity Parkway embankment does no harm "geotechnically" and could have a slight favorable impact of improving consequences by delaying failure times and potential size of breach on the East Levee. An item of note is that the risk assessment only reviewed the general features of the Trinity Parkway using two critical cross sections; therefore, the results should never be used to completely replace prudent engineering analysis and design. To this end, as the Trinity Parkway progresses to the 65% design phase, the levee system would be analyzed using site-specific geotechnical parameters and more cross sections.

Figure 4-5 presents the total baseline life-safety risk and the changes that occur with the Recommended Plan. The combined risk is dominated by PFM #2; therefore, the baseline risk is located above the recommended tolerable risk guideline. Total risk is reduced with major Recommended Plan features including the 277,000 cfs levee raise, River Relocation (represented in Figure 4-5 as w/BVP, Cut-off Walls) and the Trinity Parkway.

4.4.3 Residual Risk

Although life-safety and economic risks are reduced with the Recommended Plan, residual risk remains once construction is complete. If the East and West Levees were to overtop and experience a breach, the areas behind the levees would experience significant economic damages to property and the potential for loss-of-life. Controlled overtopping to prevent a breach was evaluated, but the analysis shows if levee overtopping for some flood events exceeds the notch-capacity, then levee breaching may occur at a location on the levee outside the notch and not prevent a levee breach.

Figure 4-4 Levee Raise to Contain the 277,000 cfs Overtopping with Subsequent Breach (PFM #2) f-N Chart

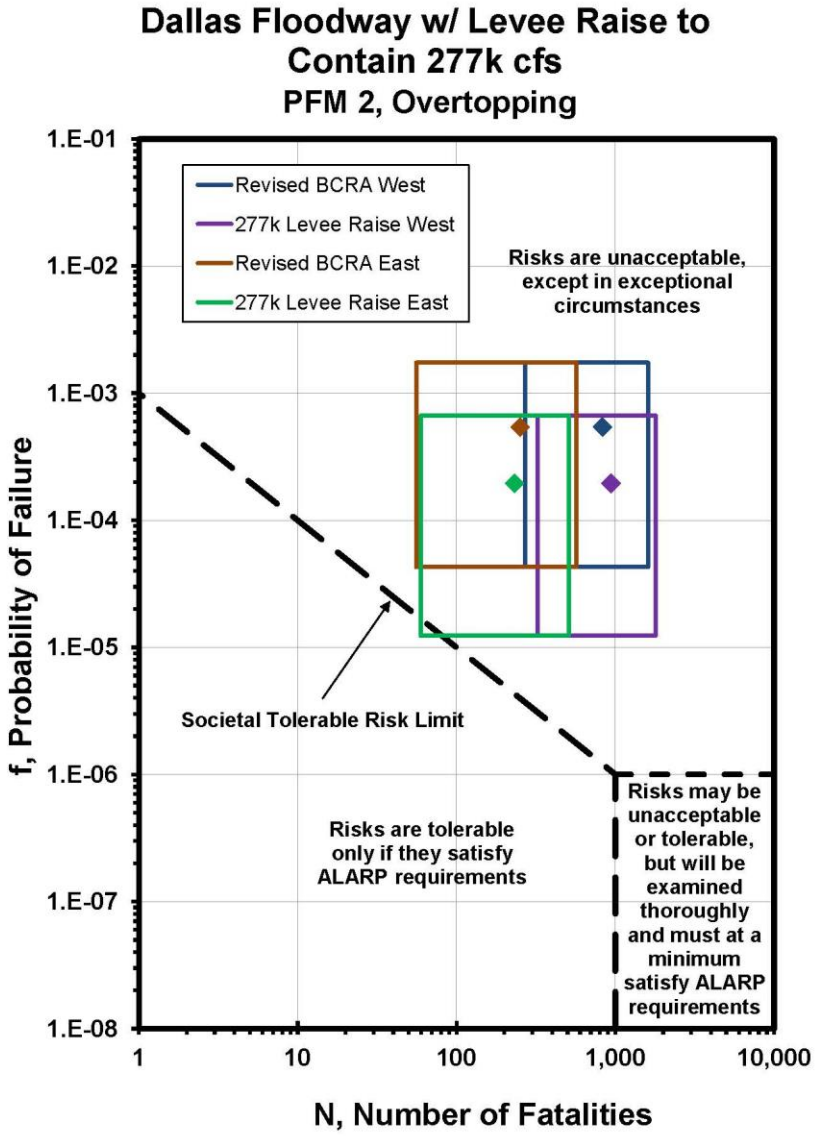
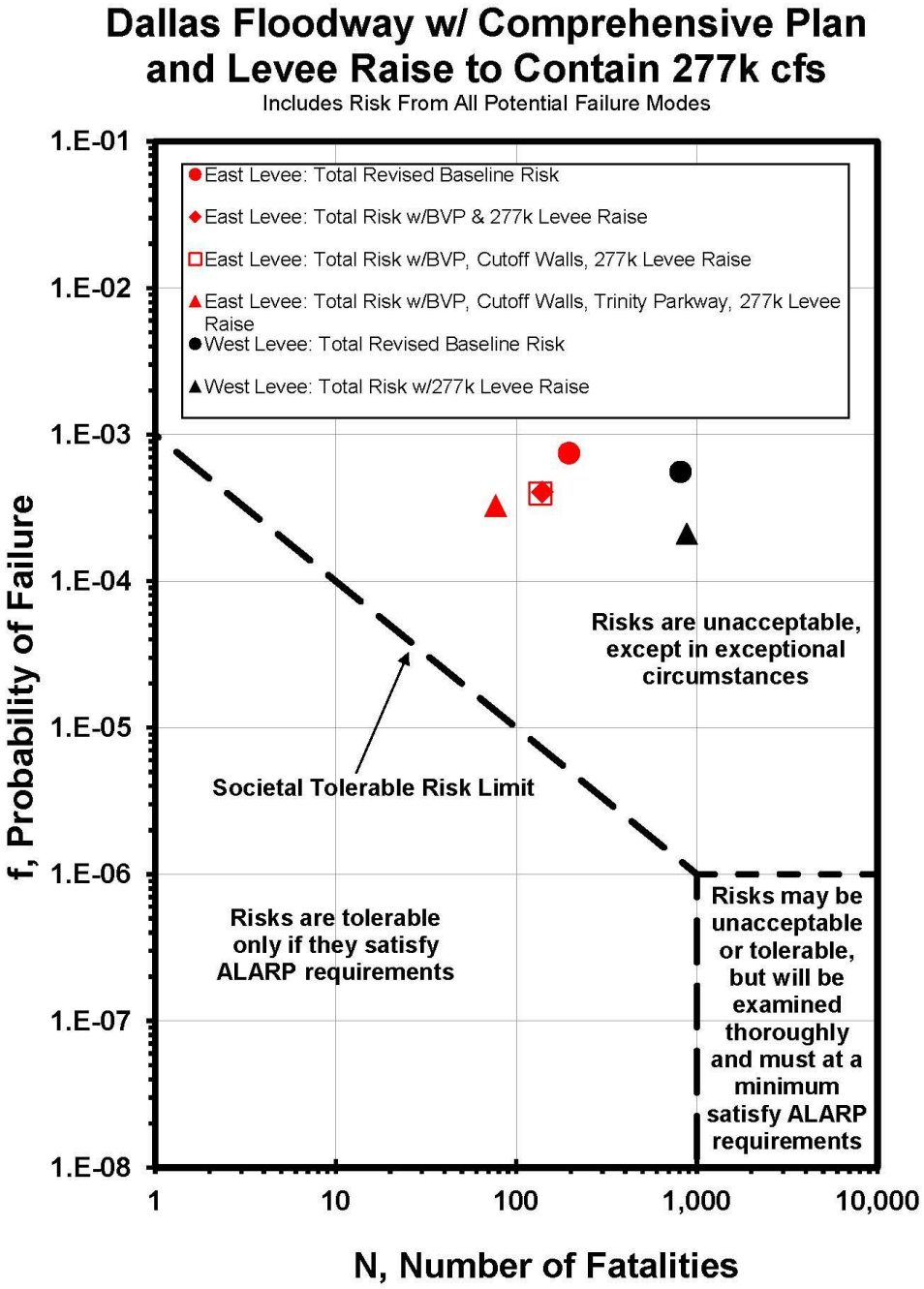


Figure 4-5 Total Risk Chart for the East and West Levee with Recommended Plan Features



Economic residual risk is expressed in an annualized dollar amount. The economic residual risk for the East and West Levee following implementation of the NED Plan is $3,817,000 in annualized damages. Life-safety residual risk can be expressed in terms of loss-of-life estimates for the East and West Levees with the Recommended Plan built. With implementation of the Recommended Plan, the estimated annualized life loss is 1.86E-2 for the East Levee and 1.85E-1 for the West Levee. Residual risk from the remaining PFMs not evaluated for risk reduction also remain. The following is the risk ranking for baseline conditions from Chapter 2. The PFM #2 risk is reduced by the implementation of the 277,000 cfs levee raise as shown in Figure 4-4. The City of Dallas intends to implement the 4H:1V side slopes, and although the risk reduction is not shown in an f-N Chart, the 4H:1V flattening is expected to further reduce risk and lower the best estimates of risk in the f-N Charts shown in Chapter 2 from the risk assessment.

- Overtopping erosion of the levee embankments (PFM #2).
- Overtopping and undermining erosion of the concrete floodwall (PFM #3).
- Backward erosion piping of a sand layer connected to the river and exposed in a landside sump (PFM #7).
- Blowout or heave of a clay confining layer in a landside sump followed by backward erosion piping of the underlying sand layer (PFM #8).
- Global instability of a levee embankment slope that takes out the crest in a single slip through the embankment and foundation (PFM #13a).
- Progressive instability of a levee embankment slope due to localized slumping, saturation, and more slumping (PFM #13b).

HEC-FDA produces project performance reports to display the hydrologic and hydraulic performance of a particular plan. Table 4-5 shows the project performance for the proposed 277,000 cfs levee raise and its impact on risk. The 277,000 cfs reduces the risk of exceeding the levee compared to the future without-project condition by 44.5% on the East Levee and 28% on the West Levee.

Table 4-5. Risk Performance of Proposed Levee Raise to 277,000 cfs

Without Project

		Long-Term Risk (years)			Assurance by Event					
Damage Reach	**Expected AEP**	**10**	**30**	**50**	**10%**	**4%**	**2%**	**1%**	**0.40%**	**0.20%**
East	0.1%	0.8%	2.3%	3.8%	100.0%	100.0%	99.9%	99.0%	92.1%	78.8%
West	0.1%	0.6%	1.8%	3.0%	100.0%	100.0%	99.94%	99.3%	93.8%	82.3%

With Project

		Long-Term Risk (years)			Assurance by Event					
Damage Reach	**Expected AEP**	**10**	**30**	**50**	**10%**	**4%**	**2%**	**1%**	**0.40%**	**0.20%**
East	0.04%	0.4%	1.3%	2.1%	100.0%	100.0%	100.0%	99.6%	95.8%	87.1%
West	0.04%	0.4%	1.3%	2.2%	100.0%	100.0%	99.97%	99.6%	95.8%	86.9%

Percent Change		Long-Term Risk (years)			Assurance by Event					
Damage Reach	**Expected AEP**	**10**	**30**	**50**	**10%**	**4%**	**2%**	**1%**	**0.40%**	**0.20%**
East	-50.0%	-44.9%	-44.6%	-44.5%	0.0%	0.0%	0.1%	0.5%	4.1%	10.6%
West	-33.3%	-29.0%	-28.3%	-28.0%	0.0%	0.0%	0.03%	0.3%	2.1%	5.6%

CHAPTER 5
PROJECT IMPLEMENTATION

5.1 STATUS OF ENVIRONMENTAL COMPLIANCE

The Environmental Impact Statement (EIS), provided under separate cover, presents the impact analysis for all resources in the study area for the Balanced Vision Plan (BVP) and Interior Drainage Plan (IDP) and can be referenced for additional detail for environmental compliance. The following sections summarize the Corps environmental compliance review of the Modified Dallas Floodway Project (MDFP). The EIS considers the overall BVP consisting of two related subsets: implementation of the MDFP and the remaining non-Federal BVP features, while taking into consideration the Trinity Parkway.

5.1.1 National Environmental Policy Act

In compliance. In accordance with NEPA, the Corps prepared and published a Notice of Intent in the Federal Register (Vol. 74, No. 195) on October 19, 2009 and hosted a public scoping meeting on November 17, 2009. The Notice of Intent is included in Appendix K (Supplemental Documentation). On May 8, 2014, the Corps and the City of Dallas hosted a public meeting to solicit comments on the Dallas Floodway Project Draft Feasibility Report and EIS. The Notice of Availability is also included in Appendix K.

5.1.2 Endangered Species Act

In compliance. Due to the lack of suitable habitat and the urbanized character of the project area, it is unlikely that any federally listed threatened or endangered species would become established in any of the study area. The Trinity River has a high diversity of bird species, and the area is likely to become more popular as an urban park. The interior least tern is the only listed species likely to be found in the area with any regularity. However, given the urban area, breeding populations are not likely to be established. Therefore, adverse effects to federally listed species are not anticipated with implementation of any of the proposed alternatives.

5.1.3 Fish and Wildlife Coordination Act

In compliance. The USFWS has provided Planning Aid Letters and Reports. The USFWS has reviewed the information contained in the EIS. The USFWS prepared a Final Fish and Wildlife Coordination Act Report for the feasibility report and is included in Appendix G. Additional detail regarding the adoption of the recommendations provided by the USFWS is provided in Section 4.1.2.3.

5.1.4 Clean Water Act

In compliance. The Section 404(b)(1) analysis is included in the Final EIS (Appendix L of the EIS). The Texas Commission on Environmental Quality (TCEQ) reviewed the EIS for the purpose of rendering a decision relative to State Water Quality Certification. Water Quality Certification was received on September 22, 2014. The EIS contains all Clean Water Act compliance documentation for the BVP and IDP.

5.1.5 Clean Air Act

In compliance. The air quality analysis in the EIS concluded that proposed emissions during construction could temporarily exceed the *de minimis* threshold for Nitrogen Oxide. Project implementation would

require additional coordination with the TCEQ for temporary exceedance authorization. General conformity compliance documentation was submitted to TCEQ to obtain a temporary exceedance authorization. The TCEQ provided a letter dated September 3, 2014 stating their requirements for General conformity have been met. The EIS contains the compliance documentation.

5.1.6 Migratory Bird Treaty Act

In compliance. Impacts to nesting bird species would be minimized to the greatest extent possible in compliance with the Migratory Bird Treaty Act. If proposed construction activities occur during the avian breeding season (February 15 through August 31), a biologist would check the proposed construction sites, including laydown areas, for active nests (in trees, shrubs, and on the ground) of Migratory Bird Treaty Act-protected species before the construction phase begins. If the biologist finds an active nest, the area surrounding the nest would be marked with flagging and on maps, and construction workers would avoid that area until the biologist determines the nest is no longer active.

5.1.7 Land and Water Conservation Fund Act

In compliance. There are 11 known sites in the study area constructed with the subject funds. Three sites are close to the limits of construction. Multiple parcels of lands were purchased with Land and Water funds in an area referred to as the Trinity River Greenbelt. The Texas Parks and Wildlife Department (TPWD) were contacted to determine whether there were any issues with developing these lands with the BVP and IDP. There are no anticipated impacts associated with these Land and Water sites. Coordination between the Corp, the City of Dallas and the TPWD would occur if any conservation and enhancement projects are proposed in the future.

5.1.8 Executive Order 11988 – Floodplain Management

In compliance. The Corps concluded there were no practicable alternatives to locating the proposed Flood Risk Management (FRM) and ecosystem restoration features in the base floodplain because they are site specific and require action in the floodplain. Recreation features could be sited outside the base floodplain but the desire to locate the recreation features in the Floodway would continue to exist. The changes to the existing urban development would remain on the landward side of the Dallas Floodway Levee System as it exists today, and revitalization of these areas could happen with or without the proposed action. Considerations to fish and wildlife, cultural resources, recreation, and other floodplain resources were considered in the EIS. Avoidance and minimization to existing floodplain resources was considered in the development of the alternatives. The ecosystem restoration features are intended to preserve and improve natural floodplain values. The Recommended Plan provides greater habitat functions and values over existing conditions, especially for the aquatic habitats of greatest concern, i.e. wetlands, bottomland hardwoods, and aquatic riverine.

The Water Resources Council Floodplain Management Guidelines for implementation of Executive Order (EO) 11988, as referenced in Corps ER 1165-2-26, requires an eight-step process that agencies should carry out as part of their decision-making on projects that have potential impacts to or within the floodplain. The eight steps reflect the decision-making process required in Section 2(a) of the EO. A response to the eight-step process for the overall BVP and IDP is provided in Section 6.5 of the EIS.

5.1.9 Executive Order 11990 – Protection of Wetlands

In compliance. The overall BVP and IDP would initially impact lower quality wetlands, but ultimately either increase the size and/or the functional quality of wetlands occurring within the project area. There is a slight loss in wetland acreages with the MDFP; however, the AAHU estimates are positive. The River

Relocation and Corinth Wetlands increases habitat quality by approximately 143 AAHUs in the project area for the desired habitat types. For these reasons, mitigation for the MDFP is not recommended.

5.1.10 Executive Order 12898 – Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations.

In compliance. The EIS considers disproportionately high and adverse effects on minority, low-income, and child populations. Access restrictions during construction would be temporary. In the long-term beneficial recreational opportunities would increase for low-income, minority and child populations. Additional discussion is provided in Section 6.7 of the EIS for compliance with this EO.

5.1.11 U.S. Army Corps of Engineers and Federal Aviation Administration Memorandum of Agreement

In compliance. The project was coordinated with the Federal Aviation Administration, Corps, and the City of Dallas to determine if the action would create a potentially hazardous wildlife attractant. Coordination with the Federal Aviation Administration is complete and has alleviated concerns regarding hazardous wildlife impacting air traffic to and from Dallas Love Field, and helicopter traffic.

5.1.12 Cultural Resources Compliance

Section 106

In compliance. Section 405(a) of the 2010 Supplemental Disaster Relief and Summer Jobs Act (Public Law 111-212) states that the Army is not required to make determinations of eligibility under the National Historic Preservation Act for the Dallas Floodway Project. The Corps IG dated October 19, 2010 directs the Fort Worth District not to make further determinations under the National Historic Preservation Act.

NEPA

In compliance. The Corps IG dated October 19, 2010 directs the Fort Worth District to examine, describe, and consider the built environment that comprises the Dallas Floodway Project as cultural resources within the context of the scope of impacts that must be analyzed under NEPA.

A detailed description of impacts to the project regarding the integrity as a historic and cultural resource is provided in the EIS. The impacts are associated with changing the character and design of the Dallas Floodway Project. The impact is partially mitigated by the documentation provided in the 2010 Intensive Engineering Inventory and Analysis of the Dallas Floodway, Dallas, Texas as it records the Floodway holistically. Specific character-defining features that are diminished (ATS&F Bridge, Charlie and Baker Pump Stations) shall be individually documented to Historic American Building Survey Standards prior to implementing the undertaking. The remaining mitigation includes completing the documentation and recordation process.

During construction, an archeologist will monitor excavation. Should any significant cultural resources be identified, mitigation procedures will take place prior to further excavation. Costs for the mitigation are included in the total project cost. Discovery costs are captured in the contingency for the MDFP construction effort.

5.1.13 Comprehensive Environmental Response, Compensation, and Liability Act & Resource Conservation and Recovery Act

In compliance. In 2010, a Phase I Background Database Search was conducted and a report was prepared. The search was updated in 2013 and a total of 34 sites were within the estimated construction limits. A

Phase II investigation from 2008 showed presence of contaminants of concern and only two out of approximately 200 samples were slightly in excess of the Protective Conservation Levels for a 30-acre source area. All listed facilities were assessed by the Corps and no additional Phase II investigations are warranted. Contaminated areas could be encountered during demolition or constructed-related activities; however, a soil management plan would contain a contingency plan for encountering material during construction.

5.2 PROJECT CONSTRUCTION & PROJECT PHASING

Implementation of the BVP and IDP would occur over an approximately 10-year to 12-year period, with design beginning in 2015. This assumes that capability level funding would be provided. If funds are not provided then construction could extend out to 20-25 years or more. In order to construct the project efficiently, appropriate project phasing of the MDFP is imperative.

5.2.1 Additional Design and Modeling

The feasibility-level analysis conducted for this study was completed on the entire system as a comprehensive system. This Comprehensive Analysis included all features of the BVP and IDP along with the other local projects identified in the future without-project condition. The purpose of this was to ensure that the Dallas Floodway would continue to function as a system. During this process, the FRM features were modeled as a group and then each feature proposed for implementation that was not already part of the future without-project condition was added for the comprehensive analysis. Due to the size of the project, each feature was not incrementally modeled to ensure it would not have independent affects on hydrology and hydraulics or geotechnical conditions. As with any Corps project, additional modeling will have to be completed for each feature as they are designed and proposed for construction to ensure that they do not have significant impacts during the project phasing. In addition, the final design for each feature needs to be added to the Comprehensive Analysis model to ensure that it still functions from a system perspective. This may require interim hydraulic and geotechnical mitigation features during the construction phasing. Finally, if there are impacts that are significantly different from what is disclosed in this feasibility report, causing substantial impacts to costs, or increased environmental damages then the appropriate course of action will be taken to include possible Limited Reevaluation Report, General Reevaluation Report, or supplemental environmental documents.

5.2.2 Project Phasing

The MDFP construction will begin with utility relocation, followed by the FRM features (levee raises and the AT&SF Railroad Bridge modification). Side-slope flattening is recommended to take place concurrent to the levee raises. Interior drainage pump stations can be phased in any order. The River Relocation design could be initiated while the FRM features are under construction. The River Relocation design and construction would be split into three phases (bottom, middle and top segments), and would occur over multiple years. Bridge pier modifications are required as the River Relocation is constructed. Construction sequencing of MDFP features is dependent upon the construction schedule of the Trinity Parkway, specifically the River Relocation (cut-off walls, and the Trinity Parkway borrow source, and the 4H:1V side slope flattening on the East Levee); however, these MDFP features are not dependent on the Trinity Parkway being built. The Corinth Wetlands would be designed and constructed to compensate for Floodway habitat losses as they occur due to the levee raises and other MDFP features. Any excess borrow material could be utilized as rough grading for BVP features that are not part of the MDFP.

After the MDFP is constructed, it is expected that the Section 408s for the remaining BVP features will be implemented if they are approved through the Section 408 approval process. These remaining BVP features are primarily all of the recreation features being implemented. The surface treatment recreational features such as trails and flex fields can be implemented easily after construction of the MDFP. If they are implemented prior, the Corps would ensure that the construction of these facilities does not impact the ability to construct the MDFP.

The BVP Lakes are a little more difficult to plan for the construction. It is currently expected that the first phase of the lakes will be constructed as part of the Trinity Parkway, if that project is approved for construction as a Section 408. The interim condition of the lakes will be borrow pits that will be converted to lakes by the City of Dallas. During the design approval process for the lakes, the Corps will ensure that interim conditions do not result in increased risks to the levee system. For example, while the Corps is constructing the levee raises and 4H:1V slope flattening, open borrow pits after construction would not be allowed without requiring clay liners, if they are confirmed to be needed during the design phase. This is to ensure the integrity and functioning of the levee system continues throughout the construction phases.

5.2.3 Project Dependencies

The MDFP could be constructed without any other feature implemented; however, it is unlikely for this situation to occur because the City of Dallas plans to implement the remaining features of the BVP and IDP, and local projects will also be implemented. Phasing of construction needs to be coordinated to ensure critical items are constructed first (e.g. the cut-off walls need to be installed prior to the River Relocation construction effort along the stretch of the East Levee were underseepage risk is increased). In the final design efforts, the Floodway must maintain functionality at all stages of construction. Based on the designs provided several projects rely on the partial or full construction of other features prior to their construction. Design integration issues will be coordinated during the Section 408 review process and managed in a risk register and risk management plan developed and managed in the PED phase of the MDFP. There might be increased costs to construct interim measures to ensure project functionality; however, it is not anticipated this would be a cost risk for the MDFP.

Finally, as mentioned in previous sections, it was assumed that the Dallas Floodway Extension (DFE) Project is built in the future. If the DFE Project is not eventually fully constructed, then the City of Dallas might chose to improve the East Levee floodwall, because the risk assessment identified the floodwall as an area of concern. The floodwall concern is alleviated by the construction of the Lamar Levee portion of the DFE Project. However, the MDFP can be implemented without the DFE Project being fully constructed.

5.3 OPERATION, MAINTENANCE, REPAIR, REPLACEMENT, AND REHABILITATION

The non-Federal sponsor is responsible for the Operations, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R) of the complete project. The Fort Worth District will update the existing Dallas Floodway O&M Plan dated May 1960 upon successful completion of the MDFP. A comprehensive O&M Plan will be created for the entire BVP and IDP by the City of Dallas to account for the remaining BVP and IDP features and the MDFP. Maintenance will be required throughout project construction. Table 5-1 shows the expected annual OMRR&R costs over and above existing costs

associated with the MDFP. The MDFP is expected to increase existing OMRR&R costs by $1,677,000 annually.

The new design grade is based on the elevation of the 277,000 cfs flow rate for the East and West Levee at the time of construction. An updated O&M Plan will specify new design grade and maintenance requirements for the City of Dallas. The new design grade will be specific to the 277,000 cfs flow, not the associated frequency. Targeting a flow at a given time instead of a frequency will allow for clear understanding for design grade requirements in the future O&M Plan.

The BVP and IDP have started to develop an O&M Plan that is further discussed in the City of Dallas design submittals. The City of Dallas currently performs mowing operations across the existing Dallas Floodway Project. These mowing operations will be modified after the construction of all features. Future mowing plans need to be in accordance with landscape preferences for grass length and need to be aware of new wetland features and other vegetation. Additionally, it is important from a hydraulic standpoint that vegetation features be maintained to ensure proper conveyance of water. Debris after a flood event will also be prevalent and will need to be removed to allow for proper water conveyance and hydraulic performance. All BVP features will be inundated on average during the 10 to 25-year storm recurrence intervals.

Routine inspections (annual and periodic) of all elements in the MDFP are required. Features should be inspected on an annual basis prior to the rainy season and after every major flood event, at required periodic intervals. All inspections will be performed by the City of Dallas. Any defects during inspection would be remedied by the City of Dallas to ensure the functionality of the Dallas Floodway Project is not compromised. The estimated increase in annual and periodic inspections for the overall BVP and IDP is $127,500. The NED Plan and the side slope flattening would not increase existing annual inspection costs. The East and West Levee IDP and ecosystem restoration features would require the additional cost for inspections of $25,000 as presented in Table 5-1.

The existing level of maintenance performed by the City of Dallas on the levees would increase annually due to additional surface to mow. The increased capacity of the pump stations would require an increase in annual maintenance. Plantings along the relocated Trinity River and Corinth Wetlands would require annual maintenance, especially immediately after planting. The estimated increase in routine maintenance for the plantings is $22,000.

Slides would continue to require repair as they occur, but costs would decrease by 20% based on current estimated annual cost of repairs of $1,000,000. The increased capacity of the pump stations would require an increase in annual repair and replacement costs. Routine repair and replacement cost ($1,500,000) for the River Relocation were estimations derived from a percentage of the total cost to construct bank stabilization features.

Table 5-1. City of Dallas Estimated Change in Annual OMRR&R Costs for the Recommended Plan

Feature	*Annualized Cost*		
	Routine Inspections	*Routine Maintenance*	*Repair & Replacement*
Levees	$0	$30,000	($200,000)
Interior Drainage Plan	$10,000	$50,000	$50,000
River Relocation & Corinth Wetlands	$15,000	$22,000	$1,500,000
Total	**$25,000**	**$102,000**	**$1,550,000**

5.4 TOTAL PROJECT COST

The costs associated with the MDFP are presented in Table 5-2. The MDFP is estimated to cost approximately $560,839,000 at October 2013 price levels. Appendix J (Detailed Cost Estimate and Cost Analysis) contains the cost estimate and Cost and Schedule Risk Analysis for the Recommended Plan. The fully funded cost estimate is $673,066,000. The fully funded cost estimate remains under the authorized cost limit for the project provided by Section 902 of $717,260,000. The project can proceed to design and construction without additional authorization from Congress.

Table 5-2. Cost Estimate Summary for the Recommended Plan

Total First Cost October 2013 Price Level	
FLOOD RISK MANAGEMENT	
01 Lands and Damages	$12,145,000
08 Roads, Railroads, and Bridges	$1,499,000
11 Levees and Floodwalls	$6,543,000
13 Pumping Plant	$176,490,000
30 Planning, Engineering and Design	$19,607,000
31 Construction Management	$21,364,000
Flood Risk Management Total	**$237,648,000**
ECOSYSTEM RESTORATION	
01 Lands and Damages	$16,000
02 Relocations	$44,881,000
06 Fish and Wildlife	$5,796,000
08 Roads, Railroads and Bridges	$38,229,000
09 Channels	$182,483,000
30 Planning, Engineering and Design	$29,046,000
31 Construction Management	$25,740,000
Ecosystem Restoration Total	**$323,191,000**
Total	**$560,839,000**

The following is a discussion of the scope of the Recommended Plan features by code of accounts. Additional detail on the scope of the Recommended Plan features is located in Section 4.1. Cost share summaries (Federal and non-Federal) for the total project cost are described in Section 5.5 of this report.

5.4.1 Flood Risk Management

The costs for the FRM features of the MDFP are in the Lands and Damages (01); Roads, Railroads and Bridges (08); Levees and Floodwalls (11); Pumping Plant (13); Planning, Engineering and Design (30); and Construction Management (31) accounts. The total FRM cost is $237,648,000.

The Lands and Damages (01) estimate includes real estate requirements for the Interior Drainage improvements at Baker, Charlie, Hampton, and Trinity Portland Pump Stations. The real estate is estimated at $207,000 for Charlie, $8,795,000 for Hampton, $677,000 for Trinity Portland, and the City of Dallas has spent $2,466,000 on the Baker Pump Station real estate. Since the Baker Pump Station is already under construction, a determination was made that the real estate costs was integral to

implementation of the MDFP and was eligible for lands, easements, right-of-ways, and disposals (LERRDs).

The costs for the levee raise and AT&SF Bridge modification construction is included in the Roads, Railroads and Bridges (08) and Levees and Floodwalls (11) accounts. This includes the cost for the AT&SF Bridge modification of $1,499,000 and raising the low spots in the levee system for $6,543,000, respectively.

The Pumping Plant (13) account includes the estimate for construction of the Baker, Charlie, Delta, Hampton, and Trinity Portland Interior Drainage improvements. The costs for the Pump Stations are as follows: Baker Pump Station ($37,869,000), Charlie Pump Station ($39,393,000), Delta Pump Station ($4,023,000), Hampton Pump Station and Nobles Branch Sump Improvements ($59,746,000) and Trinity Portland Pump Station ($35,459,000) for a total of $176,490,000.

The Planning, Engineering and Design (30) and the Construction Management (31) cost estimates are based on 12% of the construction costs for the FRM features. The total PED estimate ($19,607,000) and Construction Management estimate ($21,364,000) for the FRM features is $40,971,000.

The total project cost estimate is a roll up of totals by account. The estimates for the individual project features including Construction, LERRDs, PED, and construction management are as follows. The levee raise and AT&SF Bridge modification ($9,744,000), Baker Pump Station ($50,206,000), Charlie Pump Station ($47,953,000), Delta Pump Improvements ($4,881,000), Hampton Pump Station and Nobles Branch Sump Improvements ($81,211,000) and Trinity Portland ($43,653,000) for a total estimate of $237,648,000 for FRM.

5.4.2 Ecosystem Restoration

The costs for the ecosystem restoration features of the MDFP are in the Lands and Damages (01); Relocations (02); Fish and Wildlife (06); Roads, Railroads and Bridges (08); Levees and Floodwalls (11); Planning, Engineering and Design (30); and Construction Management (31) accounts. The total ecosystem restoration cost is $323,191,000.

The Lands and Damages (01) estimate includes real estate requirements for the river relocation at $16,000. The Relocations (02) account includes the costs for moving the existing utilities located in the Floodway to accommodate the River Relocation feature as described in Section 4.1.2.1 of this report. The cost for the utility relocation costs is $41,881,000. This is included in the total project cost under LERRDs and is conducted at 100% non-Federal expense. Bridge pier modifications under the Roads, Railroads and Bridges (08) account are required for the River Relocation and are estimated at $38,229,000.

The Corinth Wetlands cost estimate is included in the Fish and Wildlife (06) account. The costs for grading and wetland plantings are $5,796,000. The remaining work includes the new channel excavation and the backfill of the original modified channel under the Channels (09) account for $182,483,000.

The Planning, Engineering and Design (30) and the Construction Management (31) cost estimates are based on 12% of the construction costs for the ecosystem restoration features. The total PED estimate ($29,046,000) and Cost Management estimate ($25,740,000) for the ecosystem restoration features is $54,786,000.

5.5 COST SHARING

This section of the report discusses the cost sharing requirements for the study. These requirements include showing what cost sharing would be both without considerations of work-in-kind (WIK) credit and with WIK credit. In addition, WIK credit and its applicability to the project is discussed in detail. Finally, the betterments being proposed are discussed and summarized.

Table 5-3 displays the cost sharing required for the Recommended Plan if there were no WIK credit available for the project. The Recommended Plan is estimated to cost $560,839,000 that would be cost shared 65% Federal at $364,545,000 and 35% non-Federal at $196,294,000. The structural FRM and ecosystem restoration cost share requirements differ as follows. The non-Federal interests have a flat 35% cost sharing requirement for ecosystem restoration projects, with credit granted for any LERRD, non-Federal interests for structural FRM are required to provide a minimum 5% cash contribution as well as an overall minimum 35% contribution that can be as high as 50% depending upon LERRD value. The project authorization allows the City of Dallas to receive credit for implementing project features in advance of signing the Project Partnership Agreement (PPA). Post PPA work is excluded. By the time a PPA is executed, the City of Dallas is expected to have potential WIK credit. Table 5-4 displays the cost sharing taking into consideration how much credit the City of Dallas might be eligible for. Table 5-4 is only an estimate and the actual amount of credit would be finalized at the end of the project.

Table 5-3. Cost Share Summary of the Recommended Plan Without Credit, October 2013 Price Level

Feature	*Federal*	*Non-Federal*	*Total*
FLOOD RISK MANAGEMENT			
Construction	$154,471,000		$154,471,000
LERRDs		$12,145,000	$12,145,000
5% Cash		$11,882,000	$11,882,000
Credit			$0
Additional Cash		$59,150,000	$59,150,000
Subtotal	**$154,471,000**	**$83,177,000**	**$237,648,000**
Percentage	**65%**	**35%**	
ECOSYSTEM RESTORATION			
Construction	$210,074,000		$210,074,000
LERRDs		$41,897,000	$41,897,000
Credit			$0
Additional Cash		$71,220,000	$71,220,000
Subtotal	**$210,074,000**	**$113,117,000**	**$323,191,000**
Percentage	**65%**	**35%**	
Subtotal Combined Flood Risk Management/Ecosystem Restoration	**$364,545,000**	**$196,294,000**	**$560,839,000**
Combined Percentages	**65%**	**35%**	

Table 5-4. Cost Share Summary of the Recommended Plan With Credit Consideration, October 2013 Price Level

Feature	*Federal*	*Non-Federal*	*Total*
FLOOD RISK MANAGEMENT			
Construction	$154,471,000		$154,471,000
LERRDs		$12,145,000	$12,145,000
5% Cash		$11,882,000	$11,882,000
Credit		$47,740,000	$47,740,000
Additional Cash		$11,410,000	$11,410,000
Subtotal	**$154,471,000**	**$83,177,000**	**$237,648,000**
Percentage	**65%**	**35%**	
ECOSYSTEM RESTORATION			
Construction	$210,074,000		$210,074,000
LERRDs		$41,897,000	$41,897,000
Credit		$25,739,000	$25,739,000
Additional Cash		$45,481,000	$45,481,000
Subtotal	**$210,074,000**	**$113,117,000**	**$323,191,000**
Percentage	**65%**	**35%**	
Subtotal Combined Flood Risk Management/Ecosystem Restoration	**$364,545,000**	**$196,294,000**	**$560,839,000**
Combined Percentages	**65%**	**35%**	

5.5.1 Work-in-Kind

Section 5141 of WRDA 2007 and subsequent IG authorized the City of Dallas to receive credit for WIK in accordance with Section 221(a) of the Flood Control Act of 1970, as amended, if the MDFP is determined to be technically sound and environmentally acceptable. This feasibility report is making that determination when signed. In addition, the IG for Section 5141 allows for excess credit earned during feasibility to roll over to Design and Construction. *A Memorandum of Understanding (MOU) between the Department of the Army and the City of Dallas, Texas for Work Provided or Performed Prior to the Execution of a Project Partnership Agreement* was executed for the Dallas Floodway on June 10, 2009. In order to receive credit the City of Dallas must comply with this MOU in order to receive credit for work performed as WIK. The following sections describe potential WIK performed by the City of Dallas. However, the credit is applied to both project features since there will be only one PPA that will cover the entire project.

5.5.1.1 Feasibility Study

A Feasibility Cost Share Agreement was executed for this study on May 5, 2010 for a total feasibility study cost of $38,600,000. The potential WIK for the feasibility study was estimated at $22,900,000 in the Feasibility Cost Share Agreement for this study. In accordance with the IG for Section 5141, excess feasibility study costs would roll into the design phase and excess design credit would roll into the construction phase. It is estimated that excess feasibility credit would total around $3,900,000 and that no non-Federal funds are required in addition to the WIK. However, the feasibility study only received $9,738,000 in Federal funds, so the City of Dallas provided $2,577,000 in non-Federal funds. The feasibility study is expected to be completed utilizing the Federal and non-Federal funds on hand as well

as the City of Dallas' WIK. This will be well under the estimated $38,600,000, but will result in an estimated $15,739,000 in excess feasibility study WIK. The feasibility study WIK was necessary for the study and does not get applied to the total project construction cost, but it does serve to reduce the additional cash required by the non-Federal sponsor. During budgeting processes additional Federal funds would be requested to cover the feasibility study WIK credit.

5.5.1.2 Baker Pump Station

The Baker Pump Station is a feature identified in the East Levee IDP that was approved for construction in advance of the feasibility study as a Section 408. It was approved by Corps HQ and the City of Dallas was given construction approval on May 4, 2012. Through the feasibility study process, it was determined to be integral to the project and eligible for WIK credit. Therefore, the City of Dallas is requesting WIK credit for the design and construction costs of Baker Pump Station. The potential WIK credit is estimated at $37,869,000 for construction, $3,115,000 for design, and $6,756,000 for construction management and design during construction for a total estimated WIK credit of $47,740,000.

5.5.1.3 Cut-off Wall

The cut-off wall is a feature approved for construction as a Section 408. The Channels account includes $10,000,000 of WIK credit for the seepage cut-off walls constructed by the City of Dallas for their 100-year FEMA efforts. The Comprehensive Analysis concluded the City of Dallas' cut-off walls were integral to the River Relocation construction. The cut-off walls are part of a larger system of cut-off walls required for the River Relocation as a seepage mitigation feature. Therefore, the City of Dallas is requesting WIK credit for the cut-off wall in the amount of $10,000,000.

5.5.1.4 Able Pump Station

The Able Pump Station is a feature identified in the East Levee IDP that is currently being processed for approval for construction in advance of the feasibility study as a Section 408. Through the feasibility study process, it was determined that all pump stations are integral to the project and eligible for WIK credit. However, the City of Dallas is not requesting WIK credit for the design and construction costs of Able Pump Station. Therefore, the City of Dallas is forgoing potential WIK credit of $120,183,000.

5.5.1.5 Pavaho Pump Station

The Pavaho Pump Station is a feature identified in the West Levee IDP that was approved for construction in advance of the feasibility study as a Section 408 and is currently 100% operational. Through the feasibility study process, it was determined that all pump stations are integral to the project and eligible for WIK credit. However, the City of Dallas is not requesting WIK credit for the design and construction costs of Pavaho Pump Station. Therefore, the City of Dallas is forgoing potential WIK credit of $32,473,000.

5.5.1.6 Transportation and Remaining BVP Items

The City of Dallas and other entities including Federal Highway Administration has spent a tremendous amount of funds on planning, designing and construction of transportation and recreation amenities within the Dallas Floodway. These projects were approved or are being reviewed as Section 408s and are not eligible for WIK credit.

5.5.1.7 WIK Summary

The total amount of WIK credit proposed by the City of Dallas that is integral to the Recommended Plan and can be applied towards implementation costs under FRM is $47,470,000 and under ecosystem restoration is $10,000,000 for the seepage cut-off walls required for the River Relocation for a total of

$57,470,000 in eligible WIK credit. In addition, there is an estimated $15,739,000 in excess feasibility study WIK that can be applied to additional cash requirements of either FRM or ecosystem restoration. It was applied to ecosystem restoration so that it did not have to be split out amongst both. Refer to Table 5-4 for the cost sharing considering WIK credit.

5.5.2 Betterments

The proposed construction of the MDFP is covered under the project authorization and reconstruction authority is not necessary.

Implementation of the 4H:1V side slopes is considered a betterment. Under the authority of Public Law 84-99 (Flood Control and Coastal Emergency Act), an eligible flood protection system can be rehabilitated if damaged by a flood event. The flood system would be restored to its pre-disaster status at no cost to the Federal system owner, and at 20% cost to the eligible non-Federal system owner. If the levees are damaged by a flood event, the City of Dallas would be responsible for the cost to build back to a 4H:1V in excess of the 3H:1V. The construction cost of the 4H:1V is estimated at October 2013 price levels of approximately $45,692,500 and would be 100% non-Federal financial responsibility. Betterment costs also do not count towards the Section 902 construction limit and are not included in the certified cost estimate.

5.6 PROJECT IMPLEMENTATION SCHEDULE

Table 5-5 displays the project implementation schedule and funding for the Recommended Plan. See Section 5.8.5 for additional information on the contract schedule.

Table 5-5. Project Implementation Schedule and Funding Requirements for the Recommended Plan, October 2013 Price Level

Feature	*Year*											
Flood Risk Management	**Sunk Costs**	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
01 Lands and Damages	$2,466,000				6,207,000	2,795,000	677,000					
06 Fish and Wildlife Facilities												
08 Roads, Railroads, and Bridges				1,499,000								
11 Levees and Floodwalls				6,543,000								
13 Pumping Plant	$37,869000						50,000,000	49,139,000			39,482,000	
30 Planning, Engineering and Design	$3,115,000	$903,000	6,718,000	4,429,000	457,000	3,985,000						
31 Construction Management	$6,756,000			799,000			5,000,000	4,876,000			3,933,000	
Ecosystem Restoration												
01 Lands and Damages				16,000								
02 Relocations				5,092,000				17,630,000		19,159,000		
06 Fish and Wildlife Facilities									5,796,000			
08 Roads, Railroads, and Bridges					355,000					13,708,000	24,166,000	
09 Channels	$10,000,000				54,184,000				66,156,000			52,143,000
30 Planning, Engineering and Design			6,707,000		2,000,000	8,958,000		11,381,000				
31 Construction Management					5,939,000				9,713,000			10,088,000
Total	**$60,206,000**	**$903,000**	**13,425,000**	**18,378,000**	**69,142,000**	**15,738,000**	**55,677,000**	**83,026,000**	**81,665,000**	**$32,867,000**	**67,581,000**	**62,231,000**

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5.7 FULLY FUNDED COST ESTIMATE

The fully funded cost estimate is intended to provide an indication of the total project cost when inflation is taken into account. Inflation rates are based on rates developed as part of the Corps budgeting process. The fully funded cost estimate for the MDFP is $673,066,000. Details are included in Appendix J (Detailed Cost Estimate and Cost Analysis).

5.8 PRE-CONSTRUCTION ENGINEERING AND DESIGN

5.8.1 Detailed Documentation Report and Plans and Specifications

Prior to initiating the Pre-construction, Engineering and Design (PED) phase, the design team must develop a Project Management Plan (PMP) which defines the scope, work breakdown structure, schedule, and budget to complete PED. Additional items in the PMP are related to value management and engineering, quality control, communication, change management, and acquisition strategy. The draft PMP must be developed, negotiated, and agreed upon by all parties of the PED phase prior to initiation of the PED phase.

A number of activities are expected to take place during PED phase. These include the completion of a Design Documentation Report (DDR), plans and specifications (P&S), execution of the PPA, and contract award activities. The development of the DDR includes completing the final design of project features. As part of the DDR, the team will complete any ground surveys, utility surveys, and drilling and testing for subsurface (geotechnical) conditions as necessary to complete the final design. Design parameters for all project features will be defined for development of the plans and specifications. The P&S includes the development of project construction drawings and specifications, estimation of final quantities, and completion of the Government cost estimate. It is estimated that as many as nine sets of P&S will be developed for the MDFP. Arrangements for on-site archeological monitoring during construction should be documented in the PPA.

5.8.2 Project Partnership Agreement and Items of Non-Federal Responsibility

The PPA is a binding agreement between the Federal Government and the non-Federal sponsor which must be approved and executed prior to the start of construction. The PPA sets forth the obligations of each party. The non-Federal sponsor must agree to meet the requirements for non-Federal responsibilities which will be identified in future legal documents. Federal implementation of the recommended project would be subject to the non-Federal sponsor agreeing to comply with applicable Federal laws and policies, including but not limited to:

- Provide 35% of design costs in accordance with the terms of a design agreement entered into prior to commencement of design work;
- Provide a minimum of 35%, but not to exceed 50% of total structural FRM costs as further specified below:
  - Provide, during the first year of construction, any additional funds necessary to pay the full non-Federal share of design costs allocated by the Government to the structural FRM features;
  - Provide, during construction, a contribution of funds equal to 5% of total structural FRM costs;

  - Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material all as determined by the Government to be required or to be necessary for the construction, operation, and maintenance of the structural FRM features;
  - Provide, during construction, any additional funds necessary to make its total contribution for structural FRM equal to at least 35% of total structural FRM costs;
- Provide 35% total nonstructural FRM costs as further specified below:
  - Provide, during the first year of construction, any additional funds necessary to pay the full non-Federal share of design costs allocated by the Government to the nonstructural FRM features;
  - Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material all as determined by the Government to be required or to be necessary for the construction, operation, and maintenance of the non-structural FRM features;
  - Provide, during construction, any additional funds necessary to make its total contribution for non-structural FRM equal to 35% of total nonstructural FRM costs;
- Provide 35% of total ecosystem restoration costs as further specified below:
  - Provide, during the first year of construction, any additional funds necessary to pay the full non-Federal share of design costs allocated by the Government to the ecosystem restoration features;
  - Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material all as determined by the Government to be required or to be necessary for the construction, operation, and maintenance of the ecosystem restoration features;
  - Provide, during construction, any additional funds necessary to make its total contribution for ecosystem restoration equal to 35% of total ecosystem restoration costs;
- Shall not use funds from other Federal programs, including any non-Federal contribution required as a matching share thereof, to meet any of the non-Federal obligations for the project unless the Federal agency providing the funds verifies in writing that such funds are authorized to carry out the project;
- Not less than once each year, inform affected interests of the extent of risk reduction afforded by the FRM features;
- Agree to participate in and comply with applicable Federal floodplain management and flood insurance programs;
- Comply with Section 402 of the Water Resources Development Act of 1986, as amended (33 U.S.Code 701b-12), which requires a non-Federal interest to prepare a floodplain management plan within one year after the date of signing a project partnership agreement, and to implement such plan not later than one year after completion of construction of the FRM features;
- Publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in adopting regulations, or taking other actions, to prevent

unwise future development and to ensure compatibility with protection levels provided by the FRM features;

- Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) such as any new developments on project lands, easements, and rights-of-way or the addition of facilities which might reduce the level of protection the FRM features afford, reduce the outputs produced by the ecosystem restoration features, hinder operation and maintenance of the project, or interfere with the project's proper function;
- Shall not use the ecosystem restoration features or lands, easements, and rights-of-way required for such features as a wetlands bank or mitigation credit for any other project;
- Keep the recreation features, and access roads, parking areas, and other associated public use facilities, are open and available to all on equal terms;
- Comply with all applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91 646, as amended (42 U.S.Code 4601-4655), and the Uniform Regulations contained in 49 Code of Federal Regulations (CFR) Part 24, in acquiring lands, easements, and rights-of-way required for construction, operation, and maintenance of the project, including those necessary for relocations, the borrowing of materials, or the disposal of dredged or excavated material; and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act;
- For so long as the project remains authorized, operate, maintain, repair, rehabilitate, and replace the project, or functional portions of the project, including any mitigation features, at no cost to the Federal Government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State laws and regulations and any specific directions prescribed by the Federal Government;
- Give the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal sponsor owns or controls for access to the project for the purpose of completing, inspecting, operating, maintaining, repairing, rehabilitating, or replacing the project;
- Hold and save the U.S. free from all damages arising from the construction, operation, maintenance, repair, rehabilitation, and replacement of the project and any betterments, except for damages due to the fault or negligence of the U.S. or its contractors;
- Keep and maintain books, records, documents, or other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of three years after completion of the accounting for which such books, records, documents, or other evidence are required, to the extent and in such detail as will properly reflect total project costs, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 CFR Section 33.20;
- Comply with all requirements of applicable Federal laws and implementing regulations, including, but not limited to: Title VI of the Civil Rights Act of 1964, as amended (42 U.S.Code 2000d), and Department of Defense Directive 5500.11 issued pursuant thereto; the Age Discrimination Act of 1975 (42 U.S.Code 6102); the Rehabilitation Act of 1973, as amended (29 U.S.Code 794), and Army Regulation 600-7 issued pursuant thereto; and 40 U.S.Code 3141-3148 and 40 U.S.Code 3701-3708 (labor standards originally enacted as the Davis-Bacon Act, the Contract Work Hours and Safety Standards Act, and the Copeland Anti-Kickback Act);
- Perform, or ensure performance of, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated

under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Public Law 96 510, as amended (42 U.S.Code 9601 9675), that may exist in, on, or under lands, easements, or rights of way that the Federal Government determines to be required for construction, operation, and maintenance of the project. However, for lands that the Federal Government determines to be subject to the navigation servitude, only the Federal Government shall perform such investigations unless the Federal Government provides the non-Federal sponsor with prior specific written direction, in which case the non Federal sponsor shall perform such investigations in accordance with such written direction;

- Assume, as between the Federal Government and the non-Federal sponsor, complete financial responsibility for all necessary cleanup and response costs of any hazardous substances regulated under CERCLA that are located in, on, or under lands, easements, or rights of way that the Federal Government determines to be required for construction, operation, and maintenance of the project;
- Agree, as between the Federal Government and the non-Federal sponsor, that the non-Federal sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and to the maximum extent practicable, operate, maintain, repair, rehabilitate, and replace the project in a manner that will not cause liability to arise under CERCLA; and
- Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended (42 U.S.Code 1962d-5b), and Section 103(j) of the Water Resources Development Act of 1986, Public Law 99-662, as amended (33 U.S.Code 2213(j)), which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until each non-Federal interest has entered into a written agreement to furnish its required cooperation for the project or separable element.

5.8.3 Real Estate Acquisition

The non-Federal sponsor is responsible for the LERRDs areas required for project construction, operation, and maintenance of the Dallas Floodway Project. Lands outside the existing interior drainage facilities are identified for Real Estate Acquisition, but there are no lands beyond the existing Dallas Floodway Project that are required for the MDFP. Appendix I contains the Real Estate Plan for the MDFP.

The new Trinity Portland Pump Station requires relocation of three residential homes adjacent to the West Levee. It's possible that the construction design of the new pump station can be altered to avoid these residential areas. For the purpose of this report, it was assumed they would be relocated. There are no business relocations required for the IDP.

Following the Execution of the PPA, the non-Federal sponsor will be provided a right of way map delineating the real estate necessary for construction, operation, and maintenance of the Recommended Plan. Real Estate activities will be coordinated between the City of Dallas Real Estate Office and the Real Estate Office of the Fort Worth District. Also, prior to any solicitation of construction contracts, the Fort Worth District Chief of Real Estate is required to certify in writing that sufficient real property interest is available to support construction of the contract.

5.8.4 Contract Advertisement and Award

Once the PPA is executed, the P&S completed, and the rights of entry provided to Fort Worth District, a construction contract will be solicited and advertised. Prior to awarding the contract, the non-Federal sponsor must provide any applicable cash contribution. The contract will be awarded to the lowest responsive bidder and notice to proceed can be expected within 30-45 days from bid opening.

5.8.5 Contract Schedule

After award of the construction contract, the Government will manage project construction. Up to eight contracts may be awarded for the MDFP (Contract 2 is provided by the City of Dallas). Inherent with this contract, a warranty period for actual construction items and plantings will be specified. Construction is estimated to take 10-12 years to complete for the Recommended Plan. During construction, an archeologist will monitor excavation. Should any significant cultural resources be identified, mitigation procedures will take place prior to further excavation.

The following contracts are expected to be awarded:

- Contract 1 – 277K Levee Raise and AT&SF Railroad Bridge Modification/Partial 4H:1V Side Slopes;
- Contract 2 – Remainder of the 4H:1V Side Slopes;
- Contract 3 – River Relocation Top;
- Contract 4 – River Relocation Middle;
- Contract 5 – East Levee Hampton Pump Station;
- Contract 6 – River Relocation Bottom;
- Contract 7 – West Levee Charlie Pump Station;
- Contract 8 – West Levee Delta Pump Station; and
- Contract 9 – West Levee New Trinity Portland.

The exact order of the contracts may shift depending on information developed during the detail design and the availability of funding. In addition, up to five additional contracts may be required for development of vegetation. The Corps has been unsuccessful in the past getting a planting contract in place with the construction contract to establish native vegetative covers. There are typically separate contracts for plantings.

5.9 FINANCIAL PLAN AND CAPABILITY ASSESSMENT

5.9.1 Statement of Financial Capability

The Statement of financial capability is based on information provided by the City of Dallas, and the City of Dallas description of its capability to meet the non-Federal financial obligations for the MDFP. The estimated increase in annual OMRR&R costs for the Recommended Plan is $1,677,000.

5.9.2 Financing Plan

In 1998, the City of Dallas passed a bond election that authorized funding in the amount of $246,000,000 for flood control, transportation and storm water projects. From this, the City of Dallas has spent $30,000,000 on feasibility and design efforts for the projects. It is currently estimated that approximately $15,000,000 in credit would be carried over from feasibility into design and construction.

In 2006, the City of Dallas passed another bond program for $371,000,000 for flood control and storm drainage projects. The City of Dallas has spent $11,000,000 in design efforts for Baker, Able and Hampton Pump Stations. In 2012, the City of Dallas awarded a construction contract for Baker Pump Station for $38,000,000 utilizing the 2006 bond money at 100% non-Federal funding. Therefore, approximately $49,000,000 could potentially be applied to the non-Federal share as credit or non-Federal funds for the project; however, it was decided the City of Dallas will not seek credit for the Able Pump Station work.

In 2012, the City of Dallas passed another bond program for $323,000,000 of which $91,200,000 is slated for projects including the Able Pump Station construction. A second construction contract for Able Pump Station estimated at $73,974,000 will be awarded in early fiscal year 2014 utilizing 100% non-Federal funding. If used, all $92,000,000 of the bond money could potentially qualify as non-Federal funds that could be applied to the non-Federal share of the project; however, it was decided the City of Dallas will not seek credit for the Able Pump Station work.

Finally, no earlier than 2016, the City of Dallas will propose including at least $55,000,000 for the Hampton Pump Station.

In total, $158,000,000 of the approximate $200,000,000 is already available or been spent on the project and about another $45,000,000 would be required to be funded to complete the project.

5.9.3 Assessment of Financial Capability

Based on the review of the financial capabilities and plan, it is reasonable to expect sufficient resources will be available to satisfy the non-Federal financial obligations of the Recommended Plan. The sponsor's Self-Certification of Financial Capabilities for Agreements is provided in Appendix K (Supplemental Documentation).

5.10 VIEWS OF THE LOCAL SPONSOR

The City of Dallas is the non-Federal sponsor for this project. The City of Dallas supports the Recommended Plan for the MDFP and intends to participate in its implementation. A letter of support stating this intent is provided in Appendix K, Supplemental Documentation.

5.11 RESOURCE AGENCY COORDINATION

On November 4, 2008, the Corps sent out letters to over 20 State and Federal agencies notifying them of the Corps intent to conduct a study and prepare an EIS and feasibility report for a proposed project. Pursuant to the Fish and Wildlife Coordination Act of 1958, the Corps continues to coordinate with the USFWS and TPWD. The Corps has also conducted resource-specific coordination with the State Historic Preservation Office, and the TCEQ. The FHWA was a cooperating agency for the EIS. A resource agency meeting was held May 2, 2013 to discuss the development of the proposed project and to invite resource agencies to share any concerns or questions they might have regarding the project so that the project team could proactively address their input in the Draft EIS prior to initiating the public review. The public, Federal, State and other agency documentation on agency coordination can be found in Appendix A of the EIS. The Corps addressed concerns raised by the USEPA and the FAA in their review of the Draft EIS regarding environmental justice and air traffic adjacent to the study area. Their concerns were resolved in the Final EIS.

5.12 PUBLIC INVOLVEMENT

The City of Dallas developed the entire BVP with stakeholders and community input. Chapter 2 of the EIS provides the history and planning effort by the City of Dallas that culminated in the development of the BVP. The following summarizes the public coordination for the feasibility report and the EIS. In accordance with NEPA, the Corps prepared and published a Notice of Intent in the Federal Register (Vol. 74, No. 195) on October 19, 2009 and hosted a public scoping meeting on November 17, 2009. The meeting provided the public and resource agencies an opportunity to learn about the project and provide input as to what components of the project are important to them, as well as what environmental resources the Corps should consider in their formulation of plans and impact analysis. The Corps and the City of Dallas hosted another public meeting January 29, 2013 to provide an update to the public on the on-going feasibility study and outlined the proposed levee system improvements (NED Plan). On May 8, 2014, the Corps and the City of Dallas hosted a public meeting to solicit comments on the Dallas Floodway Project Draft EIS at Dallas City Hall, L1FN Auditorium, in Dallas, Texas. The purpose of the meeting was to solicit and facilitate input from interested parties for the Draft EIS. Approximately 180 comments were received, from about 30 commenters on the Draft Feasibility Report and EIS for the Dallas Floodway Project. Appendix A of the EIS includes the public comment response matrix for the draft reports. The public comments centered on the Trinity Parkway and concerns with the cost and design of the River Relocation component and the MDFP.

Since the initiation of the study effort in 2009, the Corps coordination and collaboration efforts include the NEPA public meetings; six joint City of Dallas and Corps PowerPoint presentations (three to public town halls, and three to stakeholder groups); four Dallas City Council or Council Committee project briefings; five days of Corps project information booths at Earth Day Events; and five days of Corps project information booths at other events, primarily located on event grounds between the two Dallas Floodway levees (two were held with the local Audubon Society).

5.13 CONCLUSIONS & DISCUSSION

The Recommended Plan meets the City of Dallas' overall goals and objectives of the BVP and IDP. It also achieves the Corps objectives for Section 5141 of WRDA 2007 and aligns with Corps missions of FRM and ecosystem restoration. The Recommended Plan for the MDFP was found to be technically sound and environmentally acceptable and functions on a comprehensive system-wide level provided key risk and uncertainties are addressed in future design. The Recommended Plan for the MDFP addresses the Chief of Engineers Campaign Plan Goal 2 and Objective 2d:

- Goal 2: to deliver enduring and essential water resource solutions using effective transformation strategies.
  - Objective 2d: Deliver reliable, resilient, and sustainable infrastructure systems.

The Recommended Plan reflects the Corps Environmental Operating Principles by incorporating environmental sustainability by returning channelized streams into a more naturally functioning riverine ecosystem to create aquatic habitats and balanced sediment flows. The plan balances FRM, ecosystem restoration and recreation within the existing Dallas Floodway Project. A diligent effort was made to coordinate and collaborate with resource agencies, local industry, and environmental interests throughout the study process and public meetings. Environmental resource concerns were addressed early in the study process to assure that adverse impacts were avoided to the maximum extent practicable. The plan is

consistent with all applicable laws and policies. The study team used appropriate ways and means to assess cumulative impacts to the environment through the NEPA process.

The Trinity River EIS ROD established criteria (ROD criteria) for actions that require a Corps permit to address hydrologic and hydraulic impacts for FRM purposes. The results of the Comprehensive Analysis show that both variations of the design of Alternative 2 did not meet the ROD criteria in terms of valley storage and water surface rise; however, the potential negative impacts are insignificant. It is important to note that the criteria established by the Trinity River and TREIS and ROD were only applied in the Comprehensive Analysis as a whole collection of projects. At the current level of design for the various project components considered, the level of compliance with regard to meeting the goals of the ROD criteria is estimated to be very nearly optimal from a hydraulic standpoint. As BVP and IDP project designs move toward a higher level of detail in the final design stages, continual hydrologic and hydraulic analysis will be performed to ensure the highest reasonable level of compliance with the ROD criteria. The Recommended Plan for the Section 5141 of WRDA 2007 (the MDFP), does not require a variance to the ROD criteria. A variance would be required in the ROD for the remaining BVP and IDP features pending the Section 408 approval process.

The City of Dallas could choose to construct features of the MDFP and seek credit for those alterations toward its cost share for the work under Section 221 of the Flood Control Act of 1970. Any proposed alteration for which the City of Dallas seeks credit cannot be initiated until a Memorandum of Understanding for the work is executed, and this feasibility report approved by the ASA(CW). Additional authorizations, such as those required pursuant to Section 10/404/103 under the Corps Regulatory program, may also be required before the City of Dallas can initiate work.

5.14 RECOMMENDATION

I propose the Recommended Plan, which modifies the existing Dallas Floodway Project as described in Chapter 4 and Chapter 5 of this report, proceed with implementation in accordance with the cost sharing provisions set forth in this report.

This recommendation is made with the provision that prior to project implementation, the non-Federal sponsor shall enter into a binding agreement with the Secretary of the Army to perform the items of local cooperation, as specified in this document.

The recommendations contained herein reflect the information available at this time, and current Department of the Army, and Corps policies governing formulation of individual projects. The recommendations do not reflect the program and budget priorities inherent to the formulation of a national Civil Works construction program, nor the perspective of higher review levels within the Executive Branch of the U.S. Government. Consequently, the recommendations may be modified before they are transmitted to Congress as proposals for implementation funding. However, prior to transmittal to Congress, the sponsor, the State, interested Federal agencies, and other interested parties will be advised of any modifications, and be afforded the opportunity to comment further.

W. Neil Craig, III, P.E.
Lieutenant Colonel, U.S. Army
District Engineer

Date 12/12/2014

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CHAPTER 6
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CHAPTER 7
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7.1 EXECUTIVE SUMMARY

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