HUNTING BAYOU FLOOD RISK MANAGEMENT
HARRIS COUNTY, TEXAS

DRAFT GENERAL REEVALUATION REPORT AND INTEGRATED ENVIRONMENTAL ASSESSMENT

MAIN REPORT

June 2014

HARRIS COUNTY FLOOD CONTROL DISTRICT

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EXECUTIVE SUMMARY

Introduction

On February 12, 1990, the U.S. Army Corps of Engineers (USACE) issued a report entitled "Buffalo Bayou and Tributaries, Texas Feasibility Report" for flood damage prevention in the greater Houston, Texas area. It was transmitted to the U.S. House of Representatives on June 10, 1990 in response to an authorization by the Committee on Public Works of the U.S. House of Representatives on April 20, 1948. The plan became authorized under Section 101(a)(21), of the Water Resources Development Act (WRDA) 1990. The Harris County Flood Control District (HCFCD) is designated as the local non-federal sponsor for implementing the flood damage improvements identified in the report.

The plan itself addressed Buffalo Bayou and six of its major tributaries, one of which is Hunting Bayou. Section 211, WRDA 1996 (Public Law 104-303), authorized an approved non-federal interest to undertake studies, design and/or construct a previously authorized project such as Hunting Bayou. Subsection 211(f) identifies specific projects to demonstrate the advantages and effectiveness of non-federal interests undertaking flood control projects. Moreover, Subsection 211(f)(7) specifically identifies Hunting Bayou as one of the projects and provides the ability for the non-federal interest to evaluate an alternative to the authorized project.

The field conditions today differ significantly from the findings upon which the 1990 plan for Hunting Bayou was authorized. This justifies reexamining its conclusions. This General Reevaluation Study and Integrated Environmental Assessment (GRR/EA) documents the analysis of current conditions including a reevaluation of the 1990 Authorized Plan and several alternatives to that plan in accordance with the requirements of WRDA 1996.

Study Purpose

The purpose of this GRR/EA is to support a recommendation by the Chief of Engineers that the reevaluated alternative, referenced as the Tentatively Selected Plan (TSP), is within the existing project authorization for Hunting Bayou, Texas (the 1990 Authorized Plan). This report integrates the General Reevaluation of flood risk management (FRM) alternatives with an EA. The report was prepared based on methods and analyses necessary to respond to appropriate parts of Section 211, WRDA 1996. The National Environmental Policy Act (NEPA) review of physical, biological and socioeconomic resources which may be affected by the alternatives is found in the GRR/EA, *Section 2.0, Section 5.0* and *Section 6.0*. The GRR/EA supports Congressional appropriations and documents compliance with applicable environmental statutes such as the Endangered Species Act; Clean Air Act; Clean Water Act; Fish and Wildlife Coordination Act; Historic Preservation Act; NEPA; current USACE policies, criteria and guidance; and applicable local and state laws, regulations and ordinances.

The GRR/EA reevaluated the 1990 Authorized Plan and evaluated alternatives to that plan for engineering performance, environmental and social effects, and economic efficiency. The GRR/EA identified an alternative which under current conditions performs better than the 1990 Authorized Plan does. The GRR/EA demonstrates the TSP falls within the 1990 Authorized

Plan's footprint and intent for flood prevention along Hunting Bayou. The TSP provides higher net excess benefits than the 1990 Authorized Plan and has fewer adverse social, economic and natural consequences of implementation by effectively reducing flood risk in the area of concentrated damages. The GRR/EA also identified a smaller scale National Economic Development (NED) Plan based on net excess benefits and least cost to the federal government. The NED Plan provides the basis for federal cost-share.

Watershed Description

The Hunting Bayou watershed is approximately 30 square miles in size and is approximately 5 miles northeast of downtown Houston in Harris County, Texas. Hunting Bayou flows approximately 15 miles southeasterly, extending from its crossing with U.S. Highway (US) 59 downstream to its confluence with Buffalo Bayou at the Houston Ship Channel. The area is noted for its flat topography and slow drainage, especially in the watershed's upper reaches. The area has an industrial character with major rail yards, Englewood Railroad Yard (ERRY) and Settegast Rail Yard, traversing the watershed; and a resident population which is socially vulnerable to flood risk. The non-federal sponsor, HCFCD, has cleared and straightened portions of Hunting Bayou over time as part of general maintenance activities. However, in its current configuration, the bayou channel's capacity is exceeded by events less frequent than the 20 percent annual exceedance probability (AEP) storm event. Flooding has continued to be a significant problem. In recent years, flooding was documented in 1979, 1980, 1983, 1989, 1993, 1994, 1997, 1998 (Tropical Storm Frances), 2001 (Tropical Storm Allison), 2006, 2007 and 2008 (Hurricane Ike).

1990 Authorized Plan for Hunting Bayou

The 1990 Authorized Plan is part of the flood control project for Buffalo Bayou and Tributaries, Texas as authorized in Section 101(a)(21), WRDA 1990. The 1990 Authorized Plan consisted of a channel enlargement project (deepening and widening) over Hunting Bayou's 15 mile length with a 110-foot bottom width (BW) channel at the confluence with Buffalo Bayou. The objective of the 1990 Authorized Plan was to increase the hydraulic carrying capacity and improve the stormwater conveyance through Hunting Bayou. The 1990 Authorized Plan would have provided protection from a 4 percent AEP storm event under future urban conditions. With present local drainage conditions in the watershed, the 1990 Authorized Plan would provide protection from a flood greater than a 2.5 percent AEP storm event. Major 1990 Authorized Plan elements include the following, as specifically stated in the supporting legislative document (Buffalo Bayou and Tributaries, Texas Feasibility Report, House Document 101-208, 1990).

- Construct a trapezoidal, grass-covered channel varying in BW from 110 feet in Hunting Bayou's lower reaches to 50 feet in the upper reaches.
- Purchase and remove 23 single-family residences and 20 businesses (1988 estimate).
- Remove and replace 8 railroad bridges; replace or modify 25 road and street bridges; and modify over 50 pipelines including utility pipelines.
- Excavate about 4,389,000 cubic yards of earth material, and dispose approximately of 3,731,000 cubic yards of material on 385 acres of open upland sites.

- Channel construction would have resulted in removing approximately 66 acres of riparian vegetation and 30 acres of upland forest, resulting in wildlife habitat losses.
- Aesthetic planting of compatible vegetation to urban and suburban surroundings to replace removed riparian and upland habitats.
- Compensate for wildlife habitat losses with mitigation which included planting 75 acres of riparian forests and 20 acres of upland forest. Develop recreational amenities including constructing 1.2 miles of multipurpose trails and areas for picnic tables, grills, benches and an exercise area. An access road, restroom, drinking fountains and a parking area were to be included adjacent to the proposed recreational facilities.
- Acquire approximately 198 acres within Herman Brown Park for necessary project right-of-way (ROW).

The flood control project for Buffalo Bayou and Tributaries, Texas was authorized in 1990 at a total cost of $727,364,000, with an estimated $403,359,500 first federal cost and an estimated $324,004,500 first non-federal cost (104 Stat. 4610). Based on January 1988 price levels, the total project cost for Hunting Bayou's portion of the 1990 Authorized Plan was $60,022,000 (House Document 101-208, 1990). The 1990 Authorized Plan for Hunting Bayou had a 10.2 benefit-to-cost ratio (BCR) with benefits of $59.9 million. Benefits for the 1990 Authorized Plan for Hunting Bayou were estimated over a 100-year period of analysis, based on January 1988 price levels, at an 8.625 percent interest rate and included inundation reduction benefits, future development benefits and affluence benefits.

The 1990 Authorized Plan was not funded and was not constructed.

Table ES-1 demonstrates the economic performance of the 1990 Authorized Plan for Hunting Bayou as authorized, and the decrease in outputs by only using budgetary programming techniques to update the 1990 Authorized Plan to the current fiscal year (FY) 2014 interest rate, FY2013 price level and 50-year period of analysis without reanalyzing the Plan's performance under current conditions.

As part of the GRR process, the 1990 Authorized Plan was reevaluated under current conditions in the watershed and was included in the final array of alternatives as Alternative 1, scale A-3. The economic outputs of the 1990 Authorized Plan under current conditions and costs is also presented in *Table ES-1*. The 1990 Authorized Plan did not compete well economically under current conditions when compared against other alternatives for FRM, demonstrating a 1.18 BCR and average annual equivalent value (AAEV) net excess benefits of $3.0 million. The 1990 Authorized Plan was not advanced for further consideration based on its economic performance.

Table ES-1:
1990 Authorized Plan Cost and Benefit Summary

	Authorized Plan[^1]	Authorized Plan[^2]	Authorized Plan under Current Conditions[^3]
Price Level	Jan-1988	Jan-2013	Jan-2013
Interest Rate	0.08625	0.035	0.035
Period of Analysis, years	100	50	50
Flood Control (includes Mitigation) – First Cost			
Lands and Damages, Relocations			
Preconstruction Engineering and Design (PED) and Construction Management			
Construction			
Construction Contingency			
Total First Cost	**$59,581,000**	**$125,523,114**	**$341,583,000**
Interest During Construction (IDC)			
Uncompensated NED Losses			
Recreation First Cost[^4]	$441,000	$929,083	n/a
Total Economic Cost	**$60,022,000**	**$126,452,197**	**$341,583,000**
AAEV Total First Cost			
Flood Control	$5,870,000	$5,351,516	$16,724,430
Recreation	$62,000	$39,610	n/a
AAEV Operations & Maintenance (O&M)			
Flood Control	$193,200	$95,475	n/a
Recreation	$17,100	$8,450	n/a
AAEV Total NED Cost	**$6,142,300**	**$5,495,052**	**$16,724,430**
AAEV Total NED Benefits			
Flood Control	$59,919,000	$29,610,633	$19,732,750
Recreation	$336,400	$166,241	n/a
BCR			
Flood Control	10.2	5.39	1.18
Recreation	4.25	3.46	n/a
AAEV Net Excess Benefits			
Flood Control	$54,049,000	$24,115,581	$3,008,320
Recreation	$274,400	$157,791	n/a

1/ The authorized data is taken from Buffalo Bayou and Tributaries, Texas Feasibility Report , House Document 101-208, 1990
2/ 1990 Authorized Plan costs escalated using EM 1110-2-1304, CCWIS, Appendix A, 31Mar13
3/ Planning level estimate of Alternative 1 scale A-3 replicating 1990 Authorized Plan under current conditions and costs
4/ Non-federal sponsor, HCFCD, is not exercising the project's recreational authority at this time.

Need for Alternative to the 1990 Authorized Plan

The 1990 Authorized Plan is a legacy plan which produced an engineered solution from the Hunting Bayou headwaters to its confluence with Buffalo Bayou. During the years after the 1990 Authorized Plan was approved, remedies for flood damage reduction increasingly deemphasized large scale structural or engineered solutions and focused on considerations relating to preserving natural habitat and minimizing effects from flood damage reduction measures to neighborhoods bordering the bayou. In the period between 2000 and the present, preserving natural areas adjacent to the bayou and reducing impacts to neighborhoods became new constraints on achieving flood damage reduction in the watershed. As an example, while the authorization documentation for the 1990 Authorized Plan states 23 single-family residences and 20 businesses would be displaced with project implementation, that number had increased to 125 residences and 15 businesses by 1998 when the GRR was initiated. The projected loss of 198 wooded acres within Herman Brown Park to the Authorized Plan's channel ROW also became undesirable. Even though the 1990 Authorized Plan was highly effective in achieving flood damage reduction, its implementation would have produced adverse impacts to the natural and social environment within the Hunting Bayou watershed at an unacceptable scale for watershed residents or to the wider public.

Section 211, WRDA 1996 (Public Law 104-303) as amended by Section 223, WRDA 1999 (Public Law 106-53), authorizes non-federal interests to undertake major FRM projects with federal funding assistance (subject to federal funding availability) or credit for the non-federal interest for its portion of the work subject to Secretary of the Army approval. Section 211(e)(2), WRDA 1996, as amended, states the Secretary may also reimburse any non-federal sponsor an amount equal to the estimated federal share, without interest, of the cost for any authorized flood control project, or separable element of a flood control project, constructed pursuant to this section or provide credit for the non-federal share of the project with certain stipulations.

The non-federal sponsor, HCFCD, pursuant to their authority under Section 211(f)(7), WRDA 1996, as amended, developed an alternative to the 1990 Authorized Plan which the non-federal sponsor, HCFCD, is currently constructing at their own risk. The alternative to the 1990 Authorized Plan reflects current conditions in the watershed and ongoing concerns with flooding issues and needs. The alternative targets FRM where damages occur in Hunting Bayou's upper stream segments and allows the natural amenities in Herman Brown Park to remain unaffected by the project implementation.

To date, the non-federal sponsor, HCFCD, has expended $29 million implementing elements of the alternative, consisting primarily of preparation of the GRR/EA, design of certain project components, initial phases of detention basin construction, and limited construction of channel modifications.

Methods and Procedures

Even though the non-federal sponsor, HCFCD, has taken the lead in developing and implementing an alternative to the 1990 Authorized Plan, the planning, design and construction are in accordance with established USACE regulations, guidance and requirements for federal participation. The study period for the Hunting Bayou GRR/EA has spanned 14 years and undergone significant updates over time. The USACE HEC-HMS, HEC-RAS and HEC-FDA

modeling programs were used to determine the flood damages for the Without Project (WOP) condition and to evaluate the effectiveness of the alternative flood damage reduction components and plans. The AAEV for flood damage under the FY 2013 WOP condition is estimated to be $19.8 million along Hunting Bayou.

Alternative Reevaluation and Identification of the National Economic Development (NED) Plan

The NED Plan alternative, Alternative 5, was identified based on economic efficiency from an array of alternatives which demonstrated distinctly different FRM strategies. *Table ES-2* displays the final array of alternatives which includes the updated and optimized 1990 Authorized Plan (Alternative 1); an optimized buyout plan (Alternative 2); an optimized flood proofing plan (Alternative 3), the No Action alternative (Alternative 4) and the plan optimized through the reevaluation process (Alternative 5). The NED Plan alternative, Alternative 5, consists of a 3.8 mile channel modification in Hunting Bayou's upper reach, bridge replacements and an offline detention basin. The NED Plan alternative produced the greatest net excess economic benefits among the alternatives considered. *Table ES-2* is a reproduction of *Table 4-2* in GRR/EA, *Section 4*.

Table ES-2:
Best Performing Alternatives

Alternative	Component Description	AAEV Project Cost	AAEV Damage Reduction Benefit	AAEV Net Excess Benefit	BCR
1	Full Earth Channel (35-foot BW)	$12.692	$19.801	7.110	1.56
	Full Earth Channel (10-Year) (65-foot BW)	$14.277	$21.875	$7.598	1.53
	Full Earth Channel (25-Year) (110-foot BW) 1990 Authorized Plan scale	$20.582	$22.401	$1.819	1.09
	Full Earth Channel (50-Year) (150-foot BW)	$25.389	$22.414	($2.975)	0.88
2	Watershed-Wide Optimized Buyout (974 Structures)	$3.788	$8.148	$4.360	2.15
3	Watershed-Wide Optimized Flood Proofing (1,039 Structures)	$2.781	$5.731	$2.950	2.06
4	No Project	-	$0.000	$0.000	0.00
5	**Upper Stream Segment 50-foot BW Channel, Bridge Replacements, and Homestead Detention (B50-A1)**	**$6.780**	**$16.990**	**$10.210**	**2.51**

2001 price level, 5.625 percent discount rate.
All dollar values are in millions.

During subsequent plan reevaluation iterations, the NED Plan alternative was subjected to scale refinement, which varied the channel's bottom width modification and the size of the detention basin component in an effort to maximize net excess NED benefits. The combined component sizes which reasonably maximize net excess benefits at the least cost among an array of 32 combinations is NED Plan alternative scale B50-A25. *Table 4-7* in the GRR/EA displays the

economic performance for the 32 combinations of channel bottom-width and detention basin sizes.

B50-A25 is identified as the NED Plan for federal cost-sharing purposes. B50-A25 consists of a grass-lined trapezoidal channel modification with a 50-ft maximum channel bottom width running for 3.8 miles from US 59 to ERRY, optimized bridge replacements and an accompanying 25-acre offline detention basin at Homestead Road. B50-A25 reduces flood damage the least among the 32 NED Plan scales evaluated, but reasonably maximizes net excess benefits at the least cost and is, therefore, identified as the NED Plan. *Table ES-3* shows the economic performance for B50-A25.

Table ES-3:
Annual Project Cost and Benefit Summary, NED Plan, B50-A25, 2Q2013 Price Level, FY14 Interest Rate

GRR Study Cost	**$9,334,488**
Constructed Work, EOY 2007-2013*	**$20,104,891**
01--Lands and Damages	$11,940,013
02-Relocations	$1,395,447
30- PED	$2,510,823
31-Construction Management	$4,258,608
Unconstructed Work, EOY 2013-2021	**$105,477,352**
01--Lands and Damages (includes least cost mitigation)	$10,349,054
02-Relocations	$44,080,401
09-Channels and canals	$14,330,209
15-Floodway Control and Diversion Structures	$6,812,604
30- PED	$3,929,250
31-Construction Management	$6,548,750
Contingencies-22.6 percent **	$19,427,083
Project First Cost	**$125,582,243**
IDC	$26,665,001
Uncompensated NED Losses	$4,708,700
Total Economic First Cost	**$166,290,432**
Annualized Economic First Cost	$7,089,578
Annual O&M	$123,896
Total Annual Cost	$7,213,474
Total Annual Cost in $1,000s	$7,213
Annual Benefits in $1,000s	$13,953
Net Excess Benefits (benefits-costs)	$6,739
Benefit-Cost Ratio (benefits/costs)	1.93

**Constructed costs are actual costs-to-date with no inflationor interest added.*
***contingency established as a result of ATR review*
Notes: 3.5 percent interest rate, FY13 Price level
Project Code 30 is PED for TSP only.
Expended PED costs at time of GRR are considered sunk costs and are not counted in the IDC computations.
Project Micro-Computer Aided Cost Estimating System, Version 4.1 (MCACES), Second Generation costs not assigned to a construction contract are spread throughout the entire projected contract activity schedule.
For IDC calculation, Contract costs spread uniformly over contract period
O&M annual $123,896 cost includes mowing 116 acres and O&M for a 2-million-gallon-per-day lift station

Induced Damages

Within the 32-scale array of NED alternative scales evaluated under the current condition, 19 scales produce net excess benefits within 5 percent of the top producing scale and are considered to "reasonably" maximize net excess benefits. When ranked based on net excess benefit, NED alternative scale B60-A75, which includes a 75-acre detention basin, is the highest ranking alternative scale which does not induce damages downstream with a rise in the base flood elevation (BFE). Higher ranked alternative scales all include either a 25-acre or 50-acre detention basin, and all induce damages downstream. When these damages were included as NED costs to the project, this did not change the identification of the NED Plan. However, the damages induced would require mitigation based on Federal Emergency Management Agency (FEMA) guidelines, and would be an additional cost to the local communities participating in the National Flood Insurance Program.

Transferring risk and damages to an area downstream from the project area on Hunting Bayou is considered socially and legally unacceptable to the non-federal sponsor, HCFCD, and violates the non-federal sponsor's, HCFCD, local policy of no adverse impact at or below the 1 percent AEP storm event. In addition, increasing water surface elevations in the 1 percent AEP storm event violates FEMA policies and requires that local communities mitigate for structures impacted. Inducing additional damages to a local population with limited ability to respond to and recover from catastrophic events is neither acceptable nor implementable.

For NED Plan B50-A25 to be implemented, 240 displacements involving 400 residents would be required to provide needed ROW and to mitigate for a rise in the downstream BFE at least cost. The cost to mitigate for a rise in the BFE alone is estimated to exceed $34 million. Population displacement would occur from ROW acquisition or from mitigation for downstream impacts caused by a rise in the BFE to comply with FEMA regulations. The magnitude of displacements required to implement the NED Plan also violates a study objective to minimize disruption to the local community and existing neighborhoods.

B60-A75 is the NED alternative scale which best maximizes net excess benefits without creating a rise in the BFE and without inducing damages downstream at the 1 percent AEP storm event or more frequent events. GRR/EA *Section 4.9.6* provides detailed information related to induced damages.

Tentatively Selected Plan (TSP)

B60-A75 was identified as the non-federal sponsor's, HCFCD, Locally Preferred Plan. B60-A75 combines upper stream grass-lined trapezoidal channel modifications with a 60-foot maximum bottom width for a length of 3.8 miles from US 59 to ERRY, bridge replacements and a 75-acre offline detention basin at Homestead Road. B60-A75 is the non-federal sponsor's, HCFCD, Locally Preferred Plan because it adheres to the local policy of "no adverse impact" at the 1 percent AEP or more frequent storm events; maximizes using available vacant land for detention storage; and best addresses all study objectives by providing FRM to a socially vulnerable population while minimizing adverse impacts to the surrounding community and natural resources to the extent possible.

To propose a LPP more costly than the NED Plan, an exception from ASA(CW) is required. Approval from ASA(CW) to recommend B60-A75 as the LPP was obtained in May, 2014. Accordingly, the non-federal sponsor, HCFCD, agrees that the additional cost of the LPP over the NED Plan cost is the responsibility of the non-federal sponsor

B60-A75 provides the most effective, complete and acceptable plan, and is named the TSP. This plan is also the environmentally preferred plan, as its unavoidable adverse environmental effects are less than or equal to the other plans evaluated including the 1990 Authorized Plan. Means to minimize unavoidable adverse effects and to mitigate them have been incorporated into project development. The TSP provides $15.4 million in AAEV benefits at FY13 price levels with a 1.92 BCR.. The TSP minimizes population displacements and provides the greatest risk reduction from potentially catastrophic events to a socially vulnerable population while still achieving the federal objective of reasonably maximizing net excess benefits.

Generally, unavoidable adverse effects to resource areas include displacing an estimated 198 residents in 66 single- and multi-family homes, acquiring two businesses, a religious land use and an industrial land use for project ROW. Extensive outreach and public information programs carried out during the study period have been effective in communicating the need for an effective FRM remedy in areas subject to repetitive flood damages. Consequently, relocating some residents is understood by the community as a necessity whose impact is ameliorated through a proactive relocation program and implementing an effective FRM project. Opportunities exist for acquired business and other land uses to relocate in nearby areas if desired.

Unavoidable adverse effects to biological resources include losing 4.37 acres of wetlands, which will be mitigated by purchasing mitigation bank credits. Temporary effects to the upper segment of the Hunting Bayou stream channel and fringe wetlands will occur. This will result in a temporary increase in turbidity and water quality degradation until construction ceases. Temporary and periodic disruptions to local traffic will occur as vehicular bridges are replaced. Local traffic and associated concerns for public safety will be addressed through communication programs and signage to manage these temporary effects. Construction required for these activities and channel modifications will temporarily affect local air quality due to construction activities. Construction noise effects will also be temporary and will be managed by observing appropriate work periods. No long-term adverse effects are expected for any resource area evaluated in this EA. By reducing flood risk provided by the TSP, beneficial effects resulting from implementing the TSP will be experienced by residents and businesses primarily in Hunting Bayou's heavily populated upper reach.

There are no outstanding unresolved issues or concerns raised by resource agencies.

The TSP addresses all study objectives better than other alternatives reevaluated, including the 1990 Authorized Plan. In addition to the performance characteristics listed in *Table ES-4*, the TSP reduces risk to 4,465 structures from the 1 percent AEP event and minimizes population displacements.

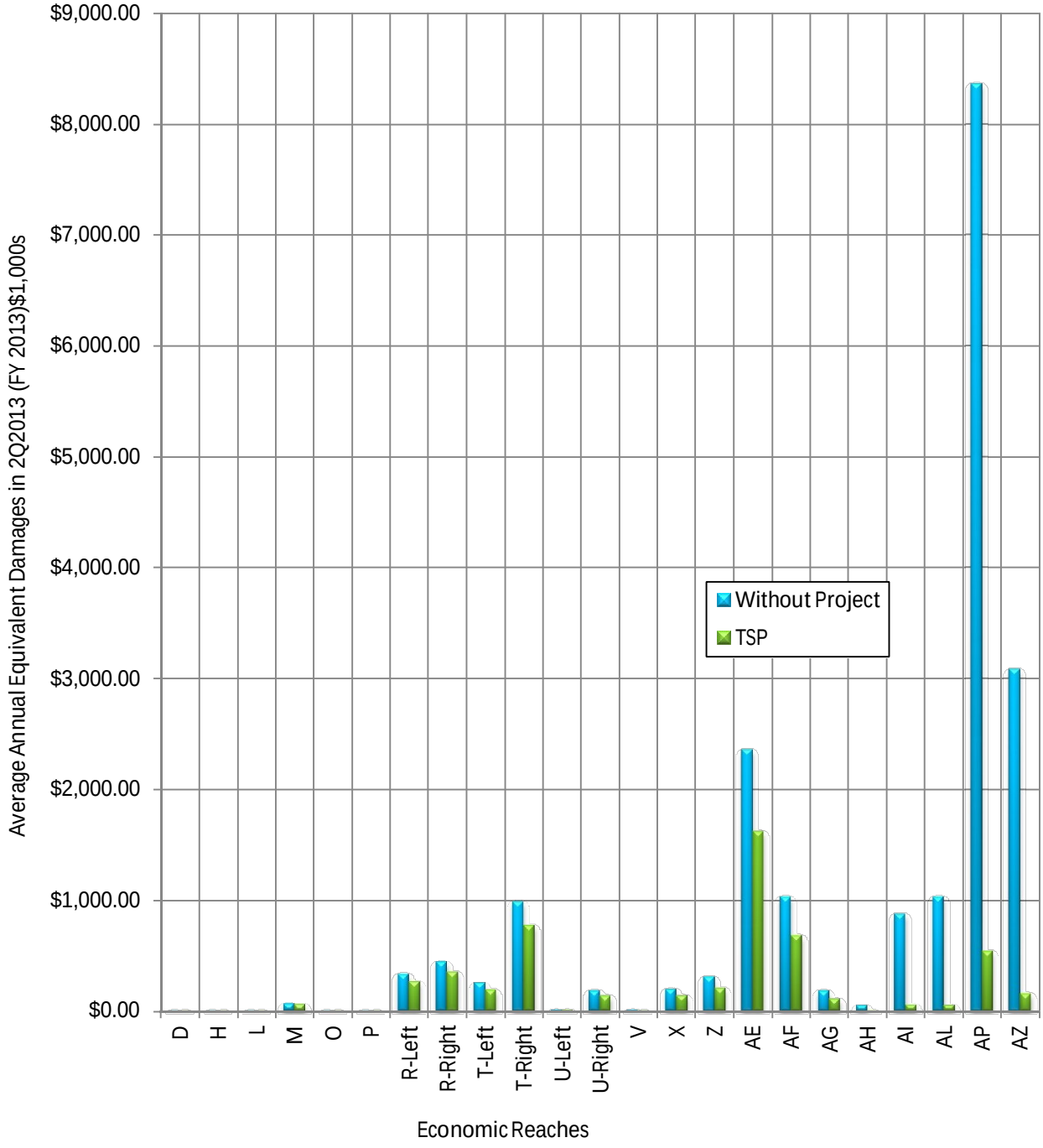
Table ES-4:
Performance Characteristics of the NED Plan, the TSP and the 1990 Authorized Plan. 2Q2013 (FY 2013) Updated Structure Inventory and Price Level, 3.5 Percent (FY 2014) Interest Rate

Performance Variables	No Action	NED Alternative Scales		Difference between NED Alternative Scales	1990 Authorized Plan under Current Conditions
	WOP	B60-A75 TSP	B50-A25 NED Plan	B60-A75 minus B50-A25	
Structures with Reduced Risk over No Action					
from 0.2 percent flood event	0	4,287	3,331	+956	7,062
from 1 percent flood event	0	4,465	4,021	+444	5,093
Residential Structures with Reduced Risk over No Action					
from 0.2 percent flood event	0	3,971	3,110	+861	6,376
from 1 percent flood event	0	4,061	3,672	+389	4,597
Population with Reduced Risk over No Action					
from 0.2 percent flood event	0	10,047	7,868	+2,178	16,131
from 1 percent flood event	0	10,274	9,290	+984	11,630
Single Occurrence Damages in $1000s					
from 0.2 percent flood event	$270,851	$132,790	$168,251	-$35,461	$13,104
from 1 percent flood event	$160,493	$43,775	$53,069	-$9,294	$828
AAEV Benefits in $1,000s	N/A	$15,364	$13,953	+$1,411	$19,733
AAEV Net Excess Benefits in $1,000s	N/A	$7,373	$6,863	+$510	$3,008

The TSP provides significant benefits to a number of public facilities and institutions which affect a community's ability to recover after major storms and are necessary during storms as 'last resort' shelters. Currently located in the 0.2 percent AEP floodplain and within the project area are schools, hospitals and clinics, including a major county hospital with the state's busiest Level III trauma center, police and fire stations, day care centers and elder care facilities.

Important infrastructures critical for access to hurricane evacuation routes include Interstate Highway 610 and US 59. Reducing flood levels on these roads is essential, as they are primary mobility and access routes for emergency vehicles and are used by residents in the watershed to access evacuation routes. After a flood event, these roadways must remain usable for recovery operations and post-flood emergency vehicles. The TSP also benefits one wastewater treatment facility, essential to human health during and after storm events. *Figure ES-1* indicates the AAEV inundation damages in the WOP and the with TSP condition, respectively.

Figure ES-1:
AAEV Inundation Damages in the WOP and the with TSP Conditions[1]



[1] *Economic reach D represents the watershed's downstream end, and economic reach AZ represents the watershed's upstream end.*

As shown in *Table ES-5*, the TSP's total Economic First Cost is $154.3 million, with a total annual cost of approximately $8.0 million. Net excess benefits (i.e., the benefits minus costs) are $7.4 million and the BCR is 1.92.

Table ES-5:
Annual Project Cost and Benefit Summary, TSP, B60-A75
3.5 Percent (FY 2014) Interest Rate, 2Q2013 (FY 2013) Price Level

GRR Study Cost	**$9,334,488**
Constructed Work, EOY 2007-2013*	**$20,104,891**
01--Lands and Damages	$11,940,013
02-Relocations	$1,395,447
30- PED	$2,510,823
31-Construction Management	$4,258,608
Unconstructed Work, EOY 2013-2021	**$124,880,248**
01--Lands and Damages (includes least cost mitigation)	$11,942,201
02-Relocations	$48,808,261
09-Channels and canals	$14,662,956
15-Floodway Control and Diversion Structures	$14,092,502
30- PED	$4,616,000
31-Construction Management	$7,757,000
Contingencies-22.6 percent **	$23,001,328
Project First Cost	**$144,985,139**
IDC	$28,535,540
Uncompensated NED Losses	$618,590
Total Economic First Cost	**$183,473,757**
Annualized Economic First Cost	$7,822,167
Annual O&M	$168,756
Total Annual Cost	$7,990,923
Total Annual Cost in $1,000s	$7,991
Annual Benefits in $1,000s	$15,364
Net Excess Benefits (benefits-costs)	$7,373
Benefit-Cost Ratio (benefits/costs)	1.92

**Constructed costs are actual costs-to-date with no inflationor interest added.*
***contingency established as a result of ATR review*
Notes: 3.5 percent interest rate, FY13 Price level
Project Code 30 is PED for TSP only.
Expended PED costs at time of GRR are considered sunk costs and are not counted in the IDC computations.
Project Micro-Computer Aided Cost Estimating System, Version 4.1 (MCACES), Second Generation costs not assigned to a construction contract are spread throughout the entire projected contract activity schedule.
For IDC calculation, Contract costs spread uniformly over contract period
O&M annual $168,756 cost includes mowing 228 acres and O&M for a 2-million-gallon-per-day lift station.

Table ES-6 shows $29 million, in study and construction costs, have been expended by the non-federal sponsor, HCFCD, for the alternative to the 1990 Authorized Plan. Under the authority of Section 211, WRDA 1996, as amended, and specifically Section 211(f)(7), WRDA 1996, as amended, the non-federal sponsor, HCFCD, can proceed with implementing improvements or an alternative for such element for Hunting Bayou, Texas, as authorized by Section 101(a)(21), WRDA 1990 (Public Law 101-640).

Costs expended to date by the non-federal sponsor, HCFCD, are shown by year expended and by activity in *Table ES-6* and *Table ES-7*, respectively. These expenditures are authorized by Section 211, WRDA 1996, as amended. These expended costs apply to implementing either the TSP or the NED Plan as an alternative to the 1990 Authorized Plan as they consist primarily of preparation of the GRR/EA, design of certain project components, initial phases of detention basin construction, and limited construction of channel modifications. These costs-to-date are actual costs and do not include inflation or interest added.

Table ES-6:
Non-Federal Sponsor, HCFCD, Expenditures by Year

Year	Total Net Expenses
1998	$597,406
1999	$1,061,598
2000	$927,169
2001	$663,150
2002	$616,325
2003	$914,059
2004	$556,521
2005	$312,932
2006	$5,170,820
2007	$4,895,980
2008	$479,317
2009	$2,708,685
2010	$5,597,038
2011	$1,612,492
2012	$1,868,571
2013	$1,457,317
Total	**$29,439,378**

Table ES-7:
Non-Federal Sponsor, HCFCD, Expenditures by Stage and Activity

Stage & Activity	Net Expenses
Construction Stage	**$4,123,576**
Construction	$4,123,576
Design	**$221,352**
Design	$221,352
Feasibility	**$9,334,488**
Planning	$9,334,488
Project Development	**$1,480,745**
PED	$1,480,745
Project Support Activities	**$808,727**
Environmental	$295,859
Geotechnical	$115,669
Materials Testing	$8,047
Public Outreach	$314,021
Survey	$75,130
ROW	**$13,335,460**
ROW	$11,940,013
Relocation	$1,017,379
Demolition	$378,068
Turnover & Startup	**$135,032**
Vegetation	$135,032
Total	**$29,439,378**

Cost Allocation

WRDA 1986, Section 103 (a) stipulates the maximum non-federal contribution will not exceed 50 percent of the total project cost. In this particular project, lands, easements, ROWs, relocations and disposals (LERR&Ds), a non-federal responsibility, contribute significantly to the total project cost, so the federal cost share will assume a portion of LERR&D cost to meet the 50 percent non-federal cost share maximum contribution. Bridge replacement and modification costs, as shown in *Table ES-8* contribute significantly to overall project cost and total $38 M. These bridge replacement costs are associated with the optimized channel modification length and are identical for the NED Plan and the TSP. Therefore, these costs apply to either NED Plan scale. Rail bridge modifications that are cost-shared as construction costs based on Section 3 of the 1946 Flood Control Act are less than one-half of one percent of all bridge modifications and total approximately $260,000.

The TSP would require replacing 17 road, railroad and pedestrian bridges and abandoning or changing several area roadways. For further information on LERR&Ds, see *Appendix 6 – Real Estate Plan*.

Table ES-8:
Identified Bridge Adjustments

Bridges to be Impacted (extended or replaced)			
Station	**Description**	**Bridge Owner**	**Estimated Cost***
564+09	Bridge Modification - Wayside	City of Houston (COH)	$4,491,900
564+09	Bridge Approaches - Wayside	COH	$742,365
566+44	Rail Bridge Modification – Southern Pacific (SP) ERRY*	Railroad	$42,800
566+44	Rail Bridge Approaches - SP ERRY*	Railroad	$80,798
566+99	Rail Bridge Modification - SP ERRY*	Railroad	$38,520
566+99	Rail Bridge Approaches - SP ERRY*	Railroad	$54,068
568+49	Rail Bridge Modification - SP ERRY*	Railroad	$37,450
568+49	Rail Bridge Approaches - SP ERRY*	Railroad	$6,008
599+52	Bridge Modification - Loop 610 2nd Crossing	Texas Department of Transportation (TxDOT)	$14,718,180
599+52	Bridge Approaches - Loop 610 2nd Crossing	TxDOT	$2,191,860
635+97	Bridge Modification - Homestead Road	COH	$624,960
635+97	Bridge Approaches - Homestead Road	COH	$121,500
648+92	Bridge Modification - Kelley Street Westbound	COH	$1,755,468
648+92	Bridge Approaches - Kelley Street Westbound	COH	$42,525
658+96	Bridge Modification - Loop 610 3rd Crossing	TxDOT	$4,255,680
661+53	Walkway Bridge Modification - Hutcheson	COH	$189,720
661+53	Walkway Approaches - Hutcheson	COH	$6,683
672+94	Walkway Bridge Modification - Hutcheson	COH	$189,720
672+94	Walkway Approaches - Hutcheson	COH	$4,860
692+95	Walkway Bridge Modification - Pickfair	COH	$223,200
692+95	Walkway Approaches - Pickfair	COH	$5,468
704+55	Bridge Modification - Wipprecht	COH	$1,487,070
704+55	Bridge Approaches - Wipprecht	COH	$43,740
716+69	Bridge Modification - Wayne Street	COH	$1,522,968
716+69	Bridge Approaches - Wayne Street	COH	$161,595
724+66	Bridge Modification - Hirsch Street	COH	$2,529,600
724+66	Bridge Approaches - Hirsch Street	COH	$18,360
729+22	Bridge Modification - Leffingwell Street	COH	$1,182,030
729+22	Bridge Approaches - Leffingwell Street	COH	$88,695
732+67	Bridge Modification - Falls Street	COH	$1,210,860
732+67	Bridge Approaches - Falls Street	COH	$105,705
739+35	Walkway Bridge Modification - Russell	COH	$149,730
739+35	Walkway Approaches - Russell	COH	$4,860
Total	**All Bridge Relocations**		**$38,328,943**
	Bridge Relocations as Part of LERR&D		**$38,069,301**

*Railroad relocation costs are considered Federal construction costs for the purposes of cost share, in accordance with Section 3, 1946 Flood Control Act.
Note: no contingencies are included in the estimated cost shown

Cost apportionment for the federal project will be based on the NED Plan cost as discussed in GRR/EA, *Section 4.12*. The cost apportionment between federal and non-federal interests is shown in *Table ES-9*. As stipulated in Section 202(a), WRDA 1996, projects authorized prior to enacting WRDA 1996 (October 12, 1996) have a 25 percent non-federal/75 percent federal cost share. Section 103 (a), WRDA 1986 stipulates the maximum non-federal contribution will not exceed 50 percent of the total project cost. A 5 percent cash contribution is also required from the non-federal sponsor, HCFCD, for construction activities as stipulated by Section 103(a)(1), 1986 WRDA. Exhibit E-1 of ER 1105-2-100 (22 April 2000) echoes Section 103(a) in stipulating that the maximum non-Federal contribution will not exceed 50 percent of TPC, with a 5 percent cash contribution by the non-federal sponsor and 45 percent LERR&D. Both the 5 percent cash contribution by the non-federal sponsor, HCFCD, for construction and the limit adjustment to the federal contribution are noted in *Table ES-9*. Table ES-10 presents the cost apportionment for the TSP. The additional $19.4 million cost of the TSP over the NED Plan cost is a non-federal sponsor, HCFCD, responsibility.

The fully funded total project cost for the NED Plan B50-A25 is shown in *Table ES-*.

Table ES-9:
Cost Apportionment for the NED Plan, B50-A25
2Q2013 (FY 2013) Price Level

Flood Risk Management Components	Federal Cost	Non-Federal Cost	Total Cost
GRR Study Cost	$4,667,244	$4,667,244	$9,334,488
LERR&D	$0	$79,637,648	$79,637,648
--Rail Bridge Modifications [1]	$318,322	$0	$318,322
Construction - Federal Cost Share	$45,536,548	$0	$45,536,548
Mitigation (least cost plan)	$0	$89,724	$89,724
Subtotal	$50,522,114	$84,394,616	$134,916,730
5% Cash	($6,745,836)	$6,745,836	$0
Subtotal	$43,776,278	$91,140,452	$134,916,730
(Percent) [2]	32%	68%	100%
50% Adjustment	$23,682,087	($23,682,087)	$0
NED Plan Total Project	**$67,458,365**	**$67,458,365**	**$134,916,730**

^1 Rail Bridge Modifications are federal cost-shared construction items re: Section 3, 1946 Flood Control Act

^2 Non-federal costs will be no less than 25 percent and not greater than 50 percent for the NED Plan, Section 103(a),WRDA of 1986..

LERR&D = Lands, easements, rights-of-way, relocations and disposal costs.
NOTE: All costs shown are first costs. Contingency is applied only to unconstructed costs.

Table ES-10:
Cost Apportionment for the TSP, B60-A75
2Q2013 (FY2013) Price Level

Flood Risk Management Components	Federal Cost	Non-Federal Cost	Total Cost
GRR Study Cost	$4,667,244	$4,667,244	$9,334,488
LERR&D	$0	$79,637,648	$79,637,648
--Rail Bridge Modifications [1]	$318,322	$0	$318,322
Construction - Federal Cost Share	$45,536,548	$0	$45,536,548
Mitigation (least cost plan)	$0	$89,724	$89,724
Subtotal	$50,522,114	$84,394,616	$134,916,730
5% Cash	($6,745,836)	$6,745,836	$0
Subtotal	$43,776,278	$91,140,452	$134,916,730
(Percent) [2]	32%	68%	100%
50% Adjustment	$23,682,087	($23,682,087)	$0
NED Plan Total Project	**$67,458,365**	**$67,458,365**	**$134,916,730**
Additional NonFederal Cost of TSP		**$19,402,898**	**$154,319,628**

^1 Rail Bridge Modifications are federal cost-shared construction items re: Section 3, 1946 Flood Control Act

^2 Non-federal costs will be no less than 25 percent and not greater than 50 percent for the NED Plan, Section 103(a),WRDA of 1986..

LERR&D = Lands, easements, rights-of-way, relocations and disposal costs.
NOTE: All costs shown are first costs. Contingency is applied only to unconstructed costs.

Table ES-11:
NED Plan, B50-A25, Fully Funded Total Project Cost
Includes Escalation, 22.6 Percent Contingency and FY 2013 Baseline Prices

WBS Structure		Total Project Cost (Fully Funded) ($1,000s)
WBS Number	**Civil Works Feature & Sub-Feature Description**	
2	Relocations	$59,723
	Relocations Spent By Sponsor	$1,395
9	Channels & Canals	$19,646
15	Floodway Control & Diversion Structure	$8,966
1	Lands And Damages	$13,575
	Lands Spent By Sponsor	$11,940
30	Planning, Engineering & Design	$5,607
	Planning, Engineering & Design Spent By Sponsor	$11,845
31	Construction Management	$9,787
	CM Spent By Sponsor	$4,259
	Project Cost Totals:	**$146,743**

Even though the 1990 Authorized Plan was highly effective in achieving flood damage reduction, its implementation would have produced adverse impacts to the natural and social environment within the Hunting Bayou watershed at an unacceptable scale for watershed residents or to the wider public. Conditions within the study area coupled with societal views of acceptable flood risk management remedies had changed to the point that the 1990 Authorized Plan is no longer the most economically efficient plan nor is it implementable.

Table ES- compares the economic performance of the NED Plan, the TSP and the 1990 Authorized Plan for two interest rates. Project performance with the period of analysis, federal discount rate and price level as reported in the authorizing document of the 1990 Authorized Plan is presented as well as the 1990 Authorized Plan's project performance under current conditions and guidance requirements. The NED Plan and the TSP are presented at the period of analysis, price level and federal discount rate which is current and conforms to guidance requirements. The NED Plan and the TSP are also presented under current conditions and at the 7 percent federal discount rate as required by the Office of Management and Budget (OMB Circular A-94 and Executive Order 12893, January 26, 1994).

Table ES-12:
Comparison of the NED Plan, TSP and the 1990 Authorized Plan

	B50A25 3.50%	B50A25 7%	B60A75 3.50%	B60A75 7%	Authorized Plan [1]	Authorized Plan [2]
Price Level	Jan-13	Jan-13	Jan-13	Jan-13	Jan-88	Jan-13
Interest Rate	0.035	0.07	0.035	0.07	0.08625	0.035
Period of Analysis, years	50	50	50	50	100	50
Flood Control (includes Mitigation) – First Cost						
GRR Study	$9,334,488	$9,334,488	$9,334,488	$9,334,488		
Lands and Damages, Relocations	$67,764,915	$67,764,915	$74,085,922	$74,085,922		
PED and Construction Management [3]	$17,247,431	$17,247,431	$19,142,431	$19,142,431		
Construction	$21,142,814	$21,142,814	$28,755,459	$28,755,459		
Construction Contingency	$19,427,083	$19,427,083	$23,001,328	$23,001,328		
Total First Cost	$134,916,730	$134,916,730	$154,319,628	$154,319,628	$59,581,000	$125,523,114
IDC [4]	$26,665,001	$56,343,556	$28,535,540	$64,853,813		
Uncompensated NED Losses	$4,708,700	$2,770,489	$618,590	$363,964		
Recreation First Cost [5]	n/a	n/a	n/a	n/a	$441,000	$929,083
Total Economic Cost	$166,290,431	$194,030,775	$183,473,758	$219,537,405	$60,022,000	$126,452,197
AAEV Total First Cost						
Flood Control	$7,089,578	$14,059,441	$7,822,167	$15,907,647	$5,870,000	$5,351,516
Recreation	n/a	n/a	n/a		$62,000	$39,610
AAEV Operations & Maintenance (O&M)						
Flood Control	$123,896	$123,896	$168,756	$168,756	$193,200	$95,475
Recreation	n/a	n/a	n/a	n/a	$17,100	$8,450
AAEV Total NED Cost	$7,213,474	$14,183,337	$7,990,923	$16,076,403	$6,142,300	$5,495,052
AAEV Total NED Benefits						
Flood Control	$13,952,966	$13,952,966	$15,363,566	$15,363,566	$59,919,000	$29,610,633
Recreation	n/a	n/a	n/a	n/a	$336,400	$166,241
BCR						
Flood Control	1.93	0.98	1.92	0.96	10.2	5.39
Recreation	n/a	n/a	n/a		4.25	3.46
AAEV Net Excess Benefits						
Flood Control	$6,739,492	($230,371)	$7,372,643	($712,837)	$54,049,000	$24,115,581
Recreation	n/a	n/a	n/a	n/a	$274,400	$157,791

[1] The authorized data is taken from Buffalo Bayou and Tributaries, Texas Feasibility Report, House Document 101-208 (1990).
[2] 1990 Authorized Plan costs escalated using EM 1110-2-1304, CCWIS, AppendixA 31Mar13
[3] PED – Preconstruction Engineering and Design
[4] IDC – Interest During Construction
[5] The non-federal sponsor, HCFCD, is not exercising the project's recreational authority at this time.

Section 902, WRDA 1986 Project Cost Limit

Hunting Bayou's 1990 Authorized Plan is part of the Buffalo Bayou and Tributaries, Texas authorization found in Section 101(a)(21), WRDA 1990. Because the authorization includes the main stem of Buffalo Bayou and its tributaries, the Section 902 calculation incorporates all streams included in the authorization. Section 902 analysis results show the FY 2014 $1,513.116 million authorized cost for Buffalo Bayou and Tributaries inflated through construction is less than the $1,658.589 million maximum Section 902 cost limit.

Recommendations

The TSP is recommended for implementation as a federal project, with such modifications thereof as may be advisable at the discretion of the Commander, USACE. Federal and non-federal cost share will be $67.5 million each, based on the NED Plan's $134.9 million first cost.

Requirements and Determinations of Section 211, WRDA 1996

Requirements and determinations for the non-federal sponsor's, HCFCD, work to be considered part of the federal project are noted in the legislative language of Section 211, WRDA 1996, as amended, and in paragragh 4.c. Policy Guidance Letter No. 53, "Implementation of Section 211 of the Water Resources Development Act of 1996," 9 Dec 1997. Requirements and determinations are part of Section 211(e)(2) and Section 211(f)(7) WRDA 1996. These requirements and determinations are discussed in the GRR/EA in *Section 1.0*

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Acronyms

TERM	DEFINITION
AAEV	Average Annual Equivalent Value
AAHU	Average Annual Habitat Unit
AEP	Annual Exceedance Probability
APE	Area of Potential Effects
ASA (CW)	Assistant Secretary of the Army (Civil Works)
BB&TFR	Buffalo Bayou and Tributaries Feasibility Report
BCR	Benefit/Cost Ratio
BFE	Base Flood Elevation
bgs	Below Ground Surface
BW	Bottom Width
CAA	Clean Air Act
CAR	Coordination Act Report
CE/ICA	Cost Effectiveness/Incremental Cost Analysis
CECW-P	USACE Civil Works-Planning and Policy Division
CER	Comprehensive Environmental Response
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CERCLIS	Comprehensive Environmental Response, Compensation and Liability Information System
CFR	Code of Federal Regulations
CH_4	Methane
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COH	City of Houston Governmental Agency
CWA	Clean Water Act
dB	Decibels
dBA	A-weighted Decibels
DO	Dissolved Oxygen
EA	Environmental Assessment
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
EM	Engineering Manual
E.O. or EO	Executive Order
EPA	U.S. Environmental Protection Agency
ER	Engineer Regulation
ERNS	Emergency Response Notification System
ERRY	Englewood Railroad Yard
ESA	Endangered Species Act
FAA	Federal Aviation Administration
FEIS	Final Environmental Impact Statement
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FRM	Flood Risk Management

TERM	DEFINITION
ft	Foot or Feet
FWCAR	Fish and Wildlife Coordination Act Report
FY	Fiscal Year
GBWMB	Greens Bayou Wetlands Mitigation Bank
GHG	Greenhouse Gas
GIS	Geographic Information System
GRR	General Reevaluation Report
H&H	Hydrology and Hydraulics
H-GAC	Houston-Galveston Area Council
HCAD	Harris County Appraisal District
HCFCD	Harris County Flood Control District
HEC-FDA	Hydrologic Engineering Center Flood Damage Analysis
HEP	Habitat Evaluation Procedure
HGB	Houston-Galveston-Brazoria
HSC	Houston Ship Channel
HSI	Habitat Suitability Index
HTRW	Hazardous, Toxic and Radioactive Waste
HW	Hazardous Waste
IC	Institutional Control
IDC	Interest During Construction
IH	Interstate Highway
IOP	Innocent Operator Program
IWR	Institute for Water Resources
LARA	Land Assemblage Redevelopment Authority
LBJ	Lyndon B. Johnson
LEP	Limited English Proficiency
LERR&D	Lands, Easements, Rights-of-Way, Relocations and Disposals
LPST	Leaking Petroleum Storage Tank
MBTA	Migratory Bird Treaty Act
MCACES	Micro-Computer Aided Cost Estimating System, Version 4.1
MOA	Memorandum of Agreement
NAAQS	National Ambient Air Quality Standards
NED	National Economic Development
NEPA	National Environmental Policy Act
NFIP	National Flood Insurance Program
NFRAP	No Further Remedial Action Planned
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NMTC	New Market Tax Credit
NOAA	National Oceanic and Atmospheric Administration
NO_x	Nitrogen Oxide
NPL	National Priorities List

TERM	DEFINITION
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
O&M	Operations and Maintenance
O_3	Ozone
OMRR&R	Operating, Maintaining, Replacing, Repairing and Rehabilitating
PDM	Pre-disaster Mitigation Program
PED	Preconstruction Engineering and Design
PGN	Planning Guidance Notebook
PM	Particulate Matter
$PM_{2.5}$	Particulate Matter less than 2.5 microns in diameter
PM_{10}	Particulate Matter less than 10 microns in diameter
PPA	Project Cooperation (Partnership) Agreement
PST	Petroleum Storage Tank
RCRA	leave
REC	Record of Environmental Compliance
ROW	Right-of-Way
RSLR	Relative Sea Level Rise
SFR	Single-Family Residence
SHPO	State Historic Preservation Officer
SIP	State Implementation Plan
SP	Southern Pacific
SPL	State Priority List (i.e., Texas)
SWL	Solid Waste Landfill
SWPPP	Stormwater Pollution Prevention Plan
T&E	Threatened and Endangered
TCEQ	Texas Commission on Environmental Quality
THC	Texas Historical Commission
TMDL	Total Maximum Daily Load
TPDES	Texas Pollutant Discharge Elimination System
TPWD	Texas Parks and Wildlife Department
TRF	The Reinvestment Fund
TSD	Treatment, Storage and Disposal
TSP	Tentatively Selected Plan
TWDB	Texas Water Development Board
TxDOT	Texas Department of Transportation
TxNDD	Texas Natural Diversity Database
URA	Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 as amended (P.L. 91-646)
U.S.C.	United States Code
UPRR	Union Pacific Railroad
US or U.S.	United States
USACE	U.S. Army Corps of Engineers

TERM	DEFINITION
USACE-SWG	U.S. Army Corps of Engineers, Galveston District
USCB	U.S. Census Bureau
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VCP	Voluntary Cleanup Program
VOC	Volatile Organic Compound
WP	With Project
WOP	Without Project
WRDA	Water Resources Development Act
WSELs	Water Surface Elevations
WWTP	Wastewater Treatment Plant

1.0 INTRODUCTION AND PURPOSE OF THE GRR/EA

This report is the Draft General Reevaluation Report and Integrated Environmental Assessment (GRR/EA) prepared for the Hunting Bayou Flood Risk Management (FRM) project, located in Harris County, Texas. The Draft GRR/EA supplements and reevaluates the Congressionally-authorized FRM project in 1990 (hereafter referenced as the 1990 Authorized Plan).

On February 12, 1990 the U.S. Army Corps of Engineers issued a report entitled "Buffalo Bayou and Tributaries, Texas Feasibility Report" for flood damage prevention in the greater Houston, Texas area. It was transmitted to the U.S. House of Representatives on June 10, 1990 in response to an authorization by the Committee on Public Works of the U.S. House of Representatives on April 20, 1948. The plan became authorized under Section 101(a)(21), WRDA 1990. The Harris County Flood Control District (HCFCD) is designated as the local non-federal sponsor for implementing the flood damage improvements identified in the report.

The plan itself addressed Buffalo Bayou and six of its major tributaries, one of which is Hunting Bayou. The Water Resources Development Act of 1996 (Public Law 104-303), Section 211 authorized an approved non-federal interest to undertake studies, design and/or construction of a previously authorized project such as Hunting Bayou. Subsection 211(f) identifies specific projects to demonstrate the advantages and effectiveness of non-federal interests undertaking flood control projects. Moreover, Subsection 211(f)(7) specifically identifies Hunting Bayou as one of the projects and provides the ability for the non-federal interest to evaluate an alternative to the authorized project.

The field conditions today differ significantly from the findings upon which the 1990 plan for Hunting Bayou was authorized. This justifies a reexamination of its conclusions. This General Reevaluation Study and Integrated Environmental Assessment documents the analysis of current conditions including a reevaluation of the 1990 authorized plan and several alternatives to that plan in accordance with the requirements of WRDA 1996.

The non-federal sponsor, HCFCD, pursuant to its authority under Section 211f(7) of the 1996 Water Resource Development Act (WRDA), as amended, has developed an alternative to the 1990 Authorized Plan to reflect current existing local conditions and concerns to address ongoing flooding issues and needs. The Draft GRR/EA documents these changes and provides rationale and justifications for proposed modifications.

The Draft GRR/EA accomplishes the following.

1. Reevaluates and compares FRM alternative actions.
2. Compares alternatives and analyzes their net benefits.
3. Identifies a final array of alternatives.
4. Screens the finalist alternatives based on economic and environmental criteria and selects those to be analyzed in detail according to their impacts on the biological, socioeconomic and physical environments.

5. Analyzes the finalist alternatives including the No Action Alternative, and identifies their predicted effects on the environment so the public and decision-makers are fully informed about the effects from the proposed action
6. Assesses impacts and associated mitigation.

The purpose of the Draft GRR/EA is to support a recommendation by the Chief of Engineers regarding whether the reformulated alternative to the 1990 Authorized Plan is within the existing project authorization. The Draft GRR/EA also supports Congressional appropriations (i.e., funding and other decisions made by U.S. Army Corps of Engineers (USACE), the non-federal sponsor, HCFCD, and other agencies to implement the Tentatively Selected Plan [TSP]). In addition, the Draft GRR/EA will document compliance with applicable environmental statutes such as the Endangered Species Act (ESA), Clean Air Act (CAA), Clean Water Act (CWA), Fish and Wildlife Coordination Act, Historic Preservation Act, National Environmental Policy Act (NEPA), current USACE policies, criteria and guidance, and applicable local and state laws, regulations and ordinances.

The GRR/EA demonstrates the TSP falls within the general footprint and intent of the 1990 Authorized Plan to provide flood control to the Hunting Bayou watershed. The TSP is a smaller extent than the 1990 Authorized Plan. However, the TSP is more focused on minimizing the adverse social, economic and natural consequences from implementation; therefore, produces fewer adverse impacts with greater risk reduction in the area of concentrated damages.

1.1 Report Organization*

This Draft GRR/EA has been divided into nine primary chapters; each deals with a specific subject area relating to the planning process. The chapters are described below.

Section 1 – Introduction: describes background information concerning the purpose/goals of and need/problems (Purpose and Need) addressed by the project, project authorization and project status, and the scope for the reevaluation study. This chapter also notes links with other related studies and reports.

Section 2 – Existing Conditions (Affected Environment): presents the existing environmental conditions within the project area. This chapter also includes a discussion about environmental resources which would be affected by implementing project alternatives.

Section 3 – Plan Formulation: explains the Plan Formulation and Future Without Project (WOP) Conditions expected to exist over the 50-year period of analysis in the absence of any action taken by the federal government to solve the identified problems and underlying need for action. This chapter also identifies problems and opportunities, planning goals and objectives, as well as planning constraints. The plan formulation rationale is presented, and the process by which plan reevaluation was conducted is described. Alternatives, management measures and remedies are presented, and the top (economic) performing measures are compared.

Section 4 – Final Array of Alternatives: presents, analyzes and compares the final array of alternatives. The TSP and National Economic Development (NED) plans are identified, and a rationale is presented to justify why the TSP is the better performing plan. TSP project costs, cost apportionment and 1996 WRDA Section 575 analysis are presented.

Section 5 – Foreseeable Effects from the Proposed Action and Alternatives: evaluates the TSP, NED, 1990 Authorized Plan and No Action Alternative for their effect on the biological, physical and socioeconomic resources within the area which may be affected by proposed construction, operation or maintenance activities. Each alternative is described in terms of its positive or negative effect, and the magnitude, intensity and duration for such effects to various environmental resources by category.

Section 6 – Cumulative Effects Analysis: analyzes the Proposed Action and Alternatives and evaluates incremental impacts the project's direct and indirect effects have on a resource when added to other past, present and future effects on a resource from activities unrelated to the TSP.

Section 7 – Public Involvement and Agency Coordination: summarizes public involvement and agency outreach activities conducted.

Section 8 – Conclusions, Recommendations and a Comparison between the 1990 Authorized Plan and the TSP: provides the results from alternative evaluation, project cost estimates, project schedule, items of cooperation and a recommendation for action.

Section 9 – References: lists references including studies, reports, analyses and other reference materials used to prepare this report.

1.2 Requirements for a Post Authorization Change Report

Per Engineer Regulations (ER) 1105-2-100, paragraph 4-1.b(1), a general reevaluation reanalyzes a previously completed study using current planning criteria and policies, which is required due to changed conditions and/or assumptions. The results may affirm the previous plan; reformulate and modify it as appropriate, or find no plan is currently justified. ER 1105-2-100, paragraph G-16.a details the information required in a post-authorization change report. *Table 1-1* displays the items required to complete the report and the location in the Main Report where this information is presented.

Table 1-1:
Requirements for Post Authorization Change Reports

Item No.	Description	Location in Main Report
1	Description of Authorized Design	Section 1.5
2	Authorization	Section 1.3
3	Funding since Authorization	Section 1.5
4	Changes in Scope of Authorized Project	Section 1.3
5	Changes in Project Purpose	Section 1.7
6	Changes in Local Cooperation Requirements	Section 8.4
7	Changes in Location of Project	N/A
8	Design Changes	Section 4.0 and 8.0, Table 8.5
9	Changes in Total Project First Costs	Table ES-1
10	Changes in Project Benefits	Table ES-1
11	Benefit-Cost Ratio (BCR)	Table ES-1
12	Changes in Cost Allocation	Section 8.1.3
13	Changes in Cost Apportionment	Table ES-3, Section 8.1.3
14	Environmental Considerations in Recommended Changes	Section 5.0
15	Public Involvement	Section 7.0
16	History of Project	Section 1.3 and 1.5
b	Reporting Changes in PB-3s and Justification Sheets	Awaiting concurrence of Division Commander
17	Interest Rates for Changes	Section 3.6
a	GRR-use the current interest rate.	FY14 rate of 3.5 percent, 50 years
b	Limited Reevaluation Report	N/A
c	Addition of mitigation--use rate applicable to the Authorized project is permissible.	N/A

G-16.a., ER 1105-2-100, Appendix G, Amendment #1, 30 June 2004

1.3 Project Authorities

Federal project authorities applicable to the Hunting Bayou FRM Project are numerous and have evolved over time. Following is a brief summary of applicable authorities, listed in order of their occurrence.

On April 20, 1948, the Committee on Public Works of the House of Representatives adopted the following Resolution:

> "Resolved by the Committee on Public Works of the House of Representatives, United States, that the Board of Engineers for Rivers and Harbors be, and is hereby requested, to review the reports on the Houston Ship Channel (HSC) and Buffalo Bayou, Texas contained in House Document No. 456, 75th Congress, 2nd session, with a view to determining a comprehensive plan for the betterment of navigation and for the control of floods throughout the Buffalo Bayou watershed including modification, if any, of the presently approved plan of improvement and of the requirements for local cooperation in order to meet the materially changed conditions resulting from the rapid industrial expansion of COH, and contiguous areas."

In 1988, the USACE, Galveston District (USACE-SWG) completed the requirements for the 1948 Congressional Resolution by completing and issuing the following.

- Buffalo Bayou & Tributaries, Texas Feasibility Report (Flood Damage Prevention), Volume I

- *Buffalo Bayou & Tributaries, Environmental Impact Statement*, Volume II – This Environmental Impact Statement (EIS) was filed with the U.S. Environmental Protection Agency (EPA) in September 1988.

- *Buffalo Bayou and Tributaries, Texas*, a Report of the Chief of Engineers, Department of the Army, was issued 12 February 1990 and transmits to Congress the agency's recommendation of the project.

These documents provided the administrative documentation for the 1990 Authorized Plan and included analyses to provide the following.

- Evaluate water resource problems and needs for the Buffalo Bayou watershed including the Hunting Bayou tributary watershed.

- Determine Hunting Bayou's overbank stream flooding has resulted in frequent inundation of urban properties and is a primary water resource problem in the study area.

- Evaluate an array of flood control plans and alternatives to provide FRM within the Buffalo Bayou, including the tributary Hunting Bayou watershed.

- Define a comprehensive plan consisting of structural and nonstructural flood control measures for the tributary Buffalo Bayou watersheds, including Hunting Bayou, to address flooding issues.

- Evaluate potential environmental effects associated with alternative actions and for the comprehensive plan.

WRDA 1990 (Public Law 101-640) Section 101(a)(21), relying on the administrative record provided by the Feasibility Report and Environmental Impact Statement addressed above, authorized the Buffalo Bayou and Tributaries Texas project (including the1990 Authorized Plan) as follows:

> "Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled…Except as provided in this subsection, the following projects for water resources development and conservation and other purposes are authorized to be carried out by the Secretary (Secretary of the Army) substantially in accordance with the plans, and subject to the conditions, recommended in the respective reports designated in this subsection:
>
> (21) Buffalo Bayou and its Tributaries, Texas – The project for flood control, Buffalo Bayou and tributaries, Texas: Report of the Chief of Engineers, dated February 12, 1990, at a total cost of $727,364,000, with an estimated first federal cost of $403,359,500 and an estimated first non-federal cost of $324,004,500 (104 Stat. 4610).

Section 211, WRDA 1996 (Public Law 104-303) as amended by Section 223, WRDA of 1999 (Public Law 106-53), authorized non-federal interests to undertake major FRM projects with

federal funding assistance (subject to federal funding availability) or credit for the non-federal interest for its portion of the work subject to Secretary of the Army approval. Section 211(e)(2), WRDA 1996,as amended, states the Secretary may also reimburse any non-federal sponsor an amount equal to the estimate of the federal share, without interest, of the cost of any authorized flood control project, or separable element of a flood control project, constructed pursuant to this section or provide credit for the non-federal share of the project with certain stipulations.

Even though the non-federal sponsor, HCFCD, is in the lead, the planning, design and construction are implemented in accordance with established USACE regulations, guidance and requirements for federal participation. The primary advantage for the non-federal sponsor, HCFCD, taking the lead is the project can be constructed and benefits realized sooner based on the potential for federal share reimbursement for previously constructed project components, as stated below in WRDA 1996, Section 211(e)(2)(A), *as amended*:

> "(e) REIMBURSEMENT—
>
> (2) SPECIAL RULES—
>
> (A) REIMBURSEMENT *OR CREDIT*.— For work (including work associated with studies, planning, design, and construction) carried out by a non-federal interest with respect to a project described in subsection (f), the Secretary shall, *subject to the availability of appropriations, reimburse*, without interest, the non-federal interest an amount equal to the estimated federal share of the cost of such work, *or provide credit (depending on the request of the non-federal interest) for the non-federal share of such work*, if such work is later recommended by the Chief of Engineers and approved by the Secretary [of the Army]."

Section 211(f) authorized the non-federal sponsor, HCFCD, to develop a FRM plan for Hunting Bayou:

> "(f) SPECIFIC PROJECTS—For the purposes of demonstration the potential advantages and effectiveness of non-federal implementation of flood control projects, the Secretary shall enter into agreement pursuant to this section with non-federal interests for development of the following flood control projects by such interest:
>
> (7) Hunting Bayou, Texas—The Hunting Bayou element of the project for flood control, Buffalo Bayou and tributaries, Texas, authorized by such section; except that, subject to the approval of the Secretary as provided by this section, the non-federal interest may design and construct an alternative to such element".

The non-federal sponsor, HCFCD, started implementing the proposed Hunting Bayou project to reduce future flood damage as soon as possible. Because Hunting Bayou was included in the 211(f) authorization, the non-federal sponsor, HCFCD, may be reimbursed or receive credit for the efforts taken to reduce flood damages in the Hunting Bayou watershed as approved by the Secretary of the Army.

Section 902 of WRDA 1986 allows for increases in total project costs up to 20 percent without additional authorization for modifications that did not materially change the project's scope or function.

Section 575 (a) of WRDA 1996 provides that "…during any evaluation of economic benefits and costs for projects… that occurs after the date of the enactment of this Act, the Secretary shall not consider flood control works constructed by non-federal interests within the drainage area of such projects prior to the date of such evaluation in the determination of conditions existing prior to construction of the project."

Section 575(b) of WRDA of 1996 provides that:

> (b) SPECIFIC PROJECTS. —The projects to which subsection (a) apply are—
>
> (1) the project for flood control, Buffalo Bayou Basin, Texas, authorized by Section 203 of the Flood Control Act of 1954 (68 Stat. 1258);
>
> (2) the project for flood control, Buffalo Bayou and tributaries, Texas, authorized by Section 101(a) of the WRDA of 1990 (104 Stat. 4610);
>
> (3) the project for flood control, Cypress Creek, Texas, authorized by Section 3(a)(13) of the WRDA of 1988 (102 Stat. 4014).

Section 354 of WRDA 1999 amended Section 575(a) of WRDA 1996 to remove nonstructural actions from consideration as well:

> Section 575 of the Water Resources Development Act of 1996(110 Stat. 3789) is amended—
>
> (1) in subsection (a)—
>
> (A) by inserting ''or nonstructural actions'' after ''flood control works constructed''; and
>
> (B) by inserting ''or nonstructural actions'' after ''construction of the project''; and
>
> (2) in subsection (b)—
>
> (A) in paragraph (2), by striking ''and'' at the end;
>
> (B) in paragraph (3), by striking the period at the end and inserting ''; and''; and
>
> (C) by adding at the end the following:
>
> ''(4) the project for flood control, Clear Creek, Texas, authorized by section 203 of the Flood Control Act of 1968 (82 Stat.742).''

The Authorized Design was approved for construction by Congress with WRDA 1990. As stipulated in WRDA 1996, Section 202(a), projects authorized prior to the enactment of WRDA 1996 (10/12/1996) have a 25 percent non-federal /75 percent federal cost share. WRDA 1986, Section 103(a) stipulates that the maximum non-federal contribution will not exceed 50 percent of the total project cost. In this particular project, lands, easements, rights-of-way, relocations and disposals (LERR&Ds), a non-federal responsibility, contribute significantly to the total project cost such that the federal cost share will assume a portion of LERR&D cost to meet the non-federal cost share maximum contribution of 50 percent.

1.4 Requirements and Determinations of Section 211, WRDA 1996

General requirements and determinations for the non-federal sponsor, HCFCD's work to be considered as part of the federal project are noted in the legislative language of Section 211, WRDA 1996, as amended, and in Policy Guidance Letter No. 53 (PGL 53), "Implementation of Section 211 of the Water Resources Development Act of 1996," 9 Dec 1997.

1. Section 211(f)(7) of WRDA 1996 specifically authorizes the non-federal sponsor to undertake an alternative to the Hunting Bayou element of the 1990 authorized Buffalo Bayou and Tributaries, Texas project. No LCA or implementation agreement with ASA (CW) is necessary for the pursuit of a Section 211 project by a non-federal sponsor. The legislative authority does not require prior approval from the Secretary. The non-federal sponsor is undertaking this effort at its own risk while a GRR is being prepared.

2. Specific requirements for reimbursement applicable to the Hunting Bayou federal project are found in Section 211(e)(2) WRDA 1996, as amended.

   (2) SPECIAL RULES.—

   (A) REIMBURSEMENT *OR CREDIT*.—For work (including work associated with studies, planning, design, and construction) carried out by a non-Federal interest with respect to a project described in subsection (f), the Secretary shall, *subject to the availability of appropriations, reimburse*, without interest, the non-Federal interest an amount equal to the estimated Federal share of the cost of such work *or provide credit (depending on the request of the non-Federal interest) for the non-Federal share of such work* if such work is later recommended by the Chief of Engineers and approved by the Secretary.

   (B) CREDIT.—If the non-Federal interest for a project described in subsection (f) carries out work before completion of a reconnaissance study by the Secretary and if such work is determined by the Secretary to be compatible with the project later recommended by the Secretary, the Secretary shall credit the non-Federal interest for its share of the cost of the project for such work*and*

   (C) if the construction work is substantially in accordance with plans prepared under subsection (b).

   (3) MATTERS TO BE CONSIDERED IN REVIEWING PLANS.—

   In reviewing plans under this subsection, the Secretary shall consider budgetary and programmatic priorities and other factors that the Secretary considers appropriate.

   (4) MONITORING.—The Secretary shall regularly monitor and audit any project for flood control approved for construction under this section by a non-Federal interest to ensure that such construction is in compliance with the plans approved by the Secretary and that the costs are reasonable.

   (5) LIMITATION ON REIMBURSEMENTS.—The Secretary may not make any reimbursement under this section until the Secretary determines that the work for which reimbursement is requested has been performed in accordance with applicable permits and approved plans.

(6) SCHEDULE AND MANNER OF REIMBURSEMENT.—

(A) BUDGETING.—The Secretary shall budget and request appropriations for reimbursements under this section on a schedule that is consistent with a Federal construction schedule.

(B) COMMENCEMENT OF REIMBURSEMENTS.—

Reimbursements under this section may commence on approval of a project by the Secretary.

(C) CREDIT.—At the request of a non-Federal interest, the Secretary may reimburse the non-Federal interest by providing credit toward future non-Federal costs of the project.

General implementation guidance is found in PGL53. For 211(f) projects to be approved for federal cost-share, the non-federal sponsor demonstrates that all the requirements and guidelines for a federal flood control study have been followed and met. These include all engineering, geotechnical, environmental and planning activities and assessments and cost analyses in compliance with published USACE regulations. These general considerations follow.

1. All projects pursued under the authority of Section 211 must be planned, designed, and constructed in accord with appropriate federal laws and criteria, standards and policies, including the appropriate National Environmental Policy Act (NEPA) documentation, and construction must comply with all applicable federal and State laws and regulations.

2. The non-federal sponsor must conduct NEPA investigations, prepare appropriate NEPA documents, conduct all public and agency coordination, and obtain all necessary federal and State permits.

3. Funds for activities undertaken by the USACE district offices which are necessary for the successful completion of a Section 211 project, or separable element thereof, and construction of the sponsor proposed work including, but not limited to, design, review of project economics, environmental assessments, determination of lands, easements, right-of-way (ROW) and suitable borrow and dredged or excavated material disposal areas (LERRD's) requirements, auditing, permit evaluations, and inspections, must be provided by the non-federal sponsor.

4. The non-federal sponsor must provide all LERRD's and shall perform or ensure performance of all relocations that the USACE determines are required for the construction, operation and maintenance of the project. The value of LERRD's provided by the non-federal sponsor that are required for the project will be determined in accordance with standard valuation procedures as contained in the model Project Cooperation (Partnership) Agreement (PPA) for structural flood control projects.

5. The non-federal sponsor will be responsible for the operation, maintenance, repair, replacement and rehabilitation of the project in accordance with regulations or directions prescribed by the USACE and shall perform all other items of sponsor cooperation required by the project authorization.

6. In the development of a section 211 agreement, the normal procedures for processing and reviewing a PCA will be used.

Paragraph 4(c) of Policy Guidance Letter No. 53 (Dec 1997) reiterates the specific requirements for reimbursement stated in the legislative language of Section 211 of WRDA 1996.

1. Reimbursement for those projects listed in section 211(f) will be in accordance with Section 211(e)(2)(A). These special reimbursement rules expand the definition of the work for which the non-Federal sponsor will be reimbursed to include studies, planning, design and construction if such work is later recommended by the Chief of Engineers and approved by the Secretary.

2. In addition, for the section 211 (f) projects, a non-Federal sponsor will be credited for the Federal share of any work carried out before completion of a reconnaissance study if such work is determined to be compatible with the project later recommended for construction.

3. As required by section 211 (e) (2) (A) the reimbursement must be contained in (emphasis added) an Appropriations Act; that is, the reimbursement must be earmarked in law.

4. Any eligible reimbursable Federal share of costs associated with studies, planning or design efforts will be included in the final auditing of the total project costs upon completion of the construction of a project or separable element thereof.

5. For the specifically named projects, consideration will be given to reimbursement on an incremental basis; that is, reimbursement will be recommended upon completion of the construction of a discrete segment of an economically justified and environmentally acceptable project or separable element, thereof, provided that the non-Federal sponsor has entered into a binding agreement with the Secretary and has committed to the construction of the total project or separable element thereof. A discrete segment is defined as a physical portion of the project, as described in design documents, that is environmentally acceptable, is complete, will not create a hazard, and functions independently so that the non-Federal sponsor can operate and maintain it in advance of completion of the total project or separable element thereof.

6. Reimbursements will not be made unless and until the Secretary has determined that the construction for which reimbursement is requested is complete, is consistent with the authorization of the project and its overall economic justification, and has been performed in accordance with applicable permits and approved plans.

7. Further, the agreement must contain a provision which will require the non-Federal sponsor to remit previously received reimbursements in the event that the non-Federal sponsor fails to complete the entire project or separable element thereof.

The non-federal sponsor's compliance with the requirements of Section 211, WRDA 1996 and PGL 53 is satisfied as follows:

- The non-federal sponsor, HCFCD, has produced an economically justified and environmentally acceptable alternative to the 1990 Authorized Plan as presented in the GRR/EA. The non-federal sponsor, HCFCD, is currently constructing the TSP at its own risk while a GRR is being prepared.

- The non-federal sponsor, HCFCD, has followed USACE guidelines as published in USACE Engineer Regulations for all technical disciplines contributing to this GRR/EA. Models used to develop the WOP and with project conditions are certified by the USACE. USACE guidance as published in Engineer Regulations has been followed to insure conformance with Corps policy and practices. The non-federal sponsor, HCFCD's planning and design standards include specific and current references to those local, state and federal regulations and statutes which must be complied with in the TSP's development, construction and operation.

- Based on the experience, capability and integrity of the non-federal sponsor, HCFCD's staff, USACE staff and local consultants who worked together, a technically sound plan was developed that was extensively reviewed in the Peer Review and ATR process. The required NEPA documentation is included in the GRR/EA. This and supporting documents identify the public outreach and agency coordination which have occurred during the planning period.

- The non-federal sponsor, HCFCD, has a Memorandum of Agreement with SWG to fund their participation in the non-federal sponsor's 211(f) Hunting Bayou study.

- The proposed work will require a Department of Army individual permit with conditions. The GRR/EA and supporting information demonstrates that the TSP is in compliance with the 404(b) (1) guidelines and meets the 40 CFR 230.10 standards for being the least environmentally damaging practicable alternative. In addition, the USACE public interest review has been complied with through the EA's preparation.

- The non-federal sponsor, HCFCD, will provide to the Secretary the estimated total commitment and the reimbursement requirements for project construction as appropriate.

- The non-federal sponsor, HCFCD has developed the plans, specifications and estimates needed implement the TSP.

- The non-federal sponsor, HCFCD, is acquainted with the provisions and requirements of Section 211 with regard to review and oversight by the USACE.

- The non-federal sponsor, HCFCD, understands their obligations and requirements for providing LERRDs under items of local cooperation. The non-federal sponsor, HCFCD, is acquainted with the method by which the value of LERRDs is determined by the USACE.

- The non-federal sponsor, HCFCD, will honor their commitment to the federal project as specified in the PPA.

1.5 Description of the 1990 Authorized Plan

The 1990 Authorized Plan consisted largely of a channel enlargement project (deepening and widening) over Hunting Bayou's entire length, with the objective to increase the hydraulic carrying capacity and improve the stormwater conveyance through Hunting Bayou (*Exhibit 1-3*). Based on the hydrologic and hydraulic modeling and assumptions from the 1988 feasibility study, this plan would have provided protection from a 4 percent annual exceedance probability (AEP) flood event (25-year) under future urban conditions. With present local drainage conditions in the watershed, the plan would have provided protection from a flood greater than a 40-year flood or a flood with a 2.5 percent AEP. Major 1990 Authorized Plan elements included the following.

- Construct a trapezoidal, grass-covered channel and selectively place stone for erosion control. Channel bottom widths would vary from 110 feet (ft) in Hunting Bayou's lower reaches to 50 ft in the upper reaches.
- Purchase and remove 23 single-family residences and 20 businesses.
- Remove and replace 8 railroad bridges; replace or modify 25 road and street bridges; and modify 39 pipelines including utility pipelines.
- Excavate about 4,389,000 cubic yards of earth material and dispose approximately 3,731,000 cubic yards of material on 385 acres of open upland sites.
- Aesthetically plant trees and shrubs compatible with urban and suburban surroundings.
- Channel construction would result in removing approximately 66 acres of riparian vegetation and 30 acres of upland forest, resulting in wildlife habitat losses.
- To compensate for the wildlife habitat losses, mitigation includes planting 75 acres of riparian forests and 20 acres of upland forest. Wetland mitigation would also be achieved by constructing stormwater detention and disposal areas elsewhere.
- Develop recreational amenities including constructing 1.2 miles of multipurpose trails and areas for picnic tables, grills, benches and an exercise area. An access road, restroom, drinking fountains and a parking area were included adjacent to the proposed recreational facilities.
- Acquire approximately 198 acres within Herman Brown Park for necessary project ROW.

Based on January 1988 price levels, the total project first cost for the 1990 Authorized Plan was $60,022,000 (12 Feb 1990 Chief's Report and House Document 101-208) . The first cost for flood control was $59,581,000. The 1990 Authorized Plan had a 10.2 BCR (House Document 101-208, 1990). The overall Buffalo Bayou and Tributaries, Texas project for flood control was authorized with a total $727,364,000 cost.

Based on the Chief's Report (12 Feb 1990), the 1990 Authorized Plan for Hunting Bayou's benefits would accrue from inundation damage reduction to existing and future development. At the time of the analysis, 9,823 structures were in the 100-year (1 percent AEP) floodplain and were cumulatively valued at $677 M. The value of a structure averaged $69,000 in 1988. A benefit was also estimated for a reduction in the administrative costs to the flood insurance program. *Table 1-2* displays the benefits attributable to the 1990 Authorized Plan at the time of its authorization.

Table 1-2:
1990 Authorized Plan – Hunting Bayou Plan HU-1
Average Annual Flood Damage Reduction Benefits

Description	Annual Benefits
Existing Development Benefits	$47,643,000
Future Development Benefits	
Affluence	$12,010,200
Future Development, above 100-year level	$265,400
Total Average Annual Benefits	$59,919,000

January 1988 price level, 8.625 percent discount rate

Benefits for the 1990 Authorized Plan were estimated over a 100-year period of analysis, based on January 1988 price levels, at an interest rate of 8.625 percent. *Table 1-3* demonstrates the change in outputs by simply using budgetary programming techniques to update the 1990 Authorized Plan to current interest rate, price level and period of analysis without reanalyzing current conditions. The 1990 Authorized Plan outputs are reduced by almost half from $60 million to $31million in flood control benefits and net excess benefits drop from $54 million to $25 million. The cost for the 1990 Authorized Plan changed very little based on updating indices from EM 1110-2-1304, CCWIS, Appendix A, 31Mar13. The overall BCR changed from 10.2 to 5.2 based on this technique. Therefore, applying different interest rates, price levels and periods of analysis reduced expected project performance by half.

Limited funds have been appropriated since 1990, however the project authorized by Congress was not constructed.

Table 1-3:
Hunting Bayou 1990 Authorized Plan Cost and Benefit Summary

	Authorized Plan	Authorized Plan
Price Level	Jan-1988	Jan-2013
Interest Rate	0.08625	0.035
Period of Analysis, years	100	50
Flood Control (includes Mitigation) – First Cost		
Lands and Damages, Relocations		
PED and Construction Management		
Construction		
Construction Contingency		
Total First Cost	$59,581,000	$125,523,114
IDC		
Recreation First Cost	$441,000	$929,083
Total Economic Cost	$60,022,000	$126,452,197
AAEV Total First Cost		
Flood Control	$5,870,000	$5,351,516
Recreation	$62,000	$39,610
AAEV Operations & Maintenance (O&M)		
Flood Control	$193,200	$95,475
Recreation	$17,100	$8,450
AAEV Total NED Cost	$6,142,300	$5,495,052
AAEV Total NED Benefits		
Flood Control	$59,919,000	$29,610,633
Recreation	$336,400	$166,241
BCR		
Flood Control	10.2	5.39
Recreation	4.25	3.46
AAEV Net Excess Benefits		
Flood Control	$54,049,000	$24,115,581
Recreation	$274,400	$157,791

[1] *The authorized data is taken from Buffalo Bayou and Tributaries, Texas Feasibility Report, House Document 101-208, 1990*

1.6 Need for an Alternative to the 1990 Authorized Plan

The 1990 Authorized Plan is a legacy plan which produced an engineered solution from the Hunting Bayou headwaters to its confluence with Buffalo Bayou. In the years after the 1990 Authorized Plan was approved, remedies for flood damage reduction increasingly deemphasized large scale structural or engineered solutions and focused on considerations relating to preserving natural habitat and minimizing effects from flood damage reduction measures to neighborhoods bordering the bayou. In the period between 2000 and present, preservation of natural areas adjacent to the bayou and reduction of impacts to historic neighborhoods became new constraints on achieving flood damage reduction in the watershed. Even though the 1990 Authorized Plan was effective in achieving flood damage reduction, its implementation would have produced adverse impacts on the natural and social environment within the Hunting Bayou watershed at a scale which would not be acceptable to watershed

residents or to the wider public. Natural environment impacts from the 1990 Authorized Plan would include Herman Brown Park, a 700-acre public park in Hunting Bayou's middle stream segment, 28 percent of which would be converted to project ROW and channel enlargement. Large scale and expensive environmental mitigation would be required for the full channelization project, even though the supporting legislative documentation acknowledged Hunting Bayou basin's upper reaches were the "most susceptible to urban flooding under existing conditions" (Buffalo Bayou and Tributaries, Texas: Report of the Chief of Engineers, dated February 12, 1990).

The supporting legislative documentation describing the 1990 Authorized Plan for Hunting Bayou also stated displacements would affect 23 single family residences and 20 businesses. However, when the displacements were updated during the General Reevaluation study, that number had increased to 140 displacements – a magnitude of impact which would be unacceptable to residents and other stakeholders.

The existing condition upon which the 1990 Authorized Plan was justified had changed under current conditions. Future development benefits were included in the justification for the 1990 Authorized Plan. During the General Reevaluation study, the notion that future development would be exposed to damages, albeit above the 100-year flood elevation, was unsupportable by population growth expectations. Even though the 1990 Chief's Report acknowledged Hunting Bayou's population had dwindled over the past decennial census, assumptions for future growth were accepted as the basis for future development benefits. Hunting Bayou watershed's population in 1980 was estimated to be 84,000 persons; in 2010, the watershed population had declined to 69,000 residents. Therefore the basis for future development benefits was lost as the population dwindled. Furthermore, any future development in the watershed would be subject to current floodplain regulations which mandate no adverse impact to Hunting Bayou.

The 1998 structure inventory numbered 7,689 structures in the 1 percent AEP floodplain and was valued at $800 million including structure and contents. Structure values alone averaged $58,000. With contents added, property values averaged $104,000. Any increase in the structure value was seen in the changing land use within the middle and lower stream segments as residential housing was replaced with industrial and commercial development which takes advantage of the multimodal transportation opportunities of the rail yards in the watershed and the Port of Houston deep draft navigation channel at the bayou's mouth.

Over time, the Hunting Bayou watershed evolved into a low-income area dominated by populations having limited economic resources to appropriately and robustly respond to and recover from the devastating consequences of catastrophic flood events. As the flooding risk persisted, the population and housing count diminished. The population demographics changed as low income populations inhabited lower cost housing which now existed in the watershed. While the 1990 Authorized Plan as brought forward into the GRR as Alternative 1, 110-BW, 25-year design, was still a viable federal project, the condition upon which the original project was justified had changed. The estimated project cost to implement the plan had risen from the $60,022,000 authorized cost at 1988 prices to $232 million at 1999 prices.

The non-federal sponsor, HCFCD, considered the adverse social and environmental impacts from the 1990 Authorized Plan and desired to implement a less expensive, less environmentally damaging and less socially disruptive flood damage reduction project. The non-federal sponsor,

HCFCD, wanted a plan that focused on the upstream areas directly affected by flooding, which even the study generating the 1990 Authorized Plan recognized. The flooding concentration in the upper stream segment as noted in the 1990 Chief's Report persisted. As shown in the 2001 WOP condition described in Section 3.8, over three-quarters of the flood damages within the watershed were still concentrated in the uppermost one-quarter of the watershed.

As allowed under Section 211(f)(7), WRDA1996, the non-federal sponsor, HCFCD, started implementing an alternative to the 1990 Authorized Plan to reduce future flood damage as soon as possible. Because Hunting Bayou was included in the 211(f) authorization, the non-federal sponsor, HCFCD, may be reimbursed or receive credit for the efforts taken to reduce flood damages in the Hunting Bayou watershed when such action is approved by the Secretary of the Army.

In compliance with requirements for a GRR, the non-federal sponsor, HCFCD, will compare the impacts from any proposed alternative to the 1990 Authorized Plan to those projected to occur with the 1990 Authorized Plan if it were implemented under current conditions.

WRDA 1990 Section 101(a)(21) authorized flood control and recreation features for Hunting Bayou. While that authorization is still in effect, the non-federal sponsor, HCFCD, declines to exercise recreation authority at this time to focus efforts on FRM. During plan reevaluation in 2001, a recreational plan was developed and evaluated in conjunction with reusing vacated land associated with buyout components for FRM. None of the buyout components were carried forward due to poor economic performance with low net excess benefits. While the non-federal sponsor, HCFCD, is not pursuing recreational opportunities at this time, another interest group, the Houston Parks Board, is pursuing grants not affiliated with this project with which to construct trails along the Hunting Bayou ROW. The Houston Parks and Recreation Department, in partnership with the Houston Parks Board's Bayou Greenways master plan, has received funding for one mile of new trail construction along Hunting Bayou. The project will connect with 1.5 miles of existing trails and provide a continuous path between Mickey Leland Park and Hutcheson Park.

1.7 Purpose and Need for Action*

1.7.1 Project Purpose*

The purpose for the Hunting Bayou FRM project is to

> *…develop an alternative flood risk reduction plan to the 1990 Authorized Plan that will reduce flooding of structures (residential, commercial, public, etc.) along Hunting Bayou in a manner that is less disruptive to the existing environment, and is effective and affordable.*

This project purpose statement is supported by numerous WRDA laws, as discussed above in Section 1.2, to address flooding impacts within the Hunting Bayou watershed. This project is also a vital component in the non-federal sponsor, HCFCD's efforts for FRM in the greater Houston area.

1.7.2 Problems and Opportunities

1.7.2.1 Need for Action (Flooding History)

The Hunting Bayou study area has a long flooding history. Flooding problems within the Hunting Bayou watershed are primarily caused by the very flat topography, especially in the watershed's upper portion and increased runoff resulting from urban development over many years. The lack of channel capacity (less than 20 percent) in the main stem and the inefficiency of the existing interior or secondary drainage system all contribute to the flooding problem. See *Exhibit 1-5* for the extent of flooding.

Structures affected by flooding in the study area are predominantly single-story, single family residential homes with no basements, dominated by pier-and-beam houses in the upper watershed, where the majority of flood damages occur, and slab-on-grade in the middle and lower watersheds. Industrial structures, located mostly in the middle watershed, are predominantly metal frame building and warehouses, and commercial structures throughout the watershed vary as wood or steel frame or masonry structure types. More structure type information can be found in Appendix 5, Economic Analysis. Flooding events typically produce from 1 to 4 feet of structure inundation, with low velocities (in-channel mainly 1 to 4 feet per second, with velocities significantly lower in the overbanks), and are expected to last from 3 to 5 hours, depending on the severity of the event. Warning times for impending flooding typically range from 1 to 3 hours, dependent on the rainfall type and stream location. As Hunting Bayou flows through a highly developed urban area, and except for the Herman Brown Park and lower reaches, does not have dense woody riparian cover, flooding debris would typically consist of urban refuse and objects (structural wood, toys, tires, household refuse etc.).

Need for project action is supported by the long flooding history and associated damages which have occurred in the Hunting Bayou study area. Recorded flood history in the study area dates back to 1839. The Problem Identification chapter in the Main Report (Volume I) of the *Buffalo Bayou & Tributaries, Texas Feasibility Report* (*Flood Damage Prevention*) incorporated by reference, provides a chronology for flood events in the Houston and Harris County vicinity through 1984. Over 42 thunderstorms, low pressure systems, hurricanes and flood events were documented for the Houston, Harris County area, including the Galveston Hurricane (1900), Hurricane Carla (1961), Tropical Storm Claudette (1979) and Hurricane Alicia (1983), which also affected the Hunting Bayou project area.

Flooding has continued to be a significant problem; in recent years, flooding was documented in 1979, 1980, 1983, 1989, 1993, 1994, 1997, 1998 (Tropical Storm Frances), 2001 (Tropical Storm Allison), 2006, 2007 and 2008 (Hurricane Ike). Notable flood events which also affected the project area include the following.

- Tropical Storm Allison (June 5-10, 2001): 10 to 14 inches of rain fell on Houston, Harris County and the Hunting Bayou watershed during a 24-hour period from June 8 to June 9, 2001. This storm simultaneously affected 2 million people by flooding (including 76,000 people in the Hunting Bayou project area) and resulted in $5 billion damages, 22 deaths, 73,000 flooded homes and 95,000 flooded automobiles.

- Hurricane Ike (September 13, 2008): 6 to 8 inches of widespread rain fell, with 10 to 13 inches in isolated locations. Over 1,200 homes were flooded, 20 lives lost in Texas and $21 billion in estimate damages with many people without water or electricity for up to 2 weeks after the storm.

- Named Storms: 10 named storms resulting in significant rainfall in Texas and the Houston area developed between the middle of August and late September 2010. These included Hurricane Alex, Tropical Storm Hermine and Hurricanes Igor, Julia and Karl.

- During July 11-13, 2012, Harris County received 10 to 14 inches of rain, and Hunting Bayou gauges at Interstate Highway (IH) 610 East (Gauge 830) indicated greater than 13 inches of rain fell in portions of the study area resulting in widespread flooding.

Exhibit 1-5 presents the extent for the existing 10.0 percent AEP (10-year), 1.0 percent AEP (100-year) and 0.2 percent AEP (500-year) floodplains for Hunting Bayou. *Exhibit 1-6* presents photographs from some of the residential flooding which occurred during September 1998. *Exhibit 1-7* presents photographs from some of the neighborhood flooding resulting from Tropical Storm Allison (June 8, 2001). These photographs were taken within the upper watershed within a 2-block radius of the Hunting Bayou channel, within the boundaries of the 1.0 percent AEP (100-year) floodplain. Over 8,000 structures were damaged within the watershed due to the flooding caused by Tropical Storm Allison.

Flooding events in the Hunting Bayou watershed affect low-income, minority populations with limited economic resources and a strong sense of community cohesiveness.

As of 2013, an estimated 7,329 structures (6,616 residences) are located within in the Hunting Bayou 0.2 percent AEP (500-year) floodplain. The existing flood risk in the Hunting Bayou watershed directly impacts the life, health and safety of people who live and work in the homes, businesses and schools in the Hunting Bayou 0.2 percent AEP floodplain. Many in this community of elderly and economically disadvantaged are particularly vulnerable during and after a flood event. Because it is often difficult to see the channels and roadside ditches during a flood, a dangerous condition exists for pedestrians and motorists in the area. While most floods are an inconvenience to most people, the population in the project area is more likely to lack the ability and resources to easily, quickly or completely rebound after a flood event.

In addition to the local community, the existing flood risk can also impact the life, health and safety of many of the 4.1 million people who live in Harris County. Infrastructure within the 0.2 percent floodplain includes Lyndon B. Johnson (LBJ) General Hospital, the state's busiest Level III trauma center, which serves patients and their families living in and beyond the Hunting Bayou watershed. Two major railroad yards are within the Hunting Bayou project area, and many businesses depend on these and community support facilities to transport goods to regional and interstate destinations. Other infrastructures include public schools, churches, day care facilities, pharmacies and grocery stores. Regionally significant infrastructure such as electrical transmission and oil and gas product pipelines also traverse the Hunting Bayou project area and broader watershed.

Access to freeways, major transportation routes and connections to hurricane evacuation corridors such as IH 610, U.S. Highway 59 (US 59) and IH 10, and emergency response for medical transportation, police and fire officials have been and likely will be significantly hindered during a major flood event. When sections of these facilities in the Hunting Bayou watershed are affected by flooding, the inter-regional transportation system is compromised. When intense rainfall accompanying Gulf storms floods freeways used for hurricane evacuation, consequences can be significant as coastal residents try to find their way from low lying areas to

higher ground. Freeways slowed or stopped by flooding can strand evacuees and subject them to greater risks posed by an advancing tropical flood event.

1.8 Project Location and Study Area

Hunting Bayou, a major tributary of Buffalo Bayou, is located entirely within Harris County and the city limits of Houston, Galena Park and Jacinto City. The Hunting Bayou watershed is approximately 30 square miles in size and is approximately 5 miles northeast of downtown Houston (*Exhibit 1-2*). Hunting Bayou extends approximately 15 miles from its headwaters west of US 59 to its confluence with the HSC. The estimated population within the Hunting Bayou watershed is more than 91,000 based on 2010 Census data.

Hunting Bayou is in U.S. Congressional District 18, currently represented by Sheila Jackson-Lee and U.S. Congressional District 29, currently represented by Raymond "Gene" Green. Texas' representatives to the U.S. Senate are currently Senator John Cornyn and Senator Ted Cruz. The project area is also in Harris County Precinct 1, and the County Commissioner is El Franco Lee. In addition, the project area includes Galena Park, represented by Mayor R.P. "Bobby" Barett, and Jacinto City, represented by Mayor Ana Diaz. The study area is depicted by *Exhibit 1-1*.

1.8.1 Study and Project Areas

The study area is the Hunting Bayou watershed as defined by the study's authorizing document (*Buffalo Bayou & Tributaries, Texas Feasibility Report and Final Environmental Impact Statement* filed with the EPA on September 9, 1988). The Hunting Bayou, Texas project is part of a comprehensive plan for HSC and Buffalo Bayou watershed (*Exhibit 1-2).* Pursuant to 40 CFR 1502.20 the environmental assessment integrated with this general evaluation report tiers from the 1988 feasibility report and FEIS in order that some of the issues discussed in the earlier statement can be summarized and to allow incorporation by reference of some of the discussions from that statement. The 1988 feasibility study and FEIS can be made available upon request by the USACE Galveston District.

Hunting Bayou extends from the US 59 crossing downstream to Hunting Bayou's confluence at the HSC. The Hunting Bayou watershed is approximately 30 square miles in size and is approximately 5 miles northeast of downtown Houston in Harris County, Texas. The watershed exhibits a broad, fairly shallow floodplain on the upstream end, which causes flood events to cover large topographic areas while being fairly shallow. As flood waters flow towards Buffalo Bayou and the HSC, the floodplain changes, becoming narrower due to greater slopes, causing flood waters to be confined closer to the bayou but deeper as compared to that seen in upstream flooding. Both these factors facilitate slow stormwater drainage during intense events.

Exhibit 1-1:
Vicinity Map

Exhibit 1-2:
Watershed Map

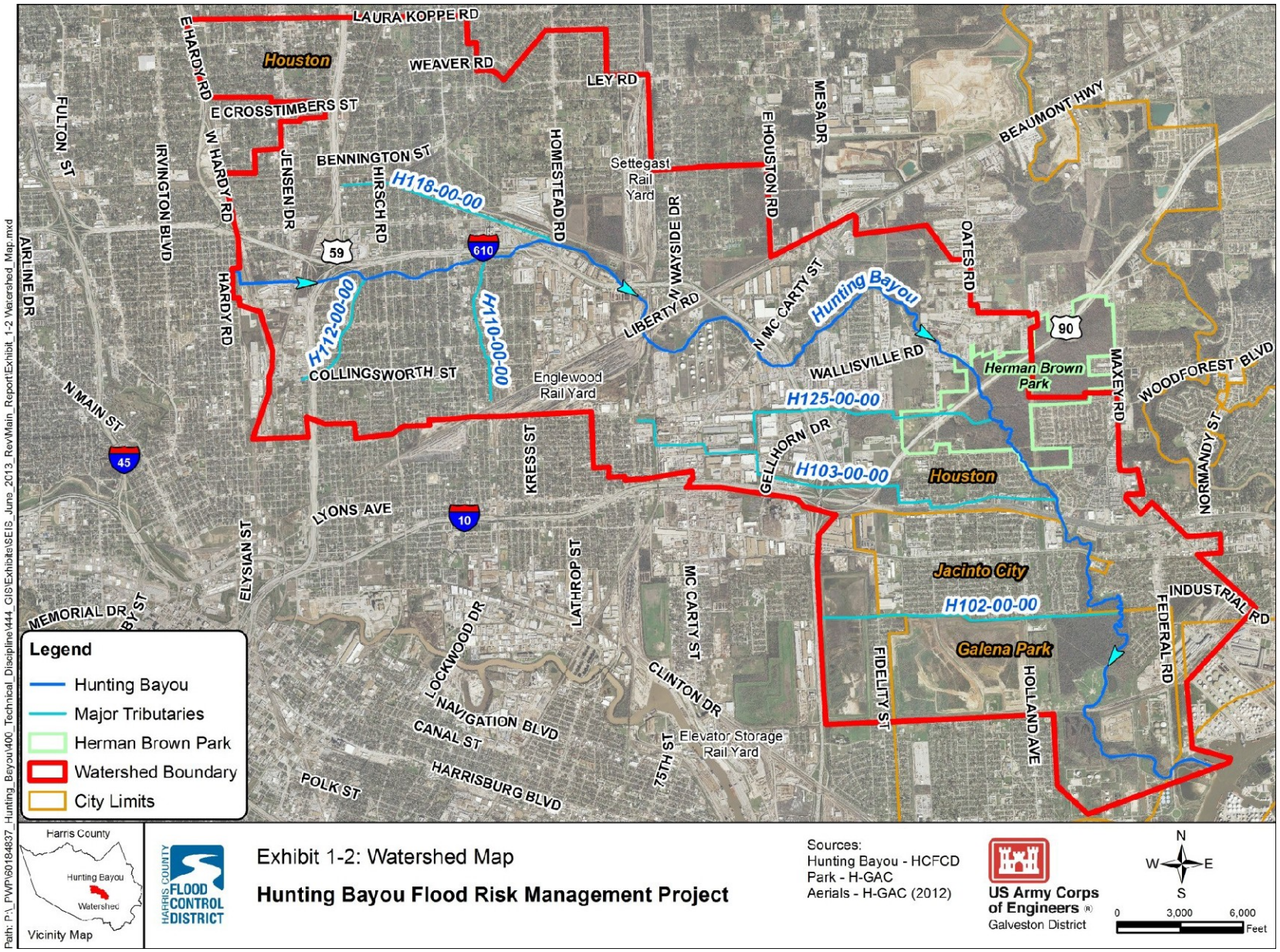


Exhibit 1-3:
Previously Authorized Plan (WRDA 1990)

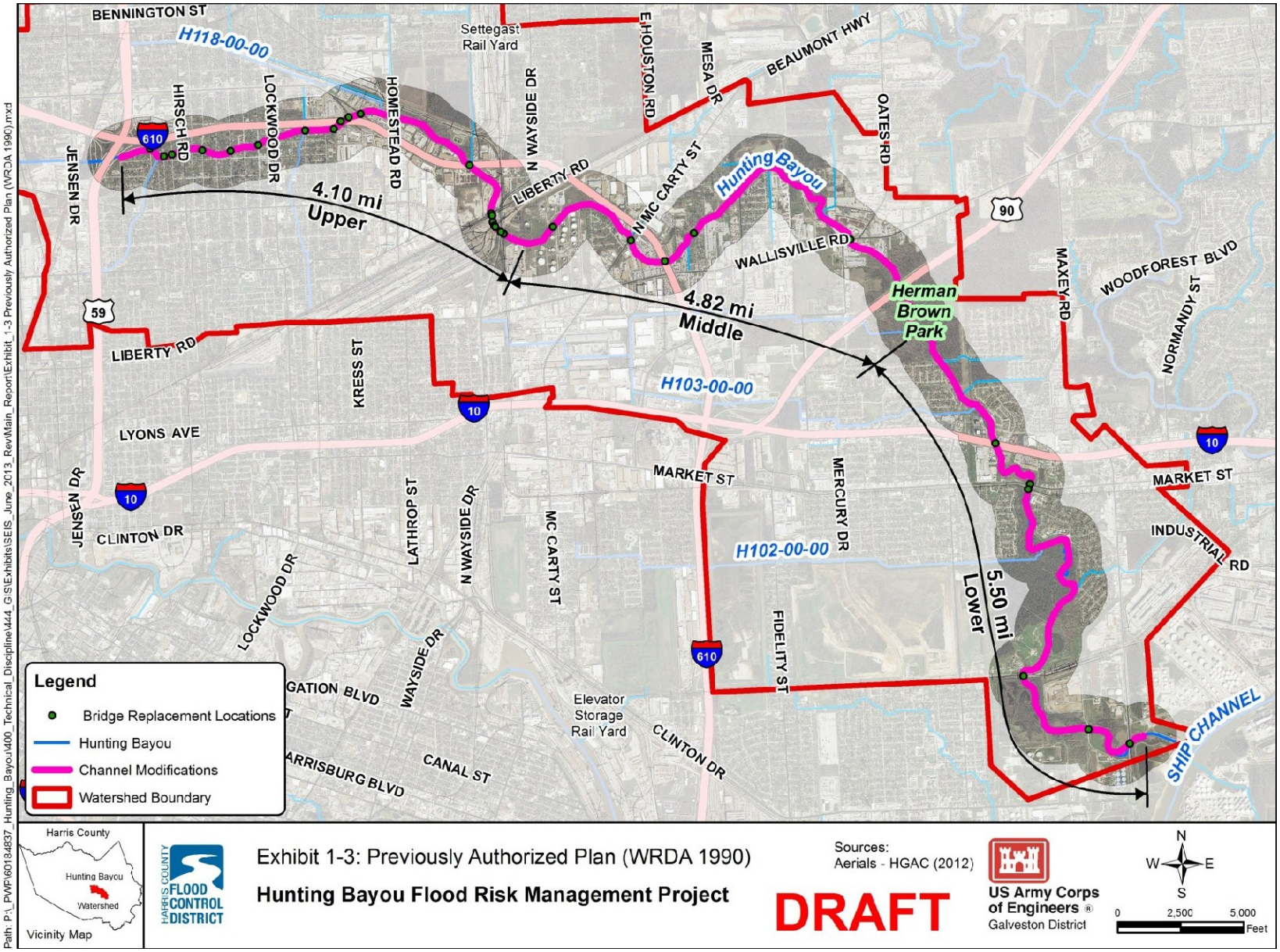
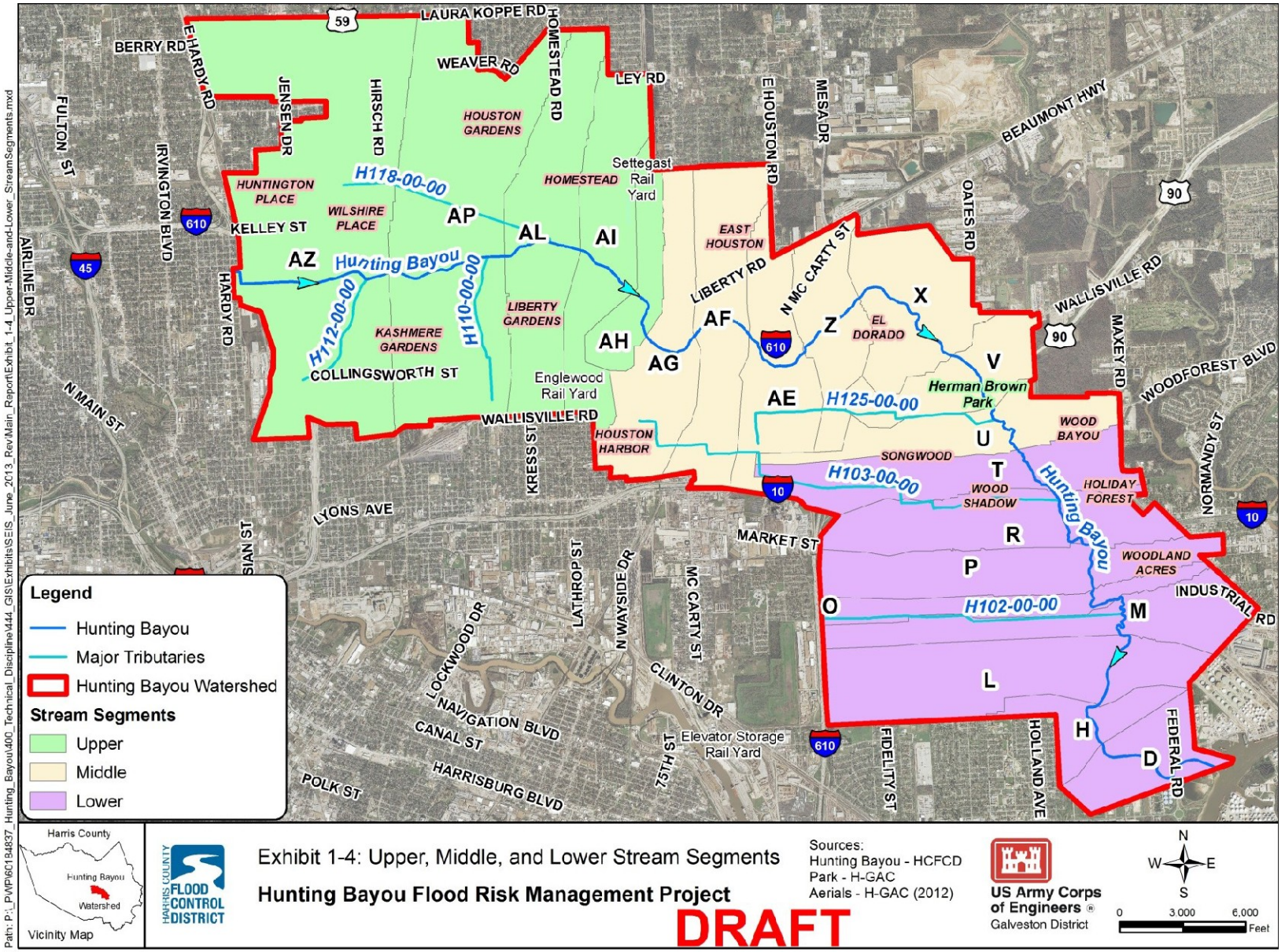


Exhibit 1-4:
Upper, Middle and Lower Stream Segments



For analyses purposes, Hunting Bayou has been divided into upper, middle and lower stream segments as shown in *Exhibit 1-4*. Hunting Bayou's upper reach stream course extends from US 59 approximately 3.2 miles downstream, immediately past Englewood Railroad Yard (ERRY). The middle and the lower segments extend from ERRY to downstream from Herman Brown Park (middle segment) and then from Herman Brown Park to a confluence with the HSC at the Turning Basin (lower stream segment).

Hunting Bayou's upper stream segment is most densely populated and experiences most of the flood damages. Land use in watershed is a combination of residential neighborhoods, commercial, industrial and transportation related facilities including freight railroad yards and industrial facilities. The middle and lower reach segments have been transitioning from residential to increased commercial/industrial development as companies take advantage of the multimodal transportation opportunities within the watershed.

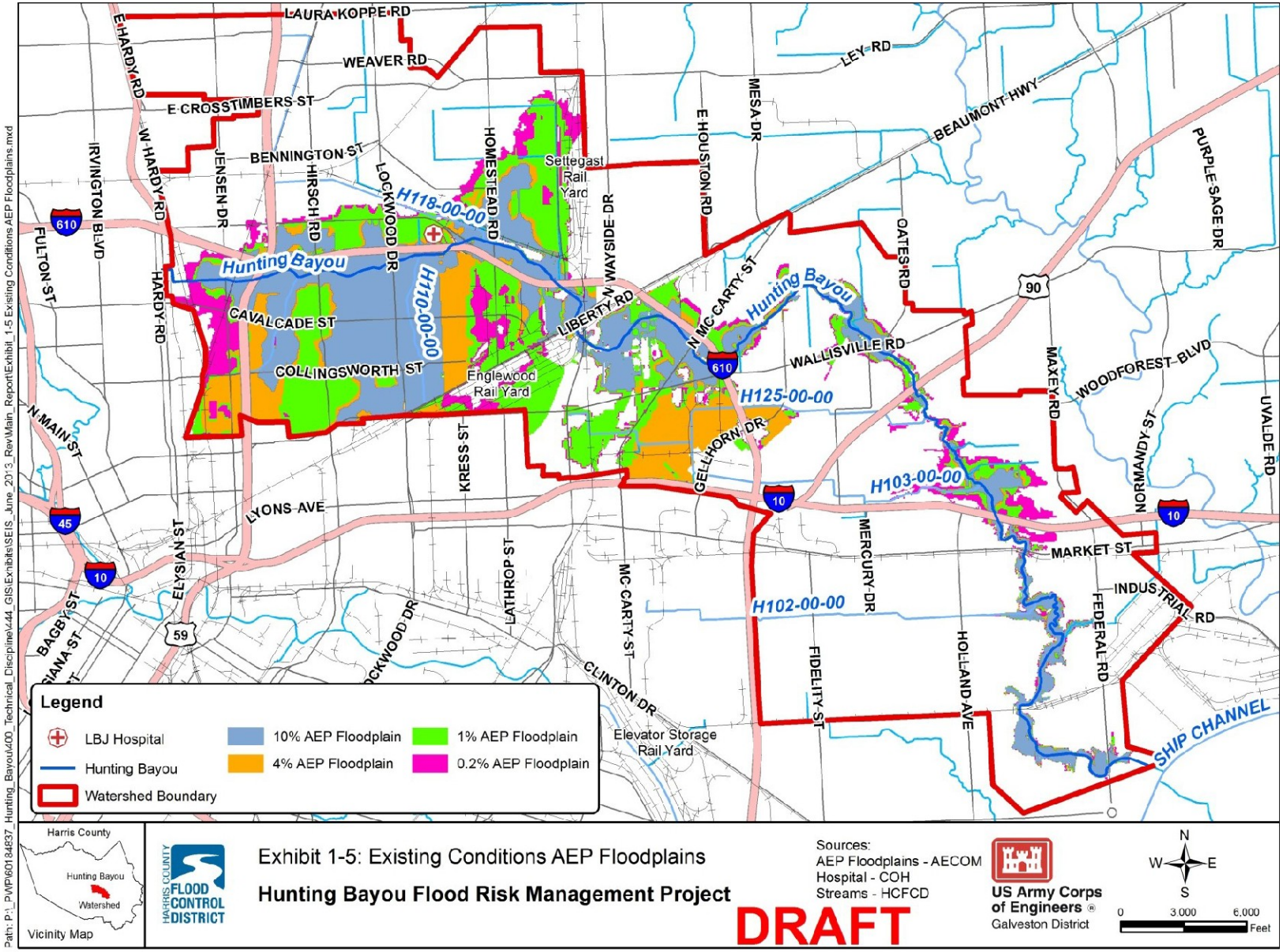
The project area proposed to be directly and indirectly affected by constructing and operating the proposed flood damage reduction project is within the upper stream segment and includes areas of the Houston-Greater Fifth Ward subdivisions and residential areas such as Kashmere Gardens and Pleasantville designated as Super Neighborhoods, Liberty Gardens and Englewood subdivision.

Commercial areas adjacent to these neighborhoods consist of automobile and engine repair businesses; car wash and engine oil change facilities; barber and beauty shops; diners and restaurants; and funeral homes. Community or public service facilities include churches; parks; nursing homes and assisted living facilities; elementary, middle and high schools; the LBJ (Harris County) Hospital, Kashmere Gardens Multi-Service Center, Hunting Bayou Hike and Bike Trail and the McCrane-Kashmere Gardens Library. Light to heavy industrial and warehousing facilities in the area include the Houston Recycling Paper Services, Lone Star Heat Treating, Mauser Corporation, Custom Pipe Coating, Grainger Industrial Supply, Lone Star Imports, Koch Filter Corporation, E-TEL, Self Industries, packing and distribution facilities, metal recyclers and landscaping companies.

Freight rail facilities are largely associated with ERRY and Settegast Rail Yard. ERRY is bounded by Liberty Road, Wallisville Road and Wayside Drive, has 64 tracks in a tight diamond area bounded by an additional 20 tracks, and is owned by Union Pacific Railroad (UPRR). On any given day, up to 80 locomotives pass through these yards.

Transit facilities in the area include Kashmere Garden Transit Center (bus terminal), the Settegast Rail Yard and the former Houston Belt and Terminal Railway.

Exhibit 1-5:
Existing Conditions Annual Exceedance Probability (AEP) Floodplain



1.9 Planning Goals and Objectives

The primary goal for this reevaluation study is to identify an economically justifiable and implementable FRM alternative to the 1990 Authorized Plan to reduce flood damages within Hunting Bayou watershed. Based on the previously identified flooding problems and needs, the following planning objectives were established to help develop alternative plans and their evaluation.

- Reduce residential and business flood risk due to riverine flooding to a socially vulnerable population along Hunting Bayou from its mouth to US 59.
- Minimize adverse effects from implementing flood risk reduction measures on existing neighborhoods and wildlife habitat.

This project is also a vital component in the non-federal sponsor, HCFCD's efforts for FRM in the greater Houston area. This project is supported by the non-federal sponsor's flood management objectives to:

- Provide FRM to structures and infrastructure in the Hunting Bayou watershed without increasing the potential for flooding in other areas.
- Maintain and protect community cohesiveness for the residents living within Hunting Bayou watershed.

1.10 Planning Constraints

Project constraints involved initial reliance on the 1990 Authorized Plan as the baseline condition then modifying specific project elements to address local needs and ordinances. Extensive outreach and coordination with the community within the watershed has been performed by the non-federal sponsor, HCFCD, throughout the general reevaluation. The community expressed a strong preference for avoiding population displacement and impacts to residential areas. Planning constraints incorporated into this general reevaluation are itemized below.

1. Sufficiently sized available vacant land for offline detention and disposal is scarce. Previous analyses have shown the majority of parcels in the project area have prohibitively high acquisition costs for detention purposes.

2. Minimize displacing minority and low income populations to the maximum extent possible to preserve community cohesion and avoid adverse impacts to the economically disadvantaged.

Exhibit 1-6:
Neighborhood Flooding from Hunting Bayou during the September 1998 Storm Event

Path: P:_PWP\60184837_Hunting_Bayou\400_Technical_Discipline\444_GIS\Exhibits\SEIS_June_2013_Rev\Main_Report\Exhibit_1-6 Neighborhood Flooding 1998 Storm Event.mxd

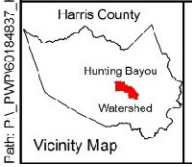


Exhibit 1-6: Neighborhood Flooding from Hunting Bayou during the September 1998 Storm Event

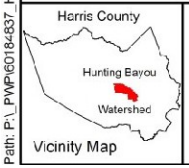
Hunting Bayou Flood Risk Management Project

DRAFT

US Army Corps of Engineers ®
Galveston District

Exhibit 1-7:
Neighborhood Flooding from Hunting Bayou during Tropical Storm Allison (June 8, 2001)

Path: P:_PWP\6018-837_Huntinc_Bayou\400_Technical_Discipline\444_GIS\Exhibits\SEIS_June_2013_Rev\Main_Report\Exhibit_1-7 Neighborhood Flooding during Tropical Storm Allison.mxd



HARRIS COUNTY FLOOD CONTROL DISTRICT

Exhibit 1-7: Neighborhood Flooding from Hunting Bayou during Tropical Storm Allison (June 8, 2001)

Hunting Bayou Flood Risk Management Project

DRAFT

US Army Corps of Engineers ®
Galveston District

1.11 Existing Studies and Reports

For the 1990 Authorized Plan, numerous studies, reports, investigations and proposals have been developed to address FRM, air quality, stormwater detention, recreation, potential for the presence of hazardous materials or constituents, population and demographics, aquatic resources, water quality, and fish and wildlife habitat in the study area. The local planning process relies on these past studies to inform and guide the analysis conducted for the Draft GRR/EA. Some of the studies, reports or procedures used or developed through time are listed below. For a detailed list, see *Section 9.0 References*. Numerous public meetings and community outreach by the non-federal sponsor, HCFCD, have also occurred.

- Offline Detention Basin Hazardous, Toxic and Radioactive Waste (HTRW) Groundwater Investigation
- Habitat Evaluation Procedure (HEP) Assessment
- Biological Assessment and Fish and Wildlife Coordination Act Report (FWCAR)
- Inline Detention Basin Landfill Investigations
- Historical Bridge Assessment Report
- Threatened and Endangered (T&E) Species Assessments
- Cultural Resources Reports and Texas Historical Commission (THC) Letters
- Real Estate Report
- Environmental Justice Memorandum
- Non-federal sponsor, HCFCD, Property Acquisition Procedures

2.0 EXISTING CONDITIONS (AFFECTED ENVIRONMENT)*

2.1 General Environmental Setting

The 1990 Authorized Plan for the Hunting Bayou study area was formulated according to conditions existing at the time of analysis and projected conditions expected to exist in the future. This section updates that information to account for current conditions in the project impact area of the anchor components; the offline detention basin and channel modifications in the upper reach. Information characterizing the environmental setting of the middle and lower bayou segments is also included for the 1990 Authorized Plan which will be compared with plans affecting only the upper segment.

Hunting Bayou extends approximately 15 miles from its mouth at the confluence with HSC to its upstream extent just above US 59. The approximately 30 square mile Hunting Bayou watershed is part of the approximately 4,016 square mile San Jacinto River basin and the approximately 1,182 square mile Buffalo Bayou watershed.

Environmental resource data for the affected environment were collected within these areas and described in the following sections. Biological, historic, archeological resources and physical data were collected from available public data sources. Socioeconomic data were based on the U.S. Census Bureau's (USCB) 2010 report and datasets, U.S. Bureau of Labor Statistics and local socioeconomic data collected by Houston-Galveston Area Council (H-GAC) related to land use and land cover. Potential locations for permitted solid and hazardous waste facilities were obtained from the EPA, Texas Commission on Environmental Quality (TCEQ), H-GAC's closed municipal solid waste landfill inventory dataset, and commercial vendors who provided an environmental database search report for within a 0.5 mile area of the Hunting Bayou main channel.

2.2 Physical Environment

The approximately 15-mile long Hunting Bayou is in Harris County, Texas and is part of the Buffalo Bayou watershed. Parts of Harris County are within the coastal management zone for Texas. Hunting Bayou outfalls into Buffalo Bayou and HSC about 8 miles upstream from the confluence of Buffalo Bayou and the San Jacinto River.

Hunting Bayou is in the northeastern quadrant of Houston, approximately 4 to 5 miles downstream from Houston's central business district. HCFCD has cleared and straightened Hunting Bayou over many years, from its mouth upstream to a distance of about 14 miles. The lower 0.5-mile segment of Hunting Bayou extending from Federal Road to HSC has been deepened to provide docks and ship berths. Hunting Bayou's lower segment (lower 4 miles) is tidally influenced and undeveloped.

2.3 Climate

The study area's climate is subtropical, with average 10 to 15 miles per hour winds typically out of the southeast (National Oceanic and Atmospheric Administration [NOAA] 2012a). Average daily temperatures range from approximately 50 degrees Fahrenheit in January to approximately 83 degrees Fahrenheit in July and August. The average annual rainfall is approximately 53 inches, and the monthly precipitation averages from approximately 3 to 6 inches

(RSS Weather 2012; NOAA 2009b). Major storm events affecting the study area include Tropical Storm Claudette (July 1979), Tropical Storm Allison (June 2001), Hurricane Rita (2005) and Hurricane Ike (2009). The study area has experienced major floods, some resulting from tropical storms and others due to intense rainfall events.

2.4 Geology

The potential environmental impact area is in Texas' southeastern part, in the physiographic region known as the Gulf Coast Coastal Prairie (*Exhibit 2-1*). The land surface in the Gulf Coast Coastal Prairie region is a nearly flat depositional plain rising from sea level to about 300 ft (Wermund 1996). Harris County is primarily drained by the Buffalo-San Jacinto Watershed (U.S. Geological Survey [USGS] Hydrologic Unit Code 12040104).

The Geologic Atlas of Texas indicates the project area of the anchor components is underlain by Pleistocene-age deposits of the Lissie Formation (Texas Water Development Board [TWDB] 2010). Sediments of the Lissie Formation consist of clays, silts, sands and very minor siliceous gravel. These sediments are fluvial in origin and on fairly flat and featureless surfaces, except for numerous shallow depressions and pimple mounds. The soils on the site are mapped as Bernard Urban land complex, Clodine-Urban land complex and Lake Charles-Urban land complex (U.S. Department of Agriculture 2010). According to the National Hydric Soils List for Harris County produced by National Technical Committee for Hydric Soils (February 2011), the Clodine-Urban land complex is listed as having hydric components.

2.4.1 Topography and Soils

2.4.1.1 Topography

The Hunting Bayou watershed is approximately 30 square miles in total land area with an average 3.1-mile width. The project area is identified on the following USGS 7.5-minute topographic quadrangle maps: Settegast, Park Place, Pasadena and Jacinto City, Texas. Land surface elevations within the watershed range from 70 ft above mean sea level in the northern portion to approximately 5 ft above mean sea level at the confluence with Buffalo Bayou (*Exhibit 2-2*). [Elevations presented are referenced to NGDV 1929, 1973 adjustment].

The project area's topography is generally level, except in the vicinity of natural channels, drainage features, intermittent/ephemeral streams and bayous. In the vicinity of natural surface water features, the land surface generally slopes toward the channel's drainage axis. In areas of improved drainage ways or built-up (urbanized) areas, such as along much of Hunting Bayou, the topography has been altered to address flooding, unsuitable soil conditions, drainage and other impediments to development. In these areas, the natural grades have been altered, and there may be locally steep slopes and constructed (widened or deepened) channels. Generally in the Hunting Bayou area, the land surface slopes to the east. Regionally, the Houston area slopes in the direction of the Gulf of Mexico. In some areas the land surface is broken by normal growth faults or the surface expression of salt domes. The lower Hunting Bayou crosses over the Clinton Salt Dome. One fault, the Pecore East, is within the Hunting Bayou watershed, as shown in *Exhibit 2-2*. This fault crosses Hunting Bayou upstream from the proposed project limit. Faults in the Houston metropolitan area are not surficial phenomena, but are part of a deep and complex overall geologic structure of the upper Texas Gulf Coast (Verbeek and others, 1979). These deep-seated faults have their origin in the depositional formation of the Gulf of Mexico.

According to evidence, they are expressed at the surface through long slow movements spanning thousands to millions of years (Shaw & Lanning-Rush, Englekemeir & Khan). They appear to have been recently (geologically-speaking) reactivated due to groundwater and petroleum withdrawal (Englekemeir & Khan). These faults are not seismically active, but move through gradual subsidence. As such, the faults do not pose a risk to public safety or constructed facilities.

2.4.1.2 Soils

Data from the soil survey reports for Harris County, containing the Hunting Bayou watershed, are provided in *Appendix 3 – Engineering Analysis*. Information included in the summary table includes soil type, percent of coverage for the watershed, and hydric soil classification and drainage class. Soils in the Hunting Bayou watershed are dominantly dark-colored, loamy and clayey (Soil Conservation Service 1976). These soils consist of the Clodine, Addicks, Gessner, Bernard, Morey, Mocarey, Lake Charles, Edna, Aldine, Ozan and Atasco series. These soils are described as nearly level prairie soils. The Aldine and Ozan series are nearly level to gently sloping soils on forested uplands. Nearly level soils are often seasonally wet and require adequate drainage outlets. The other soils are susceptible to sheet and gully erosion and require erosion protection. Soils generally have a low water-bearing capacity, high moisture content, low permeability and a high shrink-swell potential.

Extensive urbanization of soils within the study area and lack of irrigation precludes the presence of prime and/or unique farmland soils and their practical use for agricultural purposes within the Hunting Bayou project area.

Exhibit 2-1:
Geology

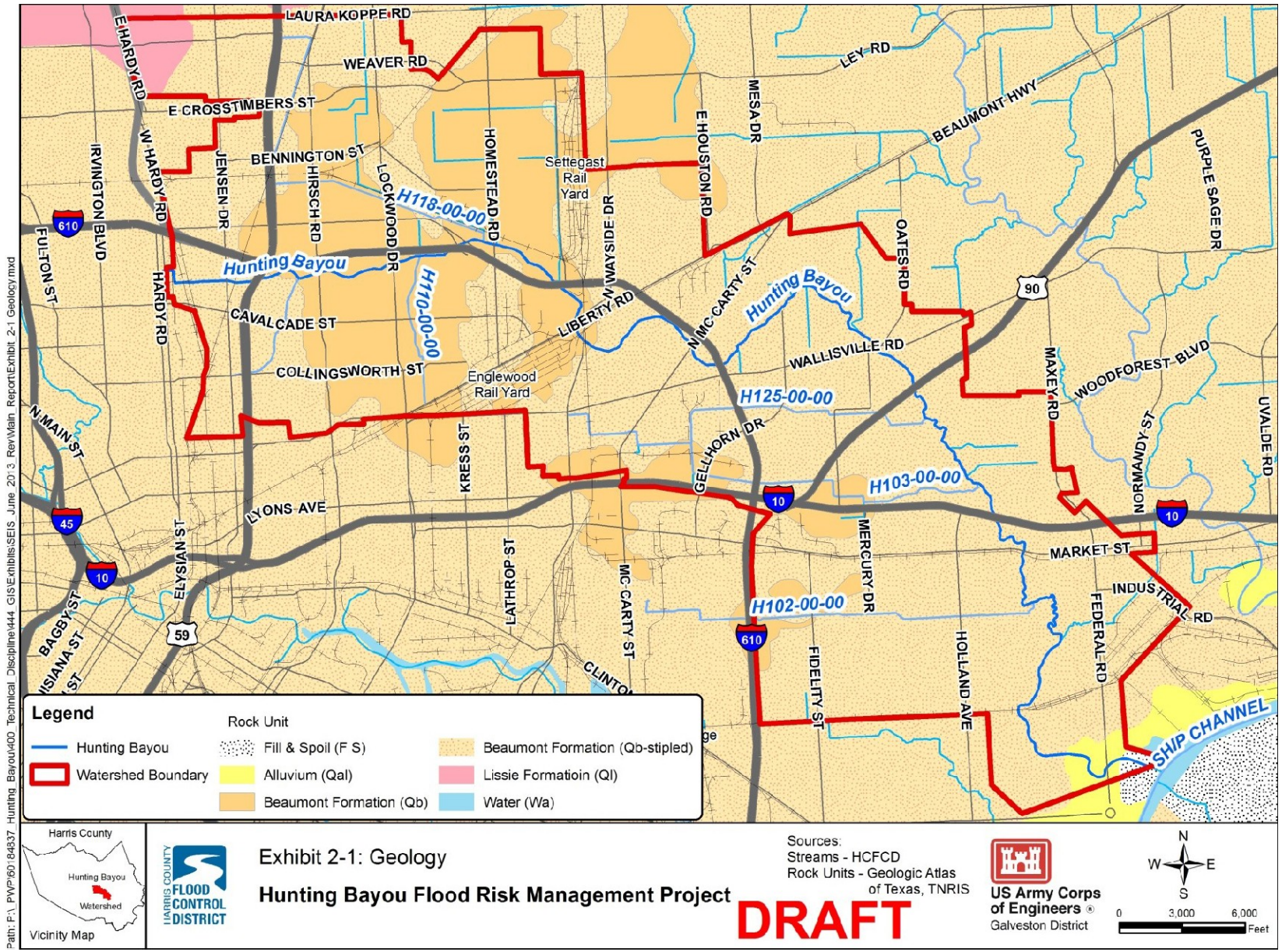
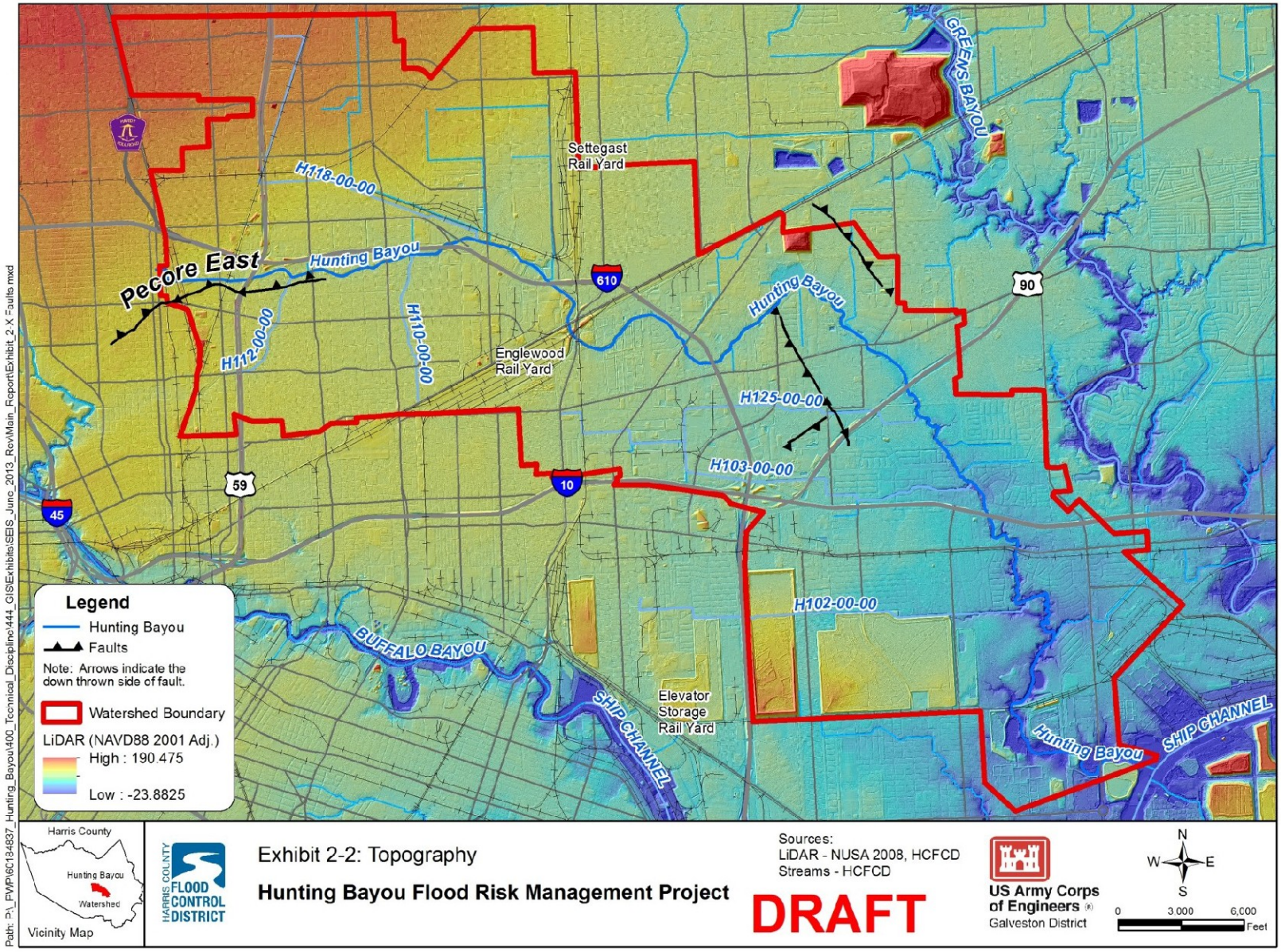


Exhibit 2-2:
Topography



2.4.2 Geology and Hydrogeology

The Geologic Atlas of Texas indicates the watershed is underlain by Holocene alluvium near the Houston Ship Channel and by Pleistocene-age deposits of the Lissie Formation (TWDB 2010). Lissie Formation sediments consist of clays, silts, sands and very minor siliceous gravel. These sediments are fluvial in origin and on fairly flat and featureless surfaces, except for numerous shallow depressions and pimple mounds (*Exhibit 2-1*). Hunting Bayou area's shallow geology is mapped as either the Beaumont or Willis Formations. The Willis Formation is the oldest geologic unit in Harris County. The Beaumont Formation is primarily characterized by clays and silty clays with interbedded, discontinuous layers of silts and sands which are alluvial, deltaic and coastal in origin. Holocene Age alluvial deposits (8,000 years ago to present) have been deposited along modern rivers, streams and bayous including Hunting Bayou.

Large fresh water quantities can extend to depths as great as 1,800 feet below mean sea level in parts of Texas. The formations containing fresh water were deposited in arcuate belts which are approximately parallel to the Gulf of Mexico shoreline. These formations are composed primarily of sand, silt and clay with smaller amounts of gravel and calcareous material, and they increase in thickness as they dip gently toward the Gulf of Mexico.

Land surface subsidence can occur when large quantities of groundwater are pumped from the Chicot or Evangeline Aquifers. Subsidence, which occurred from 1906-1987 in the San Jacinto River watershed, ranged from 0 ft in the northern portion to as much as 10 ft in Harris County, based on information provided by the Harris Galveston Subsidence District. Recent information indicates subsidence in the Hunting Bayou watershed has stabilized as water sources have transitioned to surface water.

2.4.3 Hydrology and Hydraulics (H&H)

Except for isolated improvements and maintenance activities, Hunting Bayou was constructed with its current capacity sometime during the 1940s. Many residential subdivisions in the watershed's upstream portion date back to that period.

Hunting Bayou has a relatively flat slope of approximately 0.0007 feet per foot with an extensive floodplain area in the watershed's upper half. The existing flood level of protection (channel capacity) of Hunting Bayou is less than a 10-year event (10 percent AEP). During an intense rainfall event, Hunting Bayou's existing conditions do not provide adequate flood protection, nor does the bayou serve as an adequate outfall source for the local drainage system. The Hunting Bayou watershed is within Hydrologic Unit Code 12040104. Hunting Bayou exhibits a broad, fairly shallow floodplain on the upstream end, which causes flood events to cover large geographic areas while remaining fairly shallow. As waters flow downstream within the Hunting Bayou channel in the direction of Buffalo Bayou and HSC, the floodplain changes, becoming narrower, constrained in part by railroad bridges and other impediments. This causes greater channel slope or gradient, which confines downstream flows in a narrower area, closer to the bayou's main channel. The flows in Hunting Bayou's downstream or lower reaches are deeper when compared to upper channel, and flooding effects are exacerbated in the upstream reach. These factors help cause slow stormwater drainage from the upstream channel during intense storm events and resultant flooding.

2.5 Water Quality

With EPA oversight, Texas monitors and reports on the water quality for surface water resources under CWA Section 303: (http://ofmpub.epa.gov/waters10/attains_state.control?p_state=TX).

The 2010 Texas Integrated Report for CWA Sections 305(b) and 303(d) provides information about the assessed quality of Texas' surface waters as reported in 2010. This information is sometimes referred to as the 305(b) Report and the 303(d) List, or as the Integrated Report (http://www.tceq.texas.gov/waterquality/assessment/10twqi). The Integrated Report describes the status for the state's waters, as required by Sections 305(b) and 303(d) of the federal CWA, and summarizes the status for the state's surface waters including concerns for public health, fitness for use by aquatic species and other wildlife, and specific pollutants and their possible sources. The list was submitted to the EPA on September 17, 2010 and was approved by the EPA on November 18, 2011 (http://www.epa.gov/region6/region-6/tx/tx_303d.html).

San Jacinto River's southern portion includes Greens Bayou, White Oak Bayou, Hunting Bayou and Buffalo Bayou, which traverse Houston and drain the south and southeast areas to Galveston Bay. CWA Section 303(d) and the implementing regulations in the EPA's 40 Code of Federal Regulations (CFR) 130 describe the statutory and regulatory requirements for acceptable Total Maximum Daily Loads (TMDLs) for stream segments and surface water bodies. TMDL assessments are underway for Buffalo Bayou, HSC and the project area in the Hunting Bayou vicinity due to the presence of dioxin and bacteria. See EPA's MyWaters Mapper http://watersgeo.epa.gov/mwm/?layer=LEGACY_WBD&feature=12040104&extraLayers=null.

The Environmental Baseline Conditions Report (*Appendix 1* – Attachment A) includes a table identifying each segment and associated pollutants or water quality conditions the assessment procedures indicate do not meet assigned water quality standards in one or more water body segment locations (http://nwis.waterdata.usgs.gov/usa/nwis/qwdata/?site_no=08075770).

TCEQ has assigned Hunting Bayou within the San Jacinto River basin-specific stream segment numbers to help evaluate and monitor water quality (*Exhibit 2-3*). Segment 1007_3 is the tidal portion for Hunting Bayou, and the segment is described from IH 10 to the confluence with HSC. Segment 1007R is the Above Tidal segment of Hunting Bayou. The TCEQ designates the main channel to its upstream limit as the "North Fork" of the above tidal segment, and the west Hunting Bayou tributary (H112-00-00) as the "South Fork" of the above tidal limit. Water quality in the bayou is generally poor, and is characterized by low dissolved oxygen (DO) concentrations, elevated biological oxygen demand levels and high ammonia-nitrogen concentrations. During low flow periods, water in the bayou consists primarily of storm sewer discharges and municipal and industrial wastewater treatment plant (WWTP) discharges.

The TCEQ has issued and EPA has approved water quality monitoring reports dated 2010. The following tables illustrate the 2010 water quality status for Hunting Bayou's 4.8-mile long, unclassified segment, more specifically identified as Segment 1007R_02, and described as being east of Elysian Street to Falls Street (the "North Fork" of Hunting Bayou) (see http://ofmpub.epa.gov/tmdl_waters10/attains_waterbody.control?p_list_id=&p_au_id=TX-1007R_02&p_cycle=2010&p_state=TX).

For an unnamed tributary to Hunting Bayou, identified as water quality Segment 1007V_01 described as extending from the confluence with Hunting Bayou to 1.1 miles upstream from the

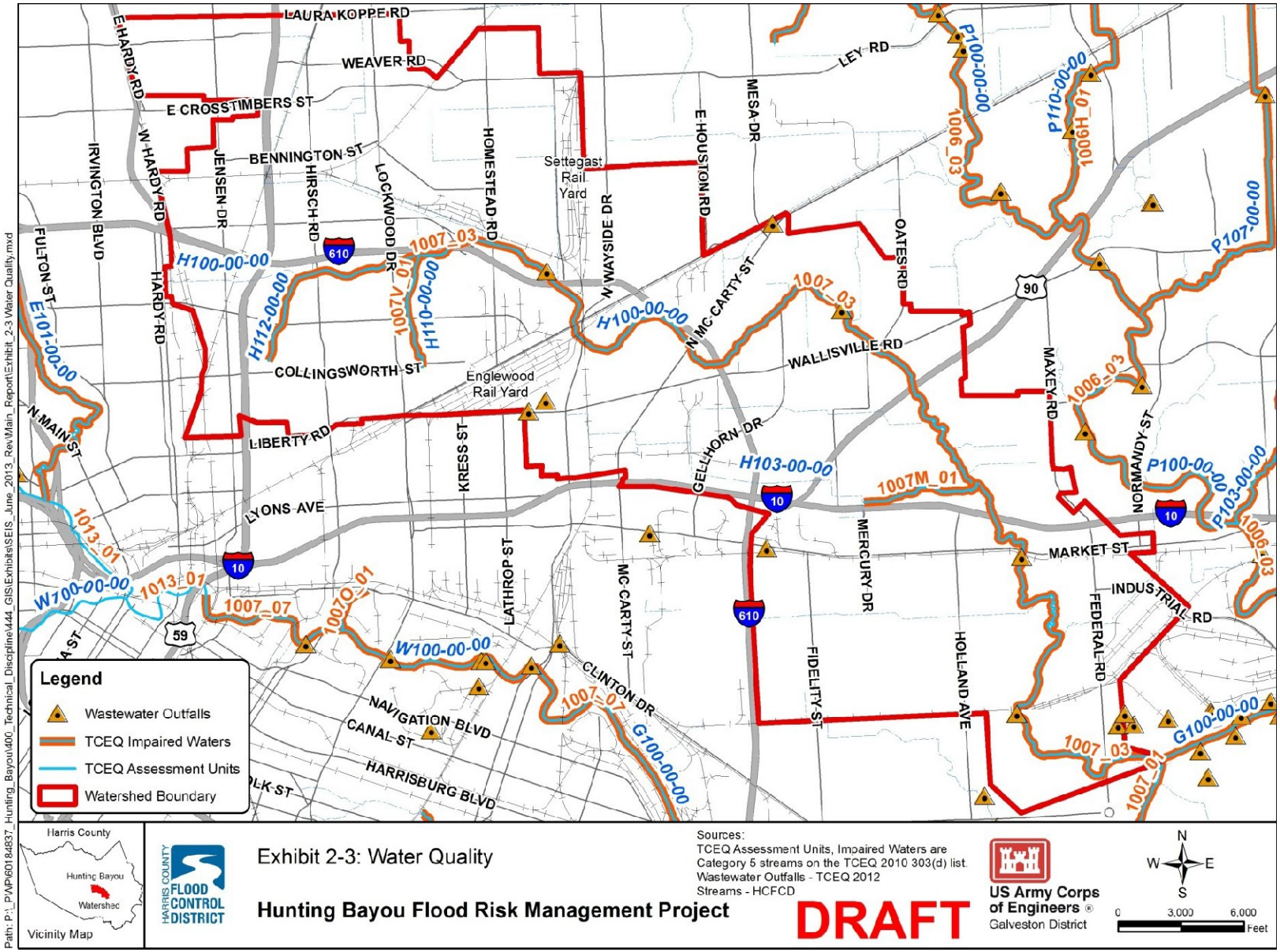
confluence west and within 1,000 ft of Collingsworth Street, TMDLs are underway for dioxin and bacteria (TCEQ 2012). The TMDL Program's primary objective is to restore and maintain the beneficial uses—such as drinking water supply, recreation, aquatic life support or fishing—for impaired or threatened water bodies. The TMDL addresses impairments to the contact recreation use because it exceeds the bacteria criteria indicator.

Hunting Bayou's tidal segment or lower reach has been listed as in non-attainment for dioxin levels in crab and catfish tissues since 1996 and for polychlorinated biphenyls in fish tissues since 2002. Sampling within the reach has also shown the segment to be non-supporting of fish consumption usage due to the presence of chlordane, dieldrin and heptachlor epoxide in fish tissue. There is also a concern about near-nonattainment of the state water quality standards for bacteria (*enterococcus*) due to municipal point source discharges and non-point source urban runoff and storm sewer discharge. There are also concerns about water quality based on screening levels for nitrate due to sanitary sewer overflows, urban runoff and storm sewer discharge.

The west Hunting Bayou tributary (H112-00-00), the "South Fork" of Hunting Bayou Above Tidal, has been deemed non-supporting of aquatic life use since 2002 due to low DO levels. There is also a concern about water quality based on screening levels for nitrate, ammonia, *E. coli* and fecal coliform due to sanitary sewer overflows, urban runoff, storm sewer discharge and municipal point source discharges.

All Hunting Bayou reaches Above Tidal have been listed in the latest Texas 303(d) report as non-supporting of recreational and general use due to bacteria and nitrate levels. Hunting Bayou non-tidal tributaries have been non-supporting of general, recreational and aquatic life use since 2002 due to *E. coli* and fecal coliform levels. Dioxin issues in Galveston Bay are more complex than previously thought, and based on reviewing two sampling datasets collected in 2008 and 2009, "hot spots" or areas with elevated dioxin concentrations were identified. Based on these analyses, sediments from Greens Bayou, Hunting Bayou and Patrick Bayou appear to be contributing to dioxin levels in the Bay system (https://www.h-gac.com/community/water/tmdl/HSC-UGB/documents/hsc_08-17-2011_meeting_summary.pdf).

Exhibit 2-3:
Water Quality



2.6 Air and Sound Quality

2.6.1.1 Air Quality

The purpose for CAA of 1977 (42 United States Code [U.S.C.] §7401-7661) is to, *protect and enhance the quality of the Nation's air resources so as to promote the public health and welfare and the productive capacities of its population* (EPA 2012). The CAA establishes the federal standards for various pollutants from stationary and mobile sources and provides for regulating polluting emissions via state implementation plans (SIPs). Under the CAA, the EPA sets National Ambient Air Quality Standards (NAAQS) for seven criteria air pollutants to protect public health and the environment, with an adequate margin of safety. *Table 2-1*, as shown on the next page, lists the NAAQS for the seven pollutants. NAAQS exist for carbon monoxide (CO), ozone (O_3), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), particulate matter (PM) for 10 and 2.5 microns and less (PM_{10} and $PM_{2.5}$) and lead. The CAA Amendments of 1990 establish specific milestones toward attaining the NAAQS, depending on the severity of the air pollution problem in the region (http://www.tceq.state.tx.us/airquality/monops/naaqs.html). The primary standard is a limit the EPA promulgated to protect humans including vulnerable populations such as children, people with asthma and the elderly from health risk.

Air quality in Texas is defined with respect to conformity with the NAAQS. The EPA and TCEQ classify geographic regions as having air quality better than or equal to (attainment) or worse than (nonattainment) these standards. The Houston-Galveston-Brazoria (HGB) area, consisting of Montgomery, Liberty, Chambers, Galveston, Brazoria, Fort Bend and Waller Counties, meets all the EPA NAAQS, except for ozone. Ozone levels in the HGB area are currently designated as being in severe nonattainment with the 8-hour ozone standard and, as a result, the area is under a State Implementation Plan (SIP) to meet the 8-hour ozone attainment by June 15, 2019.

Table 2-1:
National Ambient Air Quality Standards (NAAQS)

Pollutant	Averaging Period	Standard	Primary NAAQS	Secondary NAAQS
Ozone	1-hour standard (limited areas)	The expected number of days per calendar year with maximum hourly average ozone concentrations above 0.12 ppm is ≥1.	0.12 ppm	0.12 ppm
	8-hour (2008 standard)	The average of the annual fourth highest daily 8-hour maximum over a 3-year period should not be equal to or exceed this concentration limit.	76 ppb	76 ppb
Carbon Monoxide	1-Hour	Should not be equal to or exceed this concentration limit more than one time per calendar year.	35.5 ppm	--
	8-Hour	Should not be equal to or exceed this concentration limit more than one time per calendar year.	9.5 ppm	--
Sulfur Dioxide	1-Hour	Three year average of the annual 99th percentile of the daily maximum 1-hour averages should not be equal to or exceed this concentration limit.	76 ppb	--
	3-Hour	Should not be equal to or exceed this concentration limit more than one time per calendar year.	--	550 ppb
Nitrogen Dioxide	1-Hour	Three year average of the annual 98th percentile of the daily maximum 1-hour averages should not exceed or be equal to this concentration limit.	101 ppb	--
	Annual	Should not exceed or be equal to this concentration limit.	54 ppb	54 ppb
Respirable Particulate Matter (10 microns or less) (PM_{10})	24-Hour	Should not exceed or be equal to this concentration limit on more than 3 days over 3 years with daily sampling.	155 µg/m^3	155 µg/m^3
	Annual	The 3-year average of annual arithmetic mean concentrations at each monitor within an area should not exceed or be equal to this concentration limit.	51 µg/m^3	51 µg/m^3
Respirable Particulate Matter (2.5 microns or less) ($PM_{2.5}$)	24-Hour	The 3-year average of the annual 98th percentile for each population-oriented monitor within an area should not exceed or be equal to this concentration limit.	36 µg/m^3	36 µg/m^3
	Annual	The 3-year average of annual arithmetic mean concentrations from single or multiple community-oriented monitors should not exceed or be equal to this concentration limit.	15.1 µg/m^3	15.1 µg/m^3
Lead	3-Month	Three-month rolling average should not exceed or be equal to this concentration limit.	0.16 µg/m^3	0.16 µg/m^3
	Quarter	Should not exceed or be equal to this concentration limit.	1.55 µg/m^3	1.55 µg/m^3

Source: TCEQ 2012 (November 6, 2012; http://www.tceq.state.tx.us/airquality/monops/naaqs.html)
ppb= Parts of pollutant per billion parts of air [by volume at 25 degrees Celsius (^oC)]
ppm = Parts of pollutant per million parts of air [by volume at 25 degrees Celsius (^oC)]
µg/m^3 = micrograms of pollutant per cubic meter of air.

2.6.1.2 Sound Environment

The EPA has identified a 55 A-weighted decibel (dBA) day-night average sound level as the maximum sound level which would not adversely affect public health and welfare by interfering with speech or other activities in outdoor areas.

Noise is defined as an undesirable sound which interferes with communication; is intense enough to damage hearing; or is otherwise intrusive. Noise is characterized by many variables including frequency, duration and intensity. Sound pressure level, described in decibels (dB), is used to quantify sound intensity.

The most widely accepted method used to quantify sound for human receptors is to measure sound across a wide frequency spectrum and apply a weighting known as A-weighting to the individual dB value for each frequency interval. The logarithmic sum of these values is known as the A-weighted sound level, expressed as dBA (i.e., equivalent constant dBA sound level for the same duration). Normal speech is typically about 60 dB sound level. A 10-dBA change is normally perceived as doubling (or halving) sound levels, and is considered a substantial change. *Table 2-2* provides common sound sources and the approximate, related sound levels in dBA.

Table 2-2:
Common Sound Sources and Levels

Outdoor	Sound Level (dBA)	Indoor
Snowmobile	100	Subway train
Tractor	90	Garbage disposal
Noisy restaurant	85	Blender
Downtown (large city)	80	Ringing telephone
Freeway traffic	70	TV audio
Normal conversation	60	Sewing machine
Rainfall	50	Refrigerator
Quiet residential area	40	Library

Source: Harris 1998.

Sound is often generated by activities essential to a community's quality of life such as construction or vehicular traffic. The human ear responds differently to different frequencies. Sounds encountered during construction and their approximate dBA level about 50 ft from the sound source are provided in *Table 2-3*.

Table 2-3:
General Construction Equipment Sound Levels

Equipment	Typical Sound Level (dBA*) 50 ft from Source
Air Compressor	81
Backhoe	80
Ballast Tamper	83
Compactor	82
Concrete Mixer	85
Concrete Pump	82
Concrete Vibrator	76
Crane Mobile	83
Dozer	85
Generator	81
Grader	85
Impact Wrench	85
Jack Hammer	88
Loader	85
Paver	89
Pneumatic Tool	85
Pump	76
Roller	74
Saw	76
Scarifier	83
Scraper	89
Shovel	82
Truck	88

**dBA – A-weighted decibels*
Source: Federal Highway Administration 2006.

Texas does not regulate noise at the state level. Local ordinances have been established instead to regulate noise. The zoning ordinance for Houston outlines noise guidelines for developments in Harris County and the Houston metropolitan area.

Most of the noise sensitive receptors in the project area are residential dwellings and associated neighborhood land uses on either side of Hunting Bayou from US 59 on the west to approximately Dabney Street on the east—approximately a 2-mile distance. From Dabney Street to the east to south of the Settegast rail yards, the land uses adjacent to the bayou are primarily industrial and commercial land uses.

From US 59 in the upper bayou segment to the outfall to Buffalo Bayou in the lower segment, five churches, two public parks, a public library and multiple residential neighborhoods are adjacent to Hunting Bayou.

2.6.1.2.1 Upper Segment

From US 59 east to Lockwood Drive, noise sensitive land uses other than residential housing include the Spirit of Praise Church about one block north of the bayou on Falls Street and Canaan Missionary Baptist Church south of and adjacent to the bayou at Lockwood Drive. Hutcheson Park, which is already affected by freeway noise from IH 610, is east of Lockwood

Drive between the freeway and the bayou. Kashmere Gardens Public Library is east of Lockwood Drive and approximately 500 feet south of the bayou on Pardee Street. St. Francis of Assisi school and church are on Dabney Street approximately 600 feet south of the bayou. From Kress Street south of the bayou east to N. McCarty Drive the land uses on both sides of the bayou are primarily industrial, commercial and rail transportation oriented.

2.6.1.2.2 Middle Segment

A small residential neighborhood adjacent to the south side of the bayou between Amoor Avenue and N. McCarty Drive has two churches between 400 and 1,000 feet of the bayou: Groveland Missionary Baptist Church and Fellowship Missionary Baptist Church. The neighborhood is flanked by industrial land uses on the west, south and east. Other than pockets of residential land uses adjacent to the bayou, few other noise sensitive land uses are along the bayou or within the project areas for the 1990 Authorized Plan or other build alternatives. Herman Brown Park is bisected by the bayou's middle segment and extends from either side of US 90 south to just north of IH 10 near Dunvegan Way and Garrick Lane, which are residential streets.

2.6.1.2.3 Lower Segment

South and east of Market Street in the bayou's lower segment near Maryknoll Drive is Galena Park School District's Pyburn Elementary.

2.7 Hazardous, Toxic and Radioactive Waste (HTRW) Environment

In general, hazardous materials and hazardous waste include substances which, due to their quantity, concentration or physical, chemical or infectious characteristics, may present substantial danger to the public health, welfare or the environment when released.

HTRW investigations have been conducted at various study phases, beginning with general investigations based on existing document and database records reviews, and progressing to more detail and site-specific investigations as the potential project areas have been defined. Available hazardous waste and regulated facility records from the EPA and TCEQ websites were obtained as well as the closed municipal solid waste landfill inventory maintained by H-GAC. These records were reviewed to determine whether regulated facilities are present within the Hunting Bayou channel ROW.

Regulatory records reviewed indicated 252 separate sites with actual or potential environmental issues were within the project's study area. Some of the sites are listed in multiple environmental databases, and 287 listings for environmental concerns are at these sites within the project corridor. For example, a gasoline station may be listed in the Leaking Petroleum Storage Tank (LPST) and underground storage tank databases (Banks Information Solutions 2012). *Table 2-4* lists search results by database.

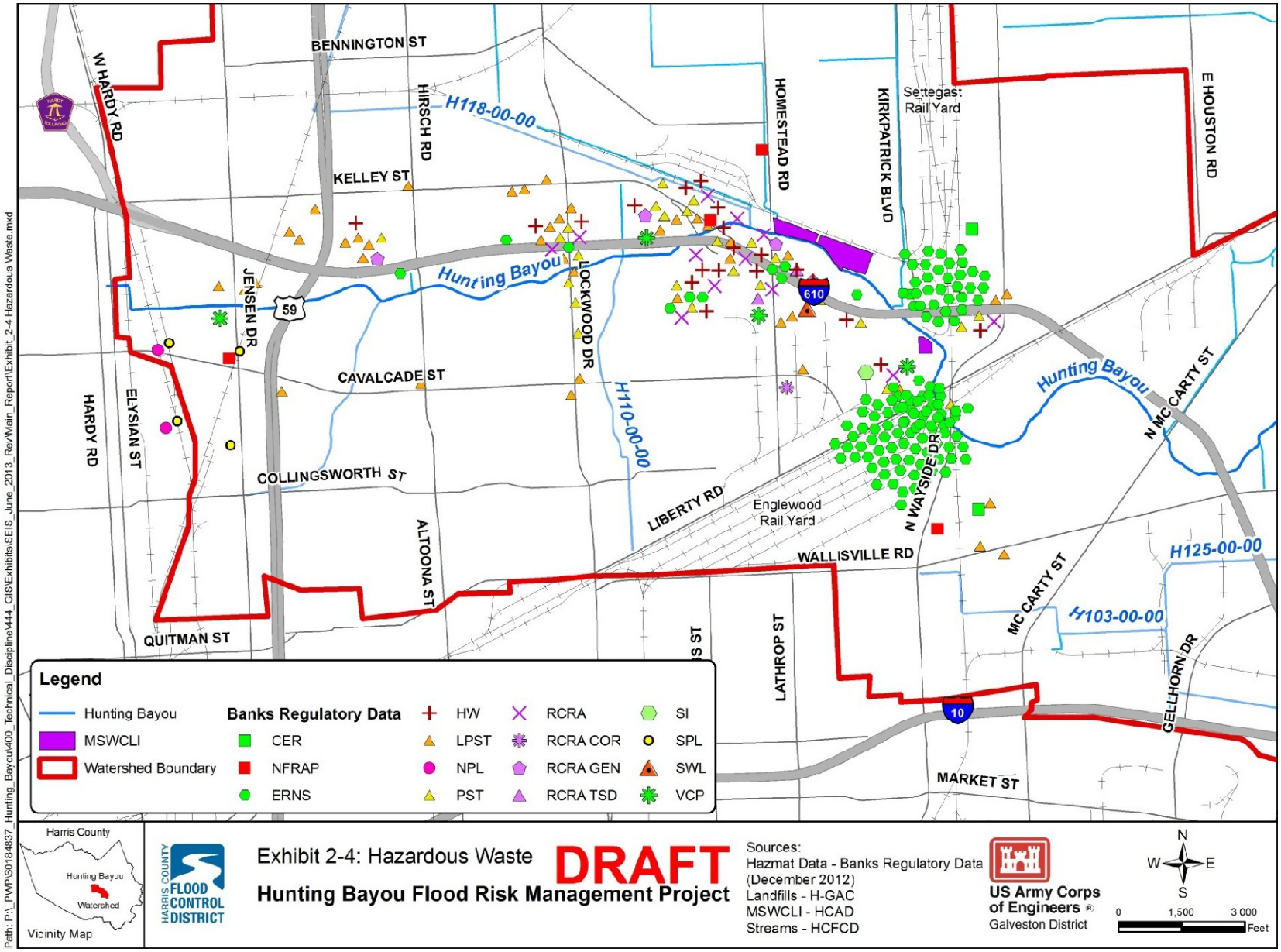
The 252 sites from a quarter mile to a mile from Hunting Bayou (indicated on *Exhibit 2-4*) are regulated in some way by the state of Texas, the state's Railroad Commission, and /or the EPA. Over half the sites reported unauthorized releases of contaminated substances or oil, and 68 sites include leaking underground storage tanks and registered above ground and underground storage tanks. One site is a registered regulated waste generator or transporter, which is consistent with the industrial/rail transport businesses in the area.

Because these identified sites are regulated according to state and federal health and safety standards, there is a low probability these documented sites pose a high risk to the bayou. Ten sites near the bayou were formerly contaminated, but are or have been cleaned up or remediated through the state's voluntary cleanup program or through other similar type programs. The largest concentration of sites, 127 or over 50 percent of the sites listed on *Table 2-4*, have had individual spills or releases of regulated substances which have been addressed by local companies contracted to respond to such incidents. One former landfill site has been discussed in other parts of this environmental assessment. This site does not pose an imminent pollution risk to the bayou's waters. A few underground storage tanks are in the bayou's vicinity in its upper reach west of and east of US 59 north of the bayou. These are approximately 1,000 ft or more from the bayou and pose little risk to the bayou itself. At least four state priority list sites 1,200 ft or more from the bayou are south of the bayou west of US 59.

Table 2-4:
Number of Environmental Sites Identified by Database Searched

Database (Site)	Database Description	Abbreviation	Search Result (No. of Sites)	Search Distance
National Priorities List	High priority hazardous waste sites in the U.S. eligible for long-term remedial action financed under the federal Superfund program and CERCLIS.	NPL	2	1 mile
Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS)	CERCLIS sites come from the Comprehensive Environmental Response, Compensation, and Liability Act, a federal law designed to clean up abandoned hazardous waste site.	CER	2	1 mile
RCRA Non-Corrective Action Sites Treatment, Storage and Disposal	All treatment, storage and disposal of hazardous material sites that fall under the RCRA.	RCRA TSD	2	0.5 mile
CERCLIS No Further Remedial Action Planned (NFRAP)	CERCLIS sites designated NFRAP have been removed from CERCLIS.	CER NFRAP	4	1 mile
RCRA Corrective Action Sites	Registered hazardous waste generators or handlers that fall under the RCRA and subject to corrective activity.	RCRA COR	1	1 mile
Emergency Response Notification System (ERNS)	A national database used to store information on unauthorized releases of oil and hazardous substances which have been reported to the National Response Center since 2001.	ERNS	127	0.25 mile
RCRA Generators	EPA regulates all Hazardous Waste Generators subject to RCRA.	RCRA GEN	4	1 mile
State/Tribal Equivalent to NPL	Sites TCEQ determined may constitute an imminent and substantial endangerment to public health and safety or to the environment due to a release or threatened release of hazardous substances into the environment.	SPL	4	1 mile
State/Tribal Disposal or Landfill	Closed and abandoned municipal solid waste landfills either unauthorized (UNUM_) or permitted (PERMAPP_).	SWL	1	0.5 mile
State/Tribal Leaking Petroleum Storage Tank	All known leaking underground petroleum storage tanks as registered with the Texas Commission on Environmental Quality (TCEQ) Remediation Services Division.	LPST	42	0.5 mile
State/Tribal Petroleum Storage Tank	All known underground and aboveground petroleum storage tanks registered with TCEQ's Remediation Services Division.	PST	26	0.25 mile
State/Tribal Institutional Control (IC)	Voluntary Cleanup Program (VCP) or Innocent Operator Program (IOP) sites which have been remediated and have had ICs placed on them.	SI	1	0.25 mile
State/Tribal VCP	VCP and IOP sites.	VCP	4	0.5 mile
State/Tribal Hazardous Waste	This database is not currently available from this state.	HW	20	0.25 mile
RCRA	All sites that fall under RCRA and are not classifiable as treatment, storage, disposers of hazardous material, hazardous waste generator or subject to corrective action activity.	RCRA	12	0.25 mile

Exhibit 2-4:
Hazardous Waste



In addition to the unpermitted, closed municipal Homestead Road SWL along Hunting Bayou within the anchor components ROW, six potential sites of environmental concern are within a 100-ft buffer of the project ROW. One is the Kirkpatrick Road Landfill; two are VCP sites at 5880 Kelley Road and 6701 North Loop East (this address is also assigned to other registered PST facilities); one is a PST/LPST at the former Humble Oil 99 Land Waste Disposal facility at 5118 Lockwood Drive; one is a PST owned by UPRR at 7000 Liberty Street; and one is an RCRA TSD facility at 5202 Lockwood (identified as a new facility formerly identified as an Exxon Mobil PST/LPST site).

A limited search was conducted for facilities permitted through the federal National Pollutant Discharge Elimination System – now covered under the Texas Pollutant Discharge Elimination System (TPDES) administered by TCEQ – which may potentially discharge effluent into Hunting Bayou.

Based on the search, 21 permitted facilities were identified within the upper Hunting Bayou watershed including cement plants, WWTPs, coatings plants, petroleum bulk storage terminals, automotive facilities and privately owned service station.

2.8 Biological Environment

The Austroriparian province, as defined by Dice (1943), encompasses the Gulf coastal plain from extreme east Texas to the Atlantic Ocean. The Hunting Bayou watershed is within the Texas Gulf Coast prairies and marshes ecological area (Gould 1975). The Gulf Coast prairie is a nearly level plain dissected by numerous streams and bayous flowing into the Gulf of Mexico. Vegetation types including *Water oak-elm-hackberry forest, Bald cypress-water tupelo swamp, Willow oak-water, Oak-blackgum forest, Young forest-grassland and Pine-hardwood forest* were identified prior to developing the region. Typical vegetation before the region was developed was tallgrass prairie or post oak savannah. Dominant grasses included big bluestem (*Andropogon gerardii*), seacoast bluestem (*Schizachyrium scoparium* var. *littoralis*), indian grass (*Sorghastrum nutans*), eastern gamagrass (*Tripsacum dactyloides*) and switchgrass (*Panicum virgatum*). Riparian hardwood forests of sugarberry (*Celtis laevigata*), pecan (*Carya illinoiensis*), elm (*Ulmus* spp.) and oak (*Quercus* spp.) were found along the region's stream corridors. These vegetation communities today are found primarily along the middle and lower reaches of Hunting Bayou and are secondary growth in nature.

2.8.1 Vegetation

The Hunting Bayou watershed is highly developed, and little of the natural plant communities remain except in a few places along the bayou just upstream and through Herman Brown Park in the Middle Watershed and south of Market Street along the tidal portion in the Lower Watershed. Outside of this, only a few scattered, small, undeveloped lots remaining in the watershed have probably experienced previous land use disturbance (e.g., agriculture). Therefore, Hunting Bayou watershed's urban and industrial nature supports ornamental plants and assemblages of native and exotic species indicative of frequent and heavy disturbance which has occurred in the watershed over several decades. Field investigations, aerial review and geospatial analysis were used to define vegetative cover into general classes. *Table 2-5* summarizes the acreages within the anchor components ROW. The remainder (not shown in the table) is either Hunting Bayou's open water or mowed, disturbed vegetation/development consisting of non-native grass cover from the existing channel ROW and residential/commercial/industrial lawn and land use, or paved surface. The ensuing paragraphs

describe the existing vegetation conditions more specifically within the anchor components ROW.

Table 2-5:
Existing Vegetation Cover within the Anchor Components ROW Including Disposal Sites

Resource	Location	Acres
Forested Wetlands	Offline Tract	1.15
	Channel	0.53
	Total	**1.68**
Scrub-Shrub Wetlands	Offline Tract	0.32
	Total	**0.32**
Emergent Wetlands	Channel	1.67
	Disposal Site 4	0.70
	Total	**2.37**
	Total Palustrine	**4.37**
Fringe Wetlands	Channel	1.18
WETLAND TOTAL		**5.55**
Upland Mixed Hardwoods	Offline Tract	37.55
	Channel	4.45
	UPRR Disposal Tract	20.68
	Disposal Site 6	7.74
	Total	**70.42**
Upland Herbaceous Areas	Offline Tract	3.22
	Total	**3.22**
Scrub-Shrub Uplands	Offline Tract	26.33
	Channel	3.45
	Disposal Site 6	5.20
	Total	**34.97**
NONWETLAND TOTAL		**108.61**
GRAND TOTAL		**114.17**

2.8.1.1 Channel Right-of-Way (ROW)

Within the upper reach's existing channel ROW, the predominant vegetation is mowed and maintained grass and other herbaceous plants growing on the tops and banks of the current earthen channel. Species within this ROW include Johnson grass (*Sorghum halepense*), *Paspalum spp.*, *Chloris spp.*, *Panicum spp.*, Bermuda grass (*Cynodon dactylon*), seacoast bluestem, Brazilian verbane (*Verbena brasiliensis*), common ragweed (*Ambrosia psilostachya*), dayflower (*Commelina erecta*) and white clover (*Trifolium repens*). Wetland/aquatic plants grow within the channel where the flow rate is low and in wetlands adjacent to the bayou. Dominant wetland/aquatic plants are smartweeds (*Polygonum* spp.), alligatorweed (*Alternanthera philoxerorides*), seedboxes (*Ludwigia* spp.) and softrush (*Juncus effusus*). Other wetland/aquatic plants growing within the channel are spikerush (*Eleocharis microcarpa*), pennywort (*Hydrocotyl* spp.), curly dock (*Rumex crispus*) and marsh flatsedge (*Cyperus pseudovegetus*).

Woody vegetation within the channel ROW consists of small fragments of woodlots or narrow bands of trees and shrubs growing along the ROW, except for the channel segment adjacent to the offline detention area between Homestead Road and IH 610 and at the downstream end of the channel modifications east of Wayside. The offline detention area segment has larger undeveloped wooded acreage and is described in more detail in the next section. Channel modifications downstream end near the Settegast rail yard consists of volunteer upland scrub-shrub growth in areas of previous disturbance. Trees and shrubs typically found in these areas include red bay (*Persea borbonia*), sugarberry, red maple (*Acer rubrum*), black willow (*Salix nigra*), laurel oak (*Quercus laurifolia*), cedar elm (*Ulmus crassifolia*), green ash (*Fraxinus pennsylvanica*), sweetgum (*Liquidambar styraciflua*), Chinese privet, (*Ligustrum sinense*), Japanese privet (*Ligustrum japonicum*), Chinese tallow (*Sapium sebiferum*), yaupon (*Ilex vomitoria*) and American beauty berry (*Callicarpa americana*). Woody vines within these woodlots include greenbriar (*Smilax* spp.), muscadine grape (*Vitis rotundifolia*), peppervine (*Ampelopsis arborea*), rattan vine (*Berchemia scandens*) and poison ivy (*Toxicodendron radicans*). Other than the segment adjacent to the offline detention area and the channel modification's downstream end, the largest areas of woody vegetation in the channel ROW are found near the IH 610 and US 59 interchange.

2.8.1.2 Offline Detention Area and Adjacent Channel Segment

Within the offline detention area, vegetation is predominantly a mix of upland scrub-shrub and second growth forest dominated by hardwoods, with a few openings dominated by grasses and other herbaceous plants. The offline detention area's forest overstory consists of sugarberry up to 12 inches in diameter at breast height, American elm (*Ulmus americana*) up to 18 inches diameter at breast height, water oak (*Quercus nigra*), cedar elm, sweetgum, deciduous holly (*Ilex decidua*), persimmon (*Diospyros virginiana*) and Chinese tallow. The understory in most locations is very dense stands of yaupon, dewberry (*Rubus louisianus*), eastern false willow, Chinese privet, palmetto (*Sabal minor*), wax myrtle (*Myrica cerifera*) and saplings of green ash and boxelder (*Acer negundo*).

Relatively few herbaceous plants are found in the understory of the offline detention forested areas, since herbaceous plants are limited primarily to clearings and at the forest edge. Herbaceous species include goldenrod (*Solidago* spp.), Cherokee sedge (*Carex cherokeensis*), white gaura (*Gaura lindheimeri*), fragrant goldenrod (*Euthamia* spp.), spurge (*Euphorbia bicolor*), basket grass (*Oplismenus hirtella*), gulf cordgrass (*Spartina spartinae*), *Paspalum spp.*, bagpod rattle bush (*Sesbania vesicaria*), giant ragweed (*Ambrosia trifida*), evening primrose (*Oenothera* spp.), Bermuda grass, St. Augustine grass (*Stenotaphrum secundatum*) and Muhly (*Muhlenbergia* spp.). Woody vines within this site include honeysuckle (*Lonicera* spp.), rattan vine (*Berchemia scandens*) and poison ivy. As the site was historically predominantly prairie which has been encroached by woody species, the upland scrub-shrub consists of younger trees and saplings in the understory.

The largest open area is a maintained drainage ditch bisecting the area and consists of maintained non-native grass. Two other upland herbaceous areas had plant species indicative of medium to high quality coastal prairie, with respect to a diversity of native grasses and forbs normally found in a prairie setting. The following prairie indicator species were found within the two open areas totaling approximately 3.2 acres: little bluestem (*Schizachyrium scoparium*), gamma grass (*Tripsacum dactyloides*), bushy bluestem (*Andropogon glomeratus*), Florida paspalum (*Paspalum floridanum*), gayfeathers (*Liatris* spp.) and various muhly grasses (*Muhenbergia*

spp.). The presence of these species is due to this site having been coastal prairie in the past. However, these areas are no longer coastal prairie as they are now highly overgrown by woody vegetation, including those species mentioned previously for the upland scrub-shrub and forested areas, and will continue to be overgrown and degrade over time.

The pale green orchid, also known as the southern rein orchid (*Plantanthera flava*), a regionally rare orchid, was found adjacent to a wetland on the western side of the offline detention area. This orchid is widely distributed and is generally rare from the pine barrens of New Jersey down the Atlantic seaboard to Florida and along the Gulf Coast to Texas (Liggio and Liggio 1999). This orchid is not a federal or state protected species.

Vegetation south of the UPRR tracks along the adjacent channel segment is second growth wood. Between the UPRR tracks and the bayou, vegetation is predominantly Chinese tallow, sugarberry, American elm and black willow, with Johnson grass, Bermuda grass and other herbaceous plants growing in openings. South of the bayou, an existing excavated depression supports a variety of upland and wetland plants. On the higher bank elevations, loblolly pine (*Pinus taeda*), American elm, sugarberry and Chinese tallow trees are dominant. The understory is yaupon, eastern false willow and saplings of overstory tree species. Poison ivy is the dominant woody vine in this area. At the water's edge, black willow and red bay are the dominant woody plants. Goldenrod, Johnson grass, *Paspalum spp*. and seacoast bluestem are the dominant herbaceous plants on the oxbow's well-drained banks. Seedbox, softrush, curly dock and smartweed grow along the water's edge.

In its upper and middle segments, Hunting Bayou traverses urban development and is crossed by roadway and railway bridges. Over time the waterway has been subject to a variety of contaminants including roadway debris, dumping of household materials, oiled material, and other substances. Sampling of excavated material from the bayou channel and detention sites would completed before commercial use of the excavate or other disposal of it could be decided.

2.8.1.3 Potential Disposal Sites

A number of sites had been considered for disposing excavated material since the start of this study, and were eliminated for various reasons including development, environmental resource avoidance/impact minimization and reductions in the needed project excavation amount. Only four disposal sites are anticipated to be needed as a contingency for potentially placing excavated materials for the project: Sites 4, 5a, 6 and the UPRR Disposal Tract; however, HCFCD does not plan to use them all. Some excavated materials may be used in local construction projects or sold to private developers or individuals for fill.

Disposal Site 4 is a highly disturbed site with little natural vegetation occurring. The site was previously used as a borrow and fill area; however, construction aggregate operations are now occurring on most of the site. The only vegetation occurs as thin bands of volunteer shrub growth at the site's borders and surrounding the wetlands associated with this site. Disposal Site 5a is a mixture of open pasture and farmland. Herbaceous plants observed at this site include Bermuda grass, bahia grass, dropseed (*Sporobolus* spp.) and neptunia (*Neptunia* spp.). Drummond's rattlebox is the only woody vegetation common to Site 5a. Disposal Site 6 is an undeveloped site consisting of upland scrub-shrub and second-growth mixed hardwood forest. Typical forest species observed include: sweetgum, Chinese tallow, water oak, willow oak (*Quercus phellos*) and loblolly pine. Typical shrubs in the understory consist of saplings of the aforementioned species and Chinese privet, yaupon, deciduous holly and American beauty berry.

The UPRR Disposal Tract is part of the larger tract on which the offline basin detention is proposed, and consists of the same upland vegetation as described above for the offline detention area.

A portion of the 1990 Authorized Plan, which consists of several of the anchor components, is being implemented prior to ASA (CW) approval. WRDA 1996, Section 211(f)(7) gives the non-federal sponsor, HCFCD, the authority to plan and construct an alternative to the 1990 Authorized Plan for Hunting Bayou. Some soil from constructing a small interim basin within the proposed offline detention has been disposed as fill for a local construction project at alternate sites. Environmental impacts and investigation requirements for this site were evaluated through a Record of Environmental Compliance (REC) to ensure environmental issues and impacts were identified, properly addressed and documented prior to using the site. As other projects are identified to reuse the excavated soil from this project, construction would be similarly evaluated through RECs as necessary.

The 1990 Authorized Plan envisioned 385 acres in multiple locations along each bayou segment for placing *about 4.4 million cubic yards of material from the (bayou) channel* (1988 Buffalo Bayou and Tributaries Feasibility Report [BB&TFR] Final Environmental Impact Statement [FEIS] Volume II p. 4-59, 1988). The disposal locations were not specifically identified but were to be located within 5 miles of the three segment construction locations on *cleared pasture and grasslands* considered low in habitat value *compared with naturally vegetated areas of the study area* (1988 BB&TFR FEIS, Volume II p. 4-59). A commitment was made to use areas with no wetlands or other environmentally sensitive areas. Disposal site locations were to be sufficiently distant from the bayou channel for placing fill to not have any impact on bayou water quality.

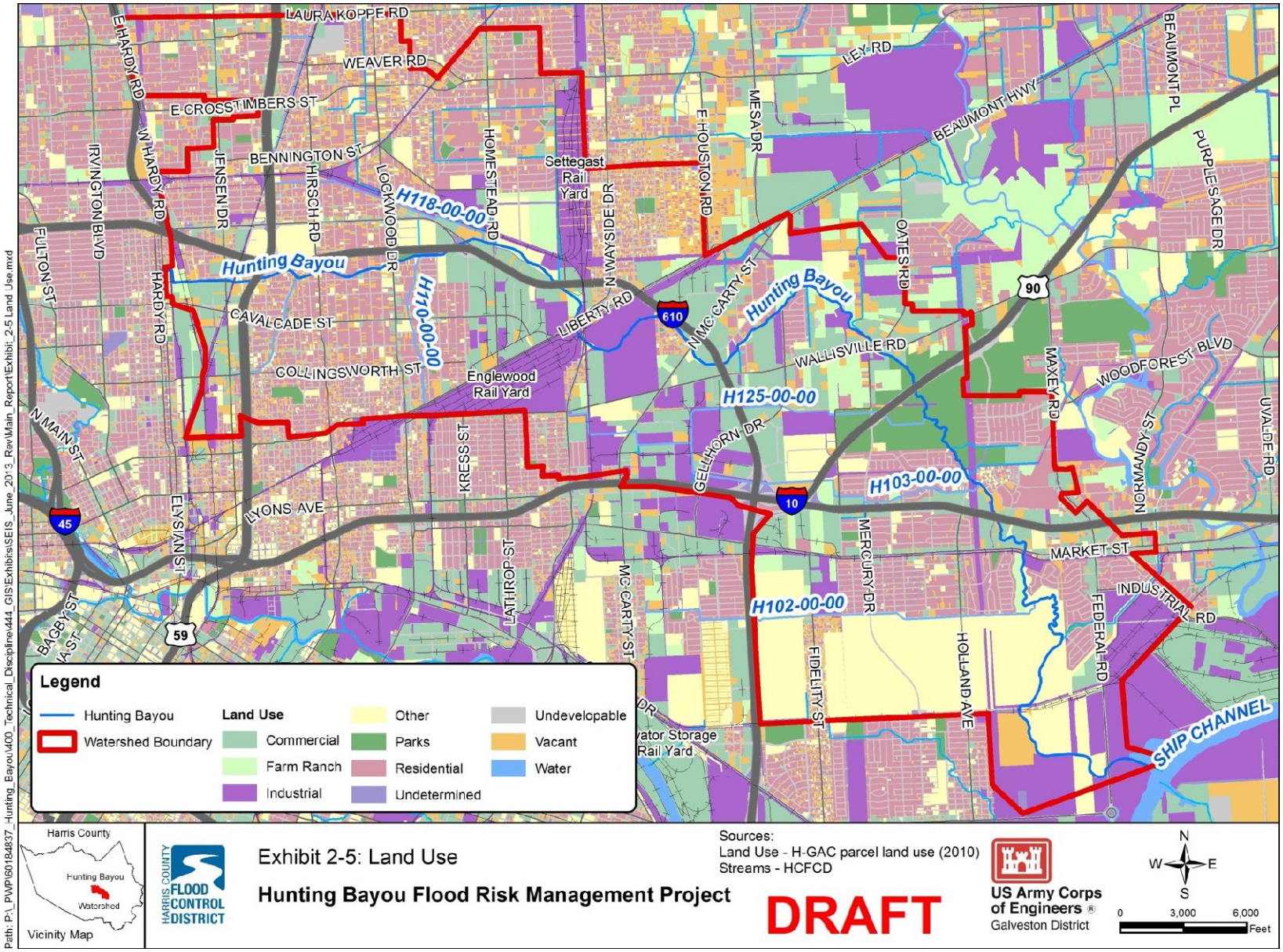
2.8.1.4 Land Use/Land Cover

The land use/land cover data were compiled from H-GAC's parcel and land use Geographic Information System (GIS) datasets and represent their best professional judgment concerning the represented land uses; these data are summarized by *Table 2-6* and *Exhibit 2-5*.

Table 2-6:
Land Use Summary Hunting Bayou Watershed

Land Use	Number of Parcels	Size in Acres
Commercial	1,715	2,711
Farm/Ranch	76	664
Industrial	608	2,973
Other	1,916	3,082
Parks	110	591
Residential	18,234	4,131
Undetermined	820	181
Undevelopable	94	3,119
Vacant	5,642	1,786
Water	2	20

Exhibit 2-5:
Land Use



2.8.2 Wildlife

2.8.2.1 Birds

The Hunting Bayou watershed generally traverses urban and developed lands. Birds expected to occur in the area include residents (present all year), bi-seasonal migrants (present spring and fall), mono-seasonal migrants (present spring or fall), summer terminal migrants (nest in area but winter elsewhere), winter terminal migrants (winter in area but nest elsewhere) and vagrants (rare visitors).

Some examples of commonly occurring bird species occurring year-round or seasonally in the Houston and Hunting Bayou watershed primarily in the middle and lower reaches of the bayou area include: wood duck (*Aix sponsa)*, great blue heron (*Ardea herodias)*, great egret (*Ardea alba*), bald eagle (*Haliaeetus leucocephalus*), red-shouldered hawk (*Buteo lineatus*), Eastern screech-owl (*Megascops asio*), barred owl (*Strix varia*), red-bellied woodpecker (*Melanerpes carolinus*), blue jay *(Cyannocitta cristata*), Northern mockingbird (*Mimus polyglottos*) and northern cardinal (*Cardinalis cardinalis*).

Common bird species found during the winter include: American wigeon (*Anas americana*), mallard (*Anas platyrhynchos*), double-crested cormorant (*Phalacrocorax auritus*), sharp-shinned hawk (*Accipiter striatus*), ruby-crowned kinglet (*Regulus calendula*), yellow-rumped warbler (*Dendroica coronata*) and swamp sparrow (*Melospiza georgiana*). Commonly occurring summer resident bird species include: little blue heron (*Egretta caerulea*), cattle egret (*Bubulcus ibis*), ruby-throated hummingbird (*Archilochus colubris*), eastern kingbird (*Tyrannus tyrannus*) and prothonotary warbler (*Protonotaria citrea*).

Bald eagle habitat exists primarily in the bayou's middle and lower segments especially in the Herman Brown Park area and in the lower segment between Market Street and the bayou outfall to Buffalo Bayou. In these undeveloped segments, sufficient habitat and desirable nest trees exist which may attract bald eagles.

Most if not all bird species which are resident or migrate through the bayou watershed are protected by the Migratory Bird Treaty Act (MBTA). For a complete list of species, habitat requirements and food resources, please see *Appendix 1* – Attachment A.

MBTA 16 U.S.C. § 701-12, first enacted in 1918, implements U.S. obligations under several international treaties and conventions to protect migratory birds. The treaty power provided the basis for sustaining MBTA's constitutionality in *Missouri v. Holland*, 252 U.S. 416 (1920). MBTA is administered by the U.S. Department of the Interior, acting through the U.S. Fish and Wildlife Service (USFWS). See 16 U.S.C. § 701.

MBTA covers almost all bird species in the U.S. USFWS regulations include most native birds found in the U.S. as species protected by MBTA – even species which do not migrate internationally. See 50 C.F.R. § 10.13. MBTA now protects nearly all the millions if not billions of native birds in the U.S.

It is unlawful to "take" a migratory bird or its nest, except as authorized by an MBTA Permit. MBTA is a criminal statute. One MBTA section makes it unlawful to "kill" or "take" a migratory bird, nest or egg, except as permitted under regulations.

2.8.2.2 Mammals

At least 47 mammal species occur or have occurred in recent times in the Austroriparian Biotic Province. Five of these species apparently reach their western limits in this eastern Texas province (Blair 1950). Mammal species which could be found within Harris County and more predominantly within the middle to Hunting Bayou watershed's lower reaches the include the following: Virginia opossum (*Didelphis virginiana*), southern short-tailed shrew (*Blarina carolinensis*), eastern pipestrelle (*Pipistrellus subflavus*), Brazilian free-tailed bat (*Tadarida brasiliensis*), nine-banded armadillo (*Dasypus novemcinctus*), eastern cottontail (*Sylvilagus floridanus*), eastern gray squirrel (*Sciurus carolinensis*), eastern fox squirrel (*Sciurus niger*), American beaver (*Castor canadensis*), marsh rice rat (*Orzyomys palustris*), deer mouse (*Peromyscus maniculatus)*, hispid cotton rat (*Sigmodon hispidus*), eastern woodrat (*Neotoma floridana*), coyote (*Canis latrans*), northern raccoon (*Procyon lotor*), bobcat (*Lynx rufus),* feral pig (*Sus scrofa*) and white-tailed deer (*Odocoileus virginianus*).

Mammals which may occur in Hunting Bayou's upper reach where the anchor component improvements are proposed include feral hogs, cats and dogs. Possum, raccoon, squirrel and various rat and mice species would also be common in the upper reach.

2.8.2.3 Recreationally and Commercially Important Wildlife Species

Numerous wildlife species providing human benefit occur primarily within the Hunting Bayou middle and lower segments. These benefits result from consumptive and non-consumptive wildlife resource use.

2.8.2.4 Amphibians and Reptiles

According to Blair (1950), the Austroriparian Biotic Province supports more species of urodeles (salamanders and newts) than any other biotic province in the state, with at least 18 species having occurred in recent times. At least 29 species of snakes, 10 lizards, two land turtles and 17 anurans (frogs and toads) are also known in the Austroriparian Biotic Province from recent times. Frog and toad species which could occur within the project footprint include: Blanchard's cricket frog (*Acris crepitans blanchardi*), Gulf Coast toad (*Bufo nebulifer*), green tree frog (*Hyla cinerea*), American bullfrog (*Rana catesbeiana*) and northern spring peeper (*Pseudacris crucifer crucifer*). Urodeles which could occur within the corridor include: spotted salamander (*Ambystoma maculatum*), central newt (*Notophthalmus viridescens*) and western lesser siren (*Siren intermedia netting*). Lizards and snakes which could commonly occur in the Hunting Bayou watershed include: green anole (*Anolis carolinensis*), five-line skink (*Eumeces fasciatus*), broad-headed skink (*Eumeces laticeps*), southern copperhead (*Agkistrodon contortrix*), Texas ratsnake (*Elaphe obsoleta*), broad-banded watersnake (*Nerodia fasciata confluens*) and western ribbon snake (*Thamnophis proximus*). Three water moccasin sub-species (*Agkistrodon piscivorus*) may occur in the project area.

Common turtle species which could occur in the Hunting Bayou watershed include: snapping turtle (*Chelydra serpentine*), red-eared slider (*Trachemys scripta elegans*), ornate box turtle (*Terrapene ornata*) and pallid spiny softshell (*Apalone spinifera pallid*).

2.8.2.5 Fish

The Hunting Bayou watershed is part of the Buffalo Bayou watershed. Fish species which may occur in the Buffalo Bayou watershed and within the Hunting Bayou watershed are: alligator gar

(*Atractosteus spatula*), gizzard shad (*Dorosoma cepedianum*), blacktail shiner (*Cyprinella venusta*), blue catfish (*Ictalurus furcatus*), channel catfish (*Ictalurus punctatus*), western mosquitofish (*Gambusia affinis*), white bass (*Morone chrysops*), warmouth (*Lepomis gulosus*), longear sunfish (*Lepomis megalotis*) and largemouth bass (*Micropterus salmoides*).

2.8.2.6 Essential Fish Habitat (EFH)

According to NOAA Fisheries Service Habitat Conservation Division, EFH is defined in the Magnuson-Stevens Act as *...those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity*. Waters include aquatic areas and associated physical, chemical and biological properties currently or historically used by fisheries. Substrate includes any sediment, hard bottom structures underlying the waters and associated biological communities. The activities potentially impacting EFH may either be direct (e.g., physical disruption) or indirect (e.g., loss of prey species), and can have site-specific, habitat-wide, cumulative and/or synergistic effects.

Based on reviewing mapped EFH in the Hunting Bayou vicinity using NOAA's EFH Mapperv3, the direct effect area for EFH would include only Hunting Bayou's tidally influenced 4-mile portion in the lower bayou between Wallisville Road and the bayou's confluence with Buffalo Bayou and HSC below IH 10. (http://www.habitat.noaa.gov/protection/efh/efhmapper/index.html).

2.8.3 Threatened and Endangered (T&E) Species

ESA 1973 (16 U.S.C. §1531-1544) regulates a wide range of activities affecting flora and fauna classified as T&E. Reauthorized in 1988, ESA provisions apply to species listed in the Federal Register as endangered or threatened. Under ESA provisions, all federal agencies are required to undertake programs to conserve T&E species, and are prohibited from authorizing, funding or carrying out any action which would jeopardize a listed species or destroy or alter its critical habitat (USFWS 2012).

2.8.3.1 Texas Parks and Wildlife Department (TPWD) Texas Natural Diversity Database (TxNDD) Research

Coordination with TPWD was conducted, and TxNDD is the current method TPWD uses to provide information for rare, T&E plants, animal, invertebrates, exemplary natural communities, and other significant features. Coordination was initiated with TPWD in December 2012, and the TxNDD report was provided on December 10, 2012. For Harris County, the USFWS County-by-County Listing, *Listed/Candidate Species and Species of Concern*, also lists Texas prairie dawn-flower (*Hymenoxys texana*) as endangered and the bald eagle (*Haliaeetus leucocephalus*) as delisted, recovered; being monitored for the first 5 years. According to the Element of Occurrence, geospatial data and the TxNDD dataset provided by TPWD, the following federally listed species were documented within a 10-mile radius of the project area:

- Bald eagle (*Haliaeetus leucocephalus*), 1 occurrence
- Texas prairie dawn (*Hymenoxys texana*), 8 occurrences
- Houston toad (*Anaxyrus houstonensis*), 1 occurrence

Based on these and other data, site-specific studies have been performed in the project vicinity to evaluate bald eagle and Texas prairie dawn presence in the area (see *Appendix 1* – Attachment B).

2.8.4 Invasive Plant Species and Noxious Weeds

Invasive and non-native vegetation and wildlife species are common in the Houston and Hunting Bayou area and are summarized below. In some cases, non-native species (particularly grasses) have been intentionally planted on bayou side slopes for maintenance reasons, or non-native species may have been planted by residential homeowners. Invasive species can be spread by a number of different methods including boat hulls. Invasive species may also be introduced by imported nursery stock and fruits, on vehicles, in packing materials and shipping containers, through human-built canals and from human travel. Dumping aquarium exotic fish and unwanted exotics into the water or wild are other common ways invasive species spread (TexasInvasives.org 2010).

Introducing exotic species into natural areas has always been a concern due to the potential for detrimental ecological effects on a native ecological system. Invasive flora in the anchor component project area includes giant salvinia (*Salvinia molesta*). Giant salvinia is a non-native aquatic plant which grows rapidly through vegetative reproduction and is tolerant of environmental stress, thereby making it an aggressive species competing with native aquatic vegetation and ecosystems. Giant salvinia is known to occur in Harris County.

In many cases, such as Chinese tallow or nutria, the non-natives were introduced or recruited from introduction to the general Houston area. Within the proposed offline detention basin tract, the vegetation includes woody species which have overgrown the previously present grassland and native trees and shrubs and nonnative or invasive species such as Chinese tallow and curly dock. Within the stream channel, aquatic or emergent vegetation, including nonnative species such as alligator weed, has developed as a result of recruitment along the stream margin.

2.8.5 Wetlands and Waters

Aquatic habitat and resources in the study area consist of Hunting Bayou, its channelized minor tributaries and palustrine wetlands in the watershed. Due to the watershed's highly developed nature, most wetlands are depressional wetlands which primarily rely on precipitation and runoff interception for hydrology, although a few adjacent to the bayou may also function with riverine overflow contributing hydrology. National Wetland Inventory datasets were used in the study's initial stages to identify potential wetlands. As the study developed and project alternatives were evaluated to identify the likely project reach, field investigations were conducted and updated between 2001 and 2009 to better define wetland areas, aided by recent and historical aerial photographic review (black and white, infrared and true color). Within the anchor components' reach, wetlands are only found in the channel segment between Homestead Road and Liberty and in the offline basin as overbank palustrine wetlands, or as an intermittent thin fringe of wetland vegetation at the perennial channel margin within the bayou, referred to as fringe wetlands. The palustrine wetlands consist of small (< 1 acre contiguous), scattered forested, scrub-shrub and emergent wetlands which are primarily natural depressional wetlands, but also include a ditched swale with continuity to the ordinary high water mark to the bayou, and previously excavated depressions adjacent to the channel which have naturalized. Within the proposed disposal sites, only Disposal Site 4 has two small emergent wetlands which also appear to be naturalized former ditches or swales. The total palustrine acreage is 4.37 acres.

Because Hunting Bayou is a highly modified channel with uniform geometry, transitional zones between inundated and dry conditions are not extensive. As a consequence, the fringe wetlands are limited to the lowest edge of the perennial channel, and bank vegetation is dominated by non-native grasses. The extent of fringe wetlands within the anchor components' reach was assessed in March 2007. The field investigation quantified the area within the banks which contain non-persistent, emergent hydrophytic vegetation and wetland hydrology to estimate the acreage of wetlands associated with the channel which could be affected by channel modification. The fringe wetland vegetation is considered non-persistent, because the erosive forces of seasonal storm event flow can scour the vegetation.

The upper project segment was divided into four parts, and average hydrophytic vegetation boundary width data were observed for a representative 1,000-ft lengthwise transect in each segment at 10-ft spacings along each transect bank. Dominant fringe wetlands plants observed were alligator weed and marsh seedbox (*Ludwigia palustris*). Smartweed (*Polygonum hydropiperoides*) was also observed but not dominant. The estimated 1.18 total project acreage was determined by multiplying the average square feet (determined from the total of both banks) of fringe wetland per linear foot of channel for the transect, times each segment's length, and summing the calculated area for the four segments. The fringe wetlands observed resulted from natural recruitment of native and non-native emergent vegetation along the edge of a perennial channel constructed during the previous Hunting Bayou modification. The same recruitment would be expected to occur along the edge of the perennial channel to be constructed within anchor component's modified channel, since the same base flow would be present and similar perennial channel dimensions would be maintained.

Wetlands in the bayou's middle and lower segments were noted in the BB&T FR Volume II FEIS as follows: *Because of previous channel work along the bayou, wetlands are now confined to a few shallow water areas and mudflats in the lower tidal reach (segment) and some backwater swamps in Galena Park.*

2.9 Cultural Resources

Methodology developed by Texas Department of Transportation (TxDOT) was employed to assess potential archaeological constraints. This assessment concluded approximately 20 percent of the middle to lower Hunting Bayou watershed exhibited medium or high potential for archaeological resources requiring investigation. Based on these results, archival research and history/architecture fieldwork were conducted to determine the number and types of cultural resource sites which would potentially be impacted by the proposed Hunting Bayou Flood Control Project (Greenstone Geoscience, Archaeological and Historic Resources Survey, 2002).

The project's Area of Potential Effects (APE) was defined as those parcels along Hunting Bayou. The APE is characterized largely by pre-1965 residential development dating from the late 1930s to the mid-1960s. The literature review for this project entailed examining the Texas Historic Commission's online GIS mapping site. The literature review identified no properties listed in the National Register of Historic Places (NRHP). A total of 47 previously recorded historical resources and 43 previously unrecorded extant historical resources were surveyed during fieldwork. Of the 47 previously recorded resources, 10 were found to have been demolished. Additional detail regarding these sites within the study area can be found in *Appendix 1* – Table 1 of Attachment F.

Archeological sites, buildings and structures, and traditional cultural places all have potential to be considered an historical place and listed in NRHP. To be eligible for inclusion in NRHP, properties must be at least 50 years old (unless they are exceptionally significant) and must be significant to American history, architecture, archaeology, engineering or culture at the national, state or local level. They must also possess integrity for location, design, setting, materials, workmanship, feeling and association, and must meet at least one of the following criteria.

Criterion A: Associated with events which have made a significant contribution to the broad history patterns

Criterion B: Associated with the lives of persons significant in our past

Criterion C: Embody the distinctive characteristics of a construction type, period or method which represents the work of a master or possesses high artistic values, or represents a significant distinguishable entity whose components may lack individual distinction

Criterion D: Have yielded or may be likely to yield information important in prehistory or history (National Register, 36 CFR Part 60.4)

As part of the National Historic Preservation Act (NHPA), Section 106 review applies when damaged historic buildings and structures are eligible for federally funded repair, renovation or replacement. There are 271 Historic Markers identified in Harris County and 176 cemeteries (10 within the Hunting Bayou watershed). The cultural resources in the study area reflect the general patterns of prehistoric settlement, early historic Spanish exploration, and early 19th Century European settlement in Texas observed in the Houston area. The more recent potentially historic properties reflect Houston's development and expansion as a city in the 19th and 20th Centuries. Based on site-specific investigations conducted, one potentially historic building (M.W. Sinai Grande Lodge A.F. and A.M. building at 5002 Wipprecht Street) in the project vicinity has been identified within 500 ft of the Hunting Bayou channel improvement area.

Some 10 recorded sites were documented by the BB&T FR FEIS Volume II, 1988 and determined to be located along Hunting Bayou banks, but recent evaluations (Greenstone Geoscience 2002a) recommended no further evaluations be made of these sites.

2.10 Socioeconomic Environment

2.10.1 Population and Demographics

The Hunting Bayou watershed is in Harris County, with portions within the cities of Houston, Galena Park and Jacinto City. Harris County's population increased from approximately 2.8 million in 1990 (TWDB 2011) to 3.4 million in 2010 (USCB 2000), and is projected to increase to approximately 4.8 million by 2030 and 5.5 million by 2050 (TWDB 2010 Region H Regional Water Plan).

The 2010 population for the cities of Houston, Galena Park and Jacinto City was 2,099,451; 10,887; and 10,553, respectively (USCB 2010). *Table 2-7* shows the population within the Hunting Bayou watershed was 89,025 in 1980, and declined from that total in 1990 and 1995. The population decline after 1980 may be attributed, in part, to the conversion of residential

acreage to commercial and industrial land uses (HCFCD 1999, University of Houston Center for Public Policy 1995, TC&B 1998). The estimated population within the Hunting Bayou watershed is currently 69,061 with approximately 28,000 households (based on Census housing units), and an average household size of 2.53 persons (USCB 2010).

Table 2-7: Population Change within the Hunting Bayou Watershed

Year	Estimated Population
1980	89,025
1990	77,837
1995	76,448
2000	76,319
2005	79,152
2010	69,061*

**Based on U.S. Census Tract 2010 population within the Hunting Bayou watershed.*

The racial/ethnic distribution for Harris County is approximately 56.6 percent Caucasian; 18.9 percent black or African American; 6.2 percent Asian; and 18.3 percent other, including persons of two or more races. The Hispanic polulation comprises 40.8 percent of the Harris County population. The racial/ethnic distribution for the watershed is approximately 37.3 percent white; 36.5 percent black or African American; 0.4 percent Asian; and 25.8 percent other, including persons of two or more races (USCB 2010). The Hispanic population comprises 57.8 percent of the watershed population. *Table 2-8* shows the racial/ethnic distribution for Harris County, the cities of Houston, Galena Park and Jacinto City, and the Hunting Bayou watershed.

Table 2-8: 2010 Population and Race/Ethnicity

Geographic Area	2010 Population	Race/Ethnicity (Percent)					Percent Hispanic
		White	Black/African American	Asian	Other[1]	Total	
Harris County	4,092,459	56.6	18.9	6.2	18.3	100	40.8
Houston	2,099,451	50.5	23.7	6	19.8	100	43.8
Galena Park	10,887	63.8	6.8	0.1	29.3	100	81.4
Jacinto City	10,553	64.3	3.5	0.3	31.9	100	83.9
Hunting Bayou Watershed	69,061	37.3	36.5	0.4	25.8	100	57.8

*Source: USCB 2010 and 2011 updates (*http://quickfacts.census.gov/qfd/states/48/48201.html

[1] *Native Hawaiian or Pacific Islander and those of two or more races (based on 2010 Census tract data).*

2.10.2 Economic Activity

The economy in Houston and Harris County has traditionally been focused on the oil and gas industry. Employment in the oil and gas industry, in decline from 1985 to 2009, has begun to revive. Over the past year, Texas added jobs in 10 of the 11 major industries including trade, transportation and utilities, leisure and hospitality, professional and business services, education

and health services, construction, other services, mining and logging, manufacturing, financial activities and government. Texas total nonfarm employment increased by 4,100 jobs during December 2012. Between December 2011 and December 2012, Texas total nonfarm employment increased by 2.5 percent (Tracking the Texas Economy updated February 2013; http://www.window.state.tx.us/).

The state's economy has been comparatively healthy as documented by a USCB report indicating Texas added more people (421,000) than any other state from 2010 to 2011. Although Texas has only 8 percent of the nation's population, the state added nearly 19 percent of the nation's population growth for the year. By December 2011, Texas employers replaced all 427,600 jobs lost during the recession as the economy rebounded more quickly than the U.S. as a whole, and continues to add jobs (February 15, 2013 update, Window on State Government http://www.window.state.tx.us/).

The upper Hunting Bayou watershed is predominantly residential with the Kashmere Gardens and Pleasantville Super Neighborhoods and Liberty Gardens residential area bordering Hunting Bayou's upper reach. The project area includes areas of the Houston-Greater Fifth Ward subdivisions and historically modest residential areas such as Kashmere Gardens (now designated a Super Neighborhood), Liberty Gardens, Englewood subdivision and others (http://houston.blockshopper.com/).

Kashmere Gardens has been a predominantly African-American neighborhood for the past 50 years. It is centrally located in the Hunting Bayou project area, part of Houston City Council Districts B and H (City of Houston Revised Redistricting Staff Plan of May 9, 2011; http://www.houstontx.gov). The Kashmere Gardens neighborhood is predominantly a residential area immediately adjacent and north of Houston's 5th Ward (geopolitical districts established in 1837). The area consists of predominantly single-family residential (SFRs) houses with relatively large lots. Kashmere Gardens is between an industrial area and a rail corridor. Between 1990 and 2000 Kashmere Gardens' Hispanic population's percentage increased from approximately 19 percent to almost 31 percent.

Commercial areas have automobile and engine repair, car wash and engine oil change facilities, barber and beauty shops, diners and restaurants and funeral homes. Community or public service facilities include churches; parks; nursing homes and assisted living facilities; elementary, secondary and high schools; the LBJ General Hospital, Kashmere Gardens Multi-Service Center, Hunting Bayou Hike and Bike Trail, East Water Purification Plant and the McCrane-Kashmere Gardens library. Light to heavy industrial and warehousing facilities include the Houston Recycling Paper Services, Lone Star Heat Treating, Mauser Corporation, Custom Pipe Coating, Grainger Industrial Supply, Lone Star Imports, Koch Filter Corporation, E-TEL, Self Industries, packing and distribution facilities, metal recyclers and landscaping companies (*Exhibit 2-5*).

Railroad facilities are largely associated with ERRY and Settegast rail yard. ERRY is bounded by Liberty Road, Wallisville Road and Wayside Drive, has 64 tracks in a tight diamond area bounded by an additional 20 tracks, and is owned by the Union Pacific Railroad (UPRR). On any given day, up to 50 locomotives pass through these yards.

Transportation, bus and rail terminal facilities in the upper and middle reaches of the Hunting Bayou watershed include Kashmere Garden Transit Center (bus terminal), the Settegast Rail Yard, and the former Houston Belt and Terminal Railway (formerly operated as a switching

railroad now 50 percent owned by UPRR and 50 percent Burlington Northern and Santa Fe Railroad).

2.10.3 Flood Hazards

Executive Order (E.O.) 11988, Floodplain Management, tasks federal agencies to *avoid to the extent possible the long and short-term adverse impacts associated with the occupancy and modification of flood plains" and "reduce the risk of flood loss, to minimize the impact of floods on human safety, health and welfare, and to restore and preserve the natural and beneficial values served by floodplains* (FedCenter 2012). Federal agencies who participate in or permit the construction of future projects are subject to this E.O.

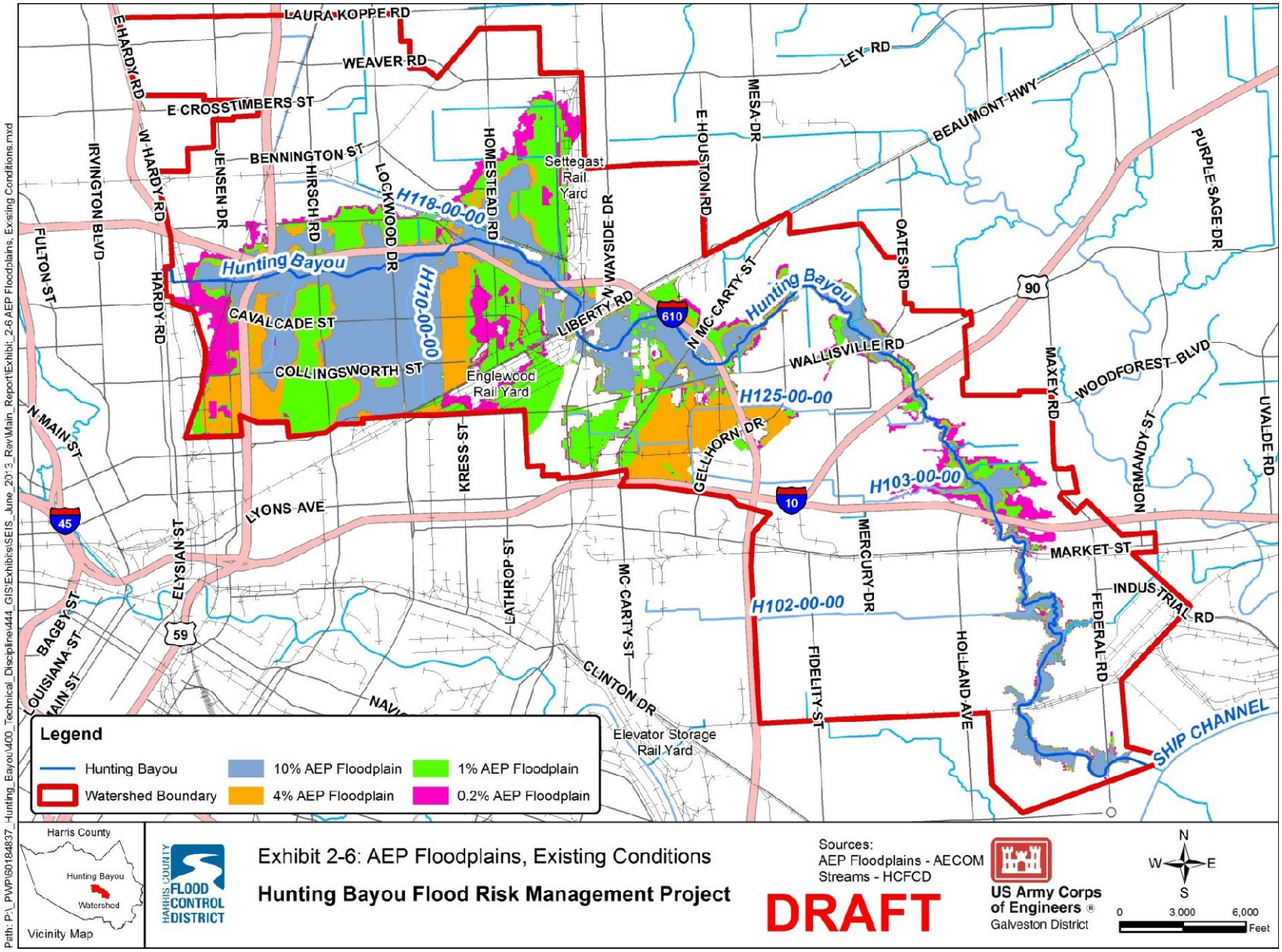
The 100-year flood is defined by Federal Emergency Management Agency (FEMA) as a flood elevation with a 1 percent chance of being equaled to or exceeded each year (FEMA 2012). As such, a 100-year floodplain is defined as a floodplain at or below the 100-year flood elevation (*Exhibit 2-6*). Floodplains are generally associated with watercourses and other water bodies or coastal areas. However, floodplains may also be associated with poorly drained level areas. FEMA manages the National Flood Insurance Program (NFIP), which provides protection to property owners within a flood-prone area. Development or construction activities within floodplains poses several potential concerns which could occur as a result of or during a flood event, such as displacing flood waters which could potentially raise the base flood elevation (BFE), provide harm to humans, property damage, or create environmental hazards.

The 1 percent AEP floodplain, also known as a Special Flood Hazard Area on a FEMA Flood Insurance Rate Map (FIRM or floodplain map), is an area at risk for flooding from a bayou or creek. Statistically, structures in a 1 percent AEP floodplain have a minimum 26 percent chance of flooding during a 30-year period and a minimum 1 percent chance of flooding in any given year. As of 2013, 5,110 structures are within Hunting Bayou watershed's existing 1.0 percent AEP floodplain. Under existing conditions, the total average annual equivalent value (AAEV) for flood damages within the watershed over the next 50 years is anticipated to be approximately $19.8 million.

2.10.4 Land Ownership

Residential land within Hunting Bayou watershed's upper reach generally consists of SFRs which have been owned for less than 10 years (31 percent) while other properties have been owned for up to 20 or 30 years. The commercial and industrial areas in Hunting Bayou's upper and middle reaches contain land which varies in size from less than 1 acre to more than 11 acres. ERRY owned by UPRR includes an area greater than 20 acres (within Hunting Bayou's upper to middle reach). Public lands include the LBJ General Hospital and the 700-acre Herman Brown Park, which is within Hunting Bayou's middle reach (along the channel's northern banks). For the anchor components project area, displacements for some residents and property purchase along the upper Hunting Bayou channel would be required for implementation.

Exhibit 2-6:
AEP Floodplains, Existing Conditions



2.10.5 Land Use and Land Classification

The Hunting Bayou watershed encompasses approximately 30 square miles (19,250 acres) in central Harris County (*Exhibit 1-2*). Major transportation routes within the watershed include IH 10 East, IH 610 East, US 90 and US 59. Several major railroads traverse the watershed, and two large rail yards are in the watershed. Approximately 75 percent of the land within the Hunting Bayou watershed is developed and 25 percent is undevelopable, vacant (10 percent) or mapped as open water (<1 percent). Areas designated as undevelopable may be dredge material placement areas or the Port of Houston Authority property.

Approximately 30 percent of the land has industrial or commercial land use likely in Hunting Bayou watershed's middle and lower reaches. Approximately 44 percent of the watershed is designated as farm or ranch, parks, residential or other land uses which may include public facilities such as schools, hospitals, cemeteries, roads, police stations, fire stations and other public uses. Land use distribution within the watershed is about 21.5 percent residential, 14 percent commercial, 15.4 percent industrial, 19.8 percent institutional/public, 3 percent agricultural, 9 percent undeveloped/open space, 17.3 percent roads and 16 percent other (H-GAC 2012). There are 5,110 structures within the existing 1 percent AEP floodplain of the Hunting Bayou watershed.

Approximately 83 percent of the upper watershed, which consists of the area east of the Hardy Toll Road to the downstream end of the ERRY, is developed. Land use in the upper watershed primarily consists of industrial, residential and commercial. A large industrial area consisting of a rail yard, tank farm and salvage yard is downstream from the second IH 610 crossing over Hunting Bayou.

Approximately 65 percent of the middle watershed's total area, which consists of the area downstream of the ERRY to downstream of Herman Brown Park, is developed. Land use in the middle watershed primarily consists of industrial, commercial, public (parkland) and residential. The bayou runs through Herman Brown Park, which is between Wallisville Road and IH 10 East.

Approximately 45 percent of the total area in the lower watershed is developed. Land use in this section primarily consists of Port of Houston Authority undeveloped and dredge placement lands, residential, commercial and industrial. Some areas of the lower watershed have revegetated and reverted back to more natural conditions. This is particularly true along the lower 3.8-mile reach of Hunting Bayou which is tidally influenced.

2.10.6 Environmental Justice

2.10.6.1 E.O. 12898

E.O. 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, mandates federal agencies identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of programs on minority and low-income populations (59 *Federal Register* 7629-7633, February 16, 1994). A minority population is defined as a group of people and/or a community experiencing common conditions of exposure or impact which consists of persons classified by the USCB as Black or African-American; Asian; American Indian or Alaska Native; Native Hawaiian or other Pacific Islander; Hispanic or Latino; or other non-white persons, including those persons of two or more

races. A low-income population is defined as a group of people and/or a community which, as a whole, live below the national poverty level. The poverty threshold for a family of four with two children, as defined by the USCB is $23,283 (https://www.census.gov/hhes/www/poverty/data/threshld/index.html; USCB 2012).

Disproportionate environmental impact occurs when the risk or rate for a minority population or low-income population from exposure to an environmental hazard exceeds the risk or rate of the general population and, where available, to another appropriate comparison group(s) (U.S. Department of Defense 1995; EPA 1998). Specifically, for analysis within this EA, disproportionate adverse impact to minority or low-income populations would occur when the population within a given block group is adversely and disproportionately impacted, and the minority and/or low-income percentage of the population within the block group is more than double the percentage of the minority and/or low-income population within an appropriate comparison group(s) (Council on Environmental Quality 1997). The percent minority and low-income population directly adjacent to the project area are as follows: approximately 95 percent minority and 29.5 percent classified as low-income. The potential effects from the proposed action have been evaluated in accordance with E.O. requirements.

Houston and Harris County citizens and residents living in the project area are those most vulnerable to health and safety effects from flood events. Economically disadvantaged populations along and within Hunting Bayou's floodplain are most likely to experience long-term or unabated flood conditions, and lack the ability and resources to easily, quickly or completely rebound after flood events. Based on data compiled during the 2010 U.S. Census, the project area (including zip code 77026) consists entirely of federally-designated low income and minority populations. In 2011, the project area consisted of areas meeting the federal requirements for the Community Development Financial Institution Fund's New Market Tax Credit (NMTC) Severely Distressed Status (The Reinvestment Fund [TRF] 2011). The NMTC Severely Distressed Status is based on whether or not a given Census tract meets the primary or secondary criteria of being Severely Distressed. A Census tract meeting either the Primary or Secondary Criteria for Severely Distressed Status is eligible for NMTC funding. The TRF uses a fully web-based GIS known as PolicyMap™ to develop custom demographic maps, tables and reports based on publicly available web-based datasets.

In the project area, the population met NMTC's Severely Distressed Status criteria based on all three designated primary factors. In 2000, the populations had a median family income at or below 60 percent of the area median income, had a poverty rate at or above 30 percent, and had an unemployment rate at least 1.5 times the national unemployment rate. These criteria are used solely by TRF to indicate particularly Severely Distressed Status areas needing investment. Census tracts which qualify as Federal Medically Underserved Areas defined in 2012 are those areas designated by the Health Resources and Services Administration as having too few primary care providers, high infant mortality, high poverty and/or high elderly population.

2.10.6.2 E.O. 13045

E.O. 13045, *Protection of Children from Environmental Health Risks and Safety Risks*, mandates federal agencies identify and assess environmental health and safety risks which may disproportionately affect children due to implementing federal policies, programs, activities and standards (62 *Federal Register* 19883-19888 April 1997). Approximately 24 public schools are within the watershed, four of which are within the 1.0 percent (100-year) floodplain (see *Chapter 6* in this draft GRR-EA).

2.10.7 Housing

There were 65,165 home sales in Houston in 2011 with an average $203,425 sale price. Approximately 442,000 apartment units are in the Houston area, with an overall 7.3 percent apartment vacancy rate. The average apartment rental rate is 83 cents per square foot (Texas A&M Real Estate Center 2011).

Approximately 28,000 households and 8,832 residential structures exist within the Hunting Bayou watershed (U.S. Census 2010 and AECOM Technical Services, Inc. 2012). The average home cost within the watershed is $56,624, which is substantially lower than home costs within Harris County or COH.

2.10.8 Public Facilities

Within Hunting Bayou's existing 1 percent AEP floodplain are 58 public structures which include the following structure types: the LBJ Hospital, school facilities, religious facilities, correctional facilities and miscellaneous public facilities.

2.10.8.1 Parks and Recreational Areas

There are 34 municipal or county parks adjacent to or within the Hunting Bayou watershed (*Table 2-9*). *Exhibit 2-7* presents the location for the majority of the parks within Hunting Bayou watershed's vicinity. Groveland Terrace Park, Hutcheson Park, the Hunting Bayou Hike and Bike Trail, Manitou Triangle Park and Herman Brown Park are within the Hunting Bayou floodplain. A small neighborhood recreational area is also on the bayou's south side near the IH 610 and US 59 intersection.

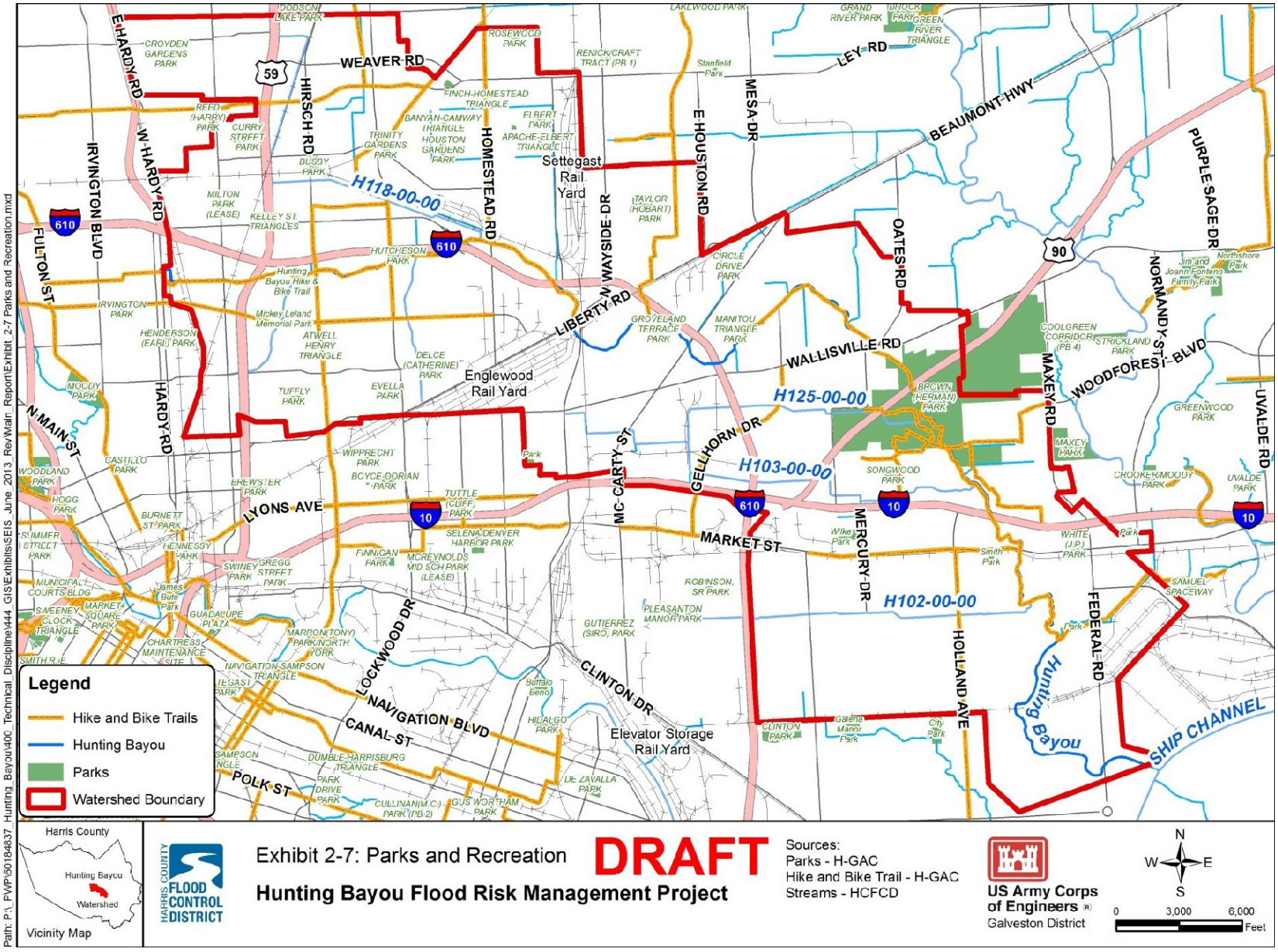
Hutcheson Park, Groveland Terrace Park and the unnamed neighborhood recreational area are in the upper watershed. The approximately 8-acre Hutcheson Park contains tennis and basketball courts, a playground, picnic tables, benches, barbeque pits, drinking fountains, trash receptacles, overhead lighting and a 4,000-ft-long paved hiking/biking trail and is between IH 610 and the bayou, east of Lockwood. The approximately 1.6-acre Groveland Terrace Park is south of the bayou near US 90A between Herald and Beaver Streets.

Herman Brown Park is approximately 700 acres, and is a regional park within the middle bayou segment. Access to Herman Brown Park is limited, as the park is accessible from Oates Road and Mercury Drive. The park's eastern portion is undeveloped and densely forested. The proposed Northeast Freeway (US 90) is planned through the park, which would likely provide improved access to the facility. The developed area is approximately 90 acres or about 12 percent of the total park. The park has significant forested areas and viable wildlife habitat which cover approximately 540 acres. About 375 acres of Herman Brown Park are within the Hunting Bayou watershed. Hunting Bayou traverses the park in a north-south direction as a natural channel.

Table 2-9:
Parks Identified within the Hunting Bayou Watershed

Number	Name of Park	Type of Park	Within 0.2 AEP Floodplain
1	Unnamed Park	Unknown	No
2	Smith Park	County	No
3	J.P. White Park	City/Municipal	No
4	Wilke Park	Unknown	No
5	Songwood Park	City/Municipal	No
6	Santos & Esther Nieto Park	City/Municipal	No
7	Park	City/Municipal	No
8	Tuffly Park	City/Municipal	Yes
9	Evella Park	City/Municipal	Yes
10	Herman Brown Park	City/Municipal	Yes
11	Catherine Delce Park	City/Municipal	No
12	Henry Atwell Park	City/Municipal	Yes
13	Manitou Triangle Park	City/Municipal	Yes
14	Groveland Terrace Park	City/Municipal	Yes
15	Mickey Leland Memorial Park	County	Yes
16	Hunting Bayou Hike & Bike Trail	County	Yes
17	Circle Drive Park	City/Municipal	No
18	Hutcheson Park	City/Municipal	Yes
19	Kelley Street Triangles Park	City/Municipal	No
20	Milton Park (Lease)	City/Municipal	No
21	Hobart Taylor Park	City/Municipal	No
22	Busby Park	City/Municipal	No
23	Houston Gardens Park	City/Municipal	No
24	Trinity Gardens Park	City/Municipal	No
25	Apache-Elbert Triangle Park	City/Municipal	Yes
26	Curry Street	City/Municipal	No
27	Darien Park	City/Municipal	Yes
28	Banyan-Camway Park Triangle Park	City/Municipal	No
29	Elbert Park	City/Municipal	Yes
30	Finch-Homestead Triangle Park	City/Municipal	No
31	Finch Circles Park	City/Municipal	No
32	Pelham Park	City/Municipal	No
33	Croyden Gardens Park	City/Municipal	No
34	Rosewood Park	City/Municipal	Yes

Exhibit 2-7:
Parks and Recreation



2.10.8.2 Schools

The Hunting Bayou watershed is within Houston, North Forest and Galena Park Independent School Districts. Approximately 24 public schools are within the Hunting Bayou watershed. Kashmere Gardens, Concord and Scott Elementary Schools (Houston Independent School District) are within the upper watershed, and Pyburn Elementary School (Galena Park Independent School District) is within the lower Hunting Bayou watershed.

2.10.9 Transportation Crossings

There are 37 transportation crossings along Hunting Bayou including six major highways which serve the general Hunting Bayou area (IH 610 [3 crossings], IH 10 East, US 59 and US 90), 18 street/vehicle crossings, four pedestrian crossings and nine railroad crossings. TxDOT indicates the main lanes for the IH 610 and IH 10 East bridges over Hunting Bayou are in good condition. However, the bridges for the adjacent frontage roads are indicated to be obsolete, and are good candidates for rehabilitation or replacement (TxDOT 2011). Peak morning traffic along IH 610 from US 59 to US 90 ranges from 5,527 to 6,163 vehicles westbound and 5,266 to 5,890 vehicles eastbound. Peak afternoon traffic along IH 610 from US 59 to US 90 ranges from 5,640 to 6,000 vehicles westbound and 5,248 to 5,902 vehicles eastbound (TxDOT 2011).

2.11 Visual and Aesthetics Resources

Proposed changes in an area's character can be defined in terms of visual dominance. For example, if residents in the area would overlook the changes to the area's setting, the changes would not be noticeable. If the changes would be noticeable but would be dominated by other features in the area's setting, then the changes would be visually subordinate. A change which would compete with an area's visual character is visually co-dominant. Finally, a change which would detract from the setting's character and would demand attention is visually dominant.

The visual and aesthetic resources analysis would include evaluating the following elements.

- Consistency with existing visual character
- Changes in visual quality
- Potential effect on viewers with high viewer sensitivity
- Blocking sensitive views with an emphasis placed on views identified by local jurisdictions as requiring protection
- Creating shadows
- Light and glare

Overall, the project area and areas in the watershed beyond it can be visually characterized as an active urban environment, with a mixture of residential, commercial, industrial, parkland and undeveloped areas. For the most part, the visual character in the upper reach project area between US 59 and Lockwood Road, the lower reach areas between IH 10 East and H102-00-00 (*Exhibit 1-2*), and the visual character for portions of the middle and lower reaches is consistent with a residential neighborhood setting. Within the upper reach project area between Lockwood Road and IH 610, the rail yard and industrial facilities are visually an industrial land use. Undeveloped and parkland areas within the middle and lower reaches would also not be affected by the anchor component improvements which exhibit visual and high aesthetic values, such as in Herman Brown Park.

3.0 PLAN REEVALUATION

In this reevaluation, the USACE six-step planning model was followed with multiple iterations over time. The plans reevaluation process included reviewing components or specific FRM remedies and determining the value or role each play in achieving effective FRM. To summarize, this section's organization and plan reevaluation included the following elements.

- Review and update existing and future expected WOP conditions.
- Review structural and nonstructural FRM remedies.
- Organize economic benefits of each remedy or component according to upper, mid and lower stream segments.
- Eliminate less effectively performing components.
- Combine effective components, optimize them, and screen them further.

3.1 Management Measures and Alternative Plans

To achieve the stated planning objectives for this study, various structural and nonstructural management measures were reevaluated to address flood risk in specific areas based on the opportunities presented by the bayou's physical configuration and location, local drainage characteristics and the potential to reduce high economic damages through improving the bayou's drainage capacity. The structural measures originally considered to support authorization, and then reconsidered in the study were as follows.

- Channel modifications
- Bridge replacement
- Diversion/by-pass
- Selected reach channel modifications with selected detention
- Selected channel widening for inline detention
- Detention only
- Levees

Nonstructural measures considered in various study stages included:

- Flood warning/flood ALERT system
- Flood proofing/raising of structures
- Permanent evacuation within floodplain (buyout)
- Management measures for floodplain development

3.2 The Planning Process

The process by which alternative FRM plans were defined comprised a series of investigations starting from the more general using mostly available existing data, to the more specific using more detailed information which was identified through additional engineering, environmental and economic planning analyses. The initial investigation identified those structural and nonstructural remedy types which could be reasonably applied to the flood situation; were

compatible with the surrounding topography; and were economically and socially desirable. A component analysis (individual structural elements which could be combined with other elements to form a complete plan) was then used to identify economically justifiable components which addressed the 1990 Authorized Plan goals and objectives. These components were evaluated in terms of net benefits to determine the optimum combinations.

These features were then screened considering the technical, economic, social and environmental impacts for each alternative.

The following technical criteria were adopted for use in developing, evaluating and comparing alternative plans.

- The plan should be effective and efficient as a remedy for reducing flood risk and achieving specified goals and objectives.
- The plan must be technically feasible using engineering and construction methods available in this region.
- The plan should be adequate to provide a 50-year period of analysis.
- The plan is to be complete within itself and not require additional future improvements other than normal replacements and operations and maintenance (O&M).
- The plan is to be designed using engineering criteria taken from the appropriate USACE engineering and design manuals and regulations related to FRM alternatives and criteria also acceptable to HCFCD.
- The plan must comply with the regulatory requirements imposed on Harris County, COH and the cities of Jacinto City and Galena Park by their participation in the NFIP.

The initial investigation identified types of structural and nonstructural flood risk reduction measures which were compatible with the flood situation, expected damages, opportunities for FRM and surrounding topography. Effort was made to identify the FRM measure types which were also socially desirable and implementable in keeping with the study's objectives and constraints. An economic analysis then identified justifiable components which addressed project objectives as discussed in the GRR/EA. These components were evaluated in terms of AAEV net excess benefits to determine the optimum economic performance based on the federal objective. These measures were then screened considering the technical, economic, social and environmental impacts from each component.

The next step was alternative reevaluation, which entailed systematically building alternatives by combining measures. This step included alternative optimization, which tested larger and smaller incremental sizes of components for each alternative in efforts to achieve symbiosis and maximize net economic benefits. These steps were originally accomplished between 1998 and 2001.

The following step was final plan reevaluation, which focused on analysis and further economic optimization for the best performing alternatives with a more comprehensive matrix of component sizes in 2009. The final plan reevaluation phase updated the reevaluation results to

current 2Q2013 (FY13) prices and federal discount rate, and compared the NED Plan and the TSP with the 1990 Authorized Plan.

Any changes within the Hunting Bayou floodplain, including structure inventory, price updates and changes to available vacant land; changes to USACE guidance; and changes to hydraulic and economic software were incorporated as appropriate during the entire planning process.

3.3 Plan Component Reevaluation and Analysis

To identify the best performing plan, a systematic building process was used to develop alternatives from components (measures) modeled in this project phase. The most current hydrology, hydraulics, and economics and more detailed modeling approaches were used. Based on some preliminary hydraulic and economic analyses, the basic configuration was determined for most components to be formulated. As discussed in the following sections, the reevaluation consisted of evaluating components on a stand-alone basis (e.g., detention only, channel modifications only) and economically optimizing them prior to combining the most effective components, and re-optimizing them economically in the subsequent alternative reevaluation phase. Nonstructural measures using buyout and flood proofing were also included in the plan reevaluation and were subjected to the same evaluation criteria as structural measures.

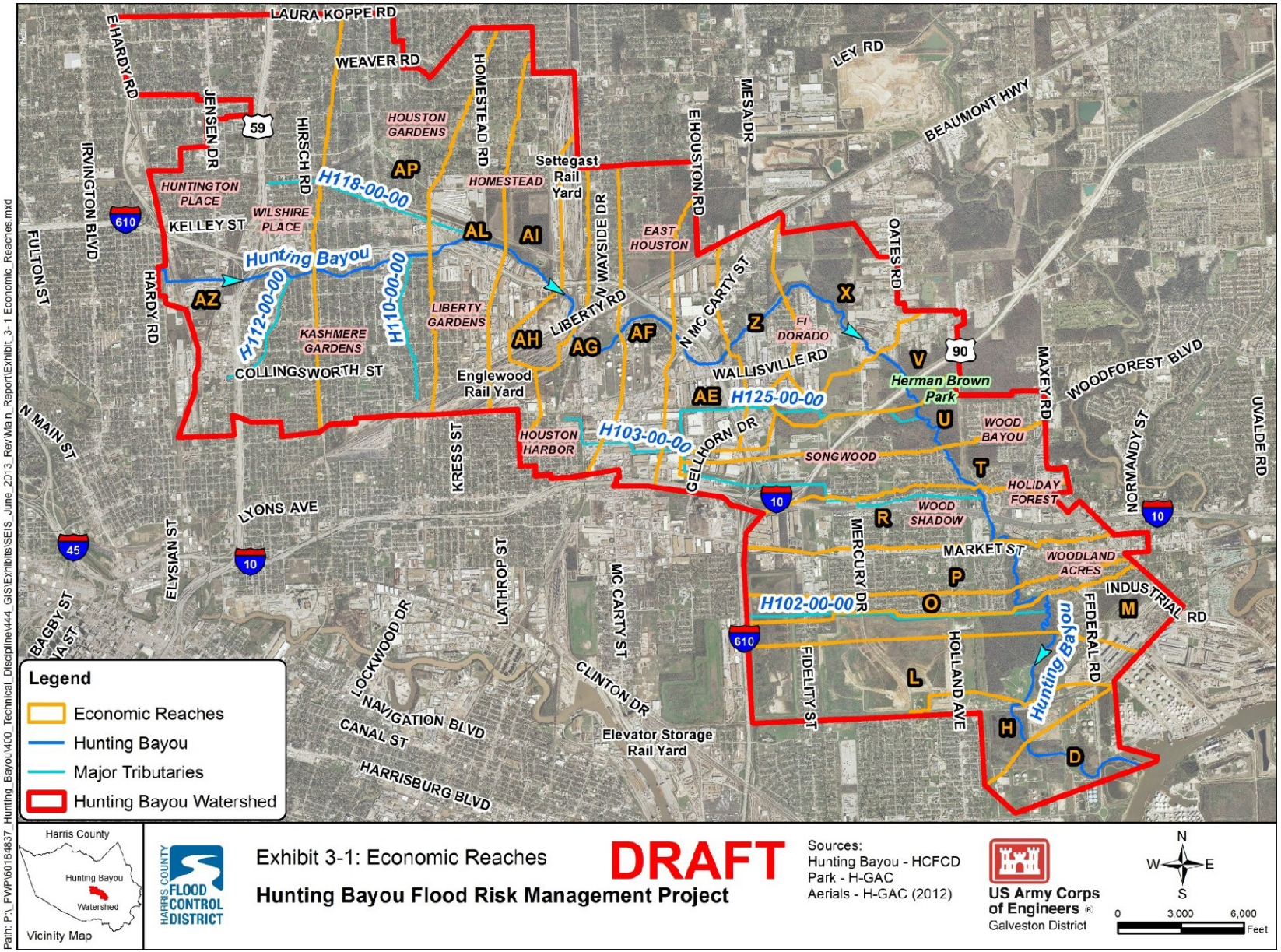
The floodplain was divided into three stream segments to facilitate plan reevaluation, as shown in *Exhibit 1-4*:

- The upper stream segment: from US 59 downstream to ERRY
- The middle stream segment: from downstream end of ERRY to the downstream end of Herman Brown Park
- The lower stream segment: from downstream from Herman Brown Park to the mouth of Hunting Bayou where it confluences with Buffalo Bayou at the Turning Basin of the HSC

These stream segments incorporated economic reaches as noted in *Appendix 5 – Economics Analysis* and are shown in *Exhibit 3-1* as follows.

- Upper stream segment: Economic reaches AH through AZ
- Middle stream segment: Economic reaches U through AG
- Lower stream segment: Economic reaches D through T

Exhibit 3-1:
Economic Reaches



3.4 Period of Analysis

The period of analysis is consistent for all alternatives evaluated and represents the time horizon during which project benefits accrue. For this GRR/EA, the period of analysis for comparing costs and benefits begins in 2022 and extends 50 years into the future to 2072, in accordance with ER 1105-2-100. A base year of 2022 was chosen as the year in which the project is anticipated to be completed and benefits begin to accrue.

3.5 Future Without Project (WOP) Condition

A basic alternative in any FRM analysis is the No Action Alternative. This alternative assumes no action by the federal government to implement the project; however, the No Action Alternative does not imply local government entities would not implement actions of their own during the period of analysis to reduce flood risk. Basic assumptions regarding the most-likely future WOP condition stem from expecting existing policies, procedures and programs to continue over time. These policies, procedures and programs, specifically oriented to managing flood risk, are expected to persist over the period of analysis to reduce flood hazards and to maintain the expectation of no increase in water surface elevations (WSELs) in the WOP condition over the 50-year period of analysis.

3.5.1 Ongoing Local Practices, Policies and Programs that Manage Local Flood Risk

As part of their agency's mission, the non-federal sponsor, HCFCD, has adopted policies and practices stipulating new residential, commercial, industrial or other land development must include measures to assure no adverse impact to the surrounding area's WSELs. These policies and compliance requirements for development within Harris County are described in the HCFCD *Policy, Criteria, and Procedure Manual*, adopted October 2004, and updated in December 2010. Due to these requirements, developers must either retain increased runoff associated with changes in land use onsite or purchase storage volume in regional detention facilities which retain runoff to equal or match pre-development levels. Due to this policy, the most likely future scenario for H&H is assumed by this analysis to equal the current existing condition. Even though the original 2001 reevaluation preceded this 2004 requirement, its effect required an adjustment to the analysis whereby any projection of future water surface elevation changes were removed from economic damage models. The hydraulic modeling for future conditions was also revised to equal the near term condition throughout this analysis. Other considerations for H&H are discussed in *Appendix 2 – Hydrology and Hydraulics*.

3.5.2 Supporting Programs

Policies and Programs which support or reinforce floodplain management activities include the following.

- The non-federal sponsor, HCFCD, participates in and supports FEMA-granted relocations to evacuate or retreat from flood prone areas where structural measures are uneconomical or not practical. The non-federal sponsor, HCFCD, also maintains a voluntary buyout program which emulates FEMA guidelines. The non-federal sponsor, HCFCD, pays relocation assistance as outlined in the Uniform Relocation and Real Property Acquisitions Act of 1970 to FEMA grant recipients and to participants in their program (see *Appendix 1* – Attachment H – HCFCD Property Acquisition Procedures).

- Local communities also participate in flood hazard mitigation through FEMA grants.

- Harris County and the cities of Houston, Galena Park and Jacinto City joined NFIP in the 1970s, and comply with floodplain regulations to elevate new construction at or above the BFE.

- COH policy requires new construction and substantial reconstruction for first-floor elevations within the 1 percent floodplain to be built at a minimum of 12 inches above the BFE.

- Harris County and COH participate in NFIP's community rating system, which is a voluntary program for NFIP participating communities. The community rating system has been developed to provide incentives in the form of insurance premium discounts for communities to go beyond the minimum floodplain management requirements and develop additional measures to provide extra protection from flooding. The premium discount's extent is determined according to a rating system with all communities beginning with a Class 10 rating. A Class 1 rating by the NFIP grants the greatest premium discounts. COH is the largest city in the nation to achieve a Class 5 rating.

- Harris County maintains a real time flood warning system that which covers the entire county by monitoring 133 stream gauges strategically placed along Harris County bayous and their tributaries. The information collected and processed by the flood warning system is used by the HCFCD, by Harris County's Office of Homeland Security and Emergency Management, and by the National Weather Service to help issue flood watches and warnings. Other partnering agencies such as COH, the TxDOT, various river authorities and surrounding municipalities all contribute data for integration into the county-wide flood warning system. Diverse warning outlets communicating the same or similar messages repetitively to the population increases the probability warnings would be noticed and heeded.

3.6 Existing Economic Assets in the Without Project (WOP) Condition, 2001 Inventory, Price Level, Federal Discount Rate

Plan reevaluation and evaluation for this study is presented with the evaluation parameters which were current when the plan was reevaluated to preserve the process integrity. Throughout the period of analysis, benefits and costs were consistently compared at similar prices and discount rates. The final array with alternative plan outputs and costs is presented at 2013 prices and at the 3.50 percent FY 2013 discount rate to demonstrate viability and federal interest.

The structure inventory and the capital investment distribution within the eight existing AEP Hunting Bayou floodplains based on first-floor elevations is presented in *Table 3-1*, and represents the 1998 structure inventory, 2001 price level and 5.625 percent 2004 federal discount rate. Based on these parameters, 89 percent of the total structures in the estimated 0.2 percent annual probability floodplain were estimated to be residential, which accounted for approximately $265 million in property value. Initial measures screening and plan reevaluation activities were based on this expression of the WOP condition for Hunting Bayou over the period of analysis.

Table 3-1:
Distribution of Capital Investment Within AEP Floodplains
Existing WOP Condition (2001)

Damage Category	Exceedance Probability Events							
	Bank to 50% Floodplain (2-Year)	Bank to 20% Floodplain (5-Year)	Bank to 10% Floodplain (10-Year)	Bank to 4% Floodplain (25-Year)	Bank to 2% Floodplain (50-Year)	Bank to 1% Floodplain (100-Year)	Bank to 0.4% Floodplain (250-Year)	Bank to 0.2% Floodplain (500-Year)
Commercial								
Number of Structures	0	124	334	463	639	693	770	823
Distribution	0.0%	15.1%	40.6%	56.3%	77.6%	84.2%	93.6%	100.0%
Structure Value	–	$18,632,221	$57,726,779	$78,587,227	$120,598,800	$132,785,758	$159,992,067	$175,646,436
Content Value	–	$25,894,056	$78,868,244	$108,064,771	$169,918,252	$186,304,648	$224,735,634	$244,872,522
Total Value	–	$44,526,277	$136,595,022	$186,651,999	$290,517,052	$319,090,406	$384,727,701	$420,518,958
Hospital								
Number of Structures	–	–	–	–	–	1	1	1
Distribution	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Structure Value	–	–	–	–	–	$63,092,306	$63,092,306	$63,092,306
Content Value	–	–	–	–	–	$19,634,360	$19,634,360	$19,634,360
Total Value	–	–	–	–	–	$82,726,666	$82,726,666	$82,726,666
Public								
Number of Structures	–	17	40	66	78	78	82	82
Distribution	0.0%	20.7%	48.8%	80.5%	95.1%	95.1%	100.0%	100.0%
Structure Value	–	$4,536,362	$12,469,308	$19,693,707	$22,015,149	$22,015,149	$23,643,564	$23,643,564
Content Value	–	$1,905,272	$5,237,109	$8,271,357	$9,246,363	$9,246,363	$9,930,297	$9,930,297
Total Value	**–**	**$6,441,633**	**$17,706,418**	**$27,965,064**	**$31,261,512**	**$31,261,512**	**$33,573,860**	**$33,573,860**
Residential								
Number of Structures	–	1,342	3,461	4,984	6,702	6,917	7,188	7,442
Distribution	0.0%	18.0%	46.5%	67.0%	90.1%	92.9%	96.6%	100.0%
Structure Value	–	$44,195,714	$111,577,684	$158,532,971	$217,800,573	$227,477,521	$244,333,288	$265,304,864
Content Value	–	$27,244,829	$68,801,822	$97,934,142	$134,281,617	$140,109,640	$150,659,278	$163,142,429
Total Value	**–**	**$71,440,543**	**$180,379,506**	**$256,467,113**	**$352,082,190**	**$367,587,161**	**$394,992,566**	**$428,447,293**
Total Property								
Number of Structures	–	1,483	3,835	5,513	7,419	7,689	8,041	8,348
Distribution	0.0%	17.8%	45.9%	66.0%	88.9%	92.1%	96.3%	100.0%
Structure Value	–	$67,364,297	$181,773,771	$256,813,905	$360,414,522	$445,370,735	$491,061,225	$527,687,169
Content Value	–	$55,044,157	$152,907,175	$214,270,271	$313,446,232	$355,295,010	$404,959,569	$437,579,608
Total Value	**–**	**$122,408,454**	**$334,680,946**	**$471,084,176**	**$673,860,754**	**$800,665,745**	**$896,020,793**	**$965,266,777**

2001 price level; residential content value assumed to be 50 percent of residential structure value.

3.7 Single Occurrence Damages

Damages expected to accrue from the various AEP events for the WOP conditions are displayed in *Table 3-2*. These values represent damages expected for individual events under the WOP hydrologic conditions, and include structure, content and ancillary damage values. Values are based on 2001 price levels.

Table 3-2:
Single Occurrence Damages by AEP Event – WOP Condition (2001)

Damage Category	50% (2-Year)	20% (5-Year)	10% (10-Year)	4% (25-Year)	2% (50-Year)	1% (100-Year)	0.40% (250-Year)	0.20% (500-Year)
Structure								
Commercial	–	$451,498	$2,124,867	$3,609,802	$5,335,242	$7,317,216	$10,182,810	$11,535,649
Hospital	–	–	–	–	–	–	–	–
Public	–	$320,727	$613,036	$1,035,896	$2,064,968	$2,386,577	$2,819,525	$3,132,517
Residential	–	$5,556,453	$19,444,757	$32,174,631	$46,587,077	$61,306,624	$81,429,444	$89,119,353
Contents								
Commercial	–	$856,000	$5,665,082	$10,642,582	$17,739,068	$26,554,641	$40,726,034	$47,315,072
Hospital	–	–	–	–	–	–	–	–
Public	–	$57,000	$307,790	$598,521	$962,421	$1,171,164	$1,742,619	$2,034,949
Residential	–	$2,276,000	$11,517,378	$21,189,156	$33,060,192	$46,126,437	$65,278,200	$73,245,432
Totals								
Commercial	–	$1,307,498	$7,789,949	$14,252,384	$23,074,310	$33,871,857	$50,908,844	$58,850,721
Hospital	–	–	–	–	–	–	–	–
Public	–	$377,727	$920,826	$1,634,417	$3,027,388	$3,557,740	$4,562,144	$5,167,466
Residential	–	$7,832,453	$30,962,135	$53,363,787	$79,647,270	$107,433,061	$146,707,644	$162,364,785
Nonstructural								
Emergency Costs	–	$3,220,548	$7,823,259	$11,253,885	$14,473,406	$14,919,656	$15,458,380	$15,877,316
Roads	–	$153,634	$402,957	$618,438	$807,486	$832,446	$877,738	$910,886
Utilities	–	$315,360	$765,949	$1,101,683	$1,416,882	$1,460,639	$1,513,336	$1,554,340
Vehicles	–	$1,131,028	$5,209,579	$8,680,301	$13,509,339	$17,060,149	$22,038,768	$24,050,784
Total by Event	**$0**	**$14,338,248**	**$53,874,654**	**$90,904,895**	**$135,956,081**	**$179,135,549**	**$242,066,854**	**$268,776,298**
Percent Distribution								
Commercial	–	9.1%	14.5%	15.7%	17.0%	18.9%	21.0%	21.9%
Hospital	–	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Public	–	2.6%	1.7%	1.8%	2.2%	2.0%	1.9%	1.9%
Residential	–	54.6%	57.5%	58.7%	58.6%	60.0%	60.6%	60.4%
Emergency Costs	–	22.5%	14.5%	12.4%	10.6%	8.3%	6.4%	5.9%
Roads	–	1.1%	0.7%	0.7%	0.6%	0.5%	0.4%	0.3%
Utilities	–	2.2%	1.4%	1.2%	1.0%	0.8%	0.6%	0.6%
Vehicles	–	7.9%	9.7%	9.5%	9.9%	9.5%	9.1%	8.9%
Total by Event	**0.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

3.8 Average Annual Equivalent Value (AAEV) Damages

AAEV damages, computed with risk and uncertainty over the 50-year period of analysis, are presented for the WOP conditions in *Table 3-3*. Approximately 78 percent of the AAEV damages are concentrated in the four most upstream reaches: AZ, AP, AL and AI, which extend from the second IH 610 crossing to the upstream watershed boundary. Other areas with concentrated damages include reaches AE and AF, which extend from the Texaco Tank Farm to Manitou Road and account for 10 percent of all damages; and reaches R through U, which extend from Market Street to Herman Brown Park and account for 9 percent of the WOP conditions total. *Exhibit 3-2* identifies the locations for the referenced stream segments or economic reaches.

Table 3-3:
Distribution of AAEV Damages by Reach, WOP Condition, 2001

Damage Reach	Downstream Section	Upstream Section	Damage Categories (Damage in $1,000s)									
			Commercial	Post-Disaster	Hospital*	Public	Residential	Roads	Utilities	Vehicles	Total	% of Total
D	2140	6110	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.0%**
H	6111	9930	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.0%**
L	9931	13551	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.02	**0.0%**
M	13552	17139	0.07	2.15	0.00	0.01	12.08	0.12	0.21	1.37	16.01	**0.1%**
O	17140	18385	0.00	0.12	0.00	0.00	0.46	0.01	0.01	0.05	0.65	**0.0%**
P	18386	22389	0.01	0.04	0.00	0.00	0.07	0.00	0.00	0.01	0.13	**0.0%**
R-Right	22390	25706	60.93	1.33	0.00	0.00	15.60	0.17	0.13	0.69	78.85	**0.4%**
R-Left	22390	25706	59.15	14.05	0.00	0.06	253.49	0.54	1.38	11.98	340.65	**1.5%**
T-Right	25707	28512	0.30	9.85	0.00	0.00	161.81	0.59	0.96	48.79	222.30	**1.0%**
T-Left	25707	28512	0.22	56.81	0.00	3.06	1,125.91	3.11	5.56	5.78	1,200.45	**5.4%**
U-Right	28513	32049	0.00	0.72	0.00	0.00	4.11	0.03	0.07	6.79	11.72	**0.1%**
U-Left	28513	32049	0.01	11.39	0.00	0.00	121.72	0.49	1.11	0.27	134.99	**0.6%**
V	32050	37029	0.17	0.01	0.00	0.00	0.03	0.01	0.00	0.00	0.22	**0.0%**
X	37030	41700	99.39	5.49	0.00	0.00	79.37	1.25	0.54	4.19	190.23	**0.8%**
Z	41701	46183	127.88	22.99	0.00	0.46	102.95	1.56	2.25	12.61	270.70	**1.2%**
AE	46184	49831	1,330.83	2.69	0.00	0.85	28.31	5.23	0.26	2.24	1,370.41	**6.1%**
AF	49832	53772	733.59	19.44	0.00	2.67	149.71	2.79	1.90	16.74	926.84	**4.1%**
AG	53773	56554	55.64	37.67	0.00	0.72	105.94	2.41	3.69	18.14	224.21	**1.0%**
AH	56555	59445	39.07	1.45	0.00	0.00	3.97	0.58	0.14	0.76	45.97	**0.2%**
AI	59446	62067	570.77	51.15	0.00	16.29	340.61	6.13	5.01	39.19	1,029.15	**4.6%**
AL	62068	66172	488.57	97.96	0.00	9.29	562.27	6.78	9.58	73.89	1,248.34	**5.6%**
AP	66173	72006	844.05	1,198.38	40.06	329.18	6,911.80	47.64	117.37	1,139.71	10,628.19	**47.4%**
AZ	72007	76752	631.94	675.75	0.00	70.94	2,479.62	38.78	66.13	516.61	4,479.77	**20.0%**
Total			**5,042.59**	**2,209.45**	**40.06**	**433.53**	**12,459.84**	**118.22**	**216.30**	**1,899.81**	**22,419.80**	**100.0%**
% of Total			**22.5%**	**9.9%**	**0.2%**	**1.9%**	**55.6%**	**0.5%**	**1.0%**	**8.5%**	**100.0%**	

2001 price levels and 5.625 percent discount rate

**While the LBJ Hospital is not shown to be in the floodplain in Table 3-2, damages are shown for the hospital because of the uncertainty bands generated by the stochastic method of determining damages. Without uncertainty included in the average annual damage calculation, the AAEV damage to LBJ Hospital would be zero. Uncertainty is applied to the LBJ Hospital structure value of $63 million, which was determined by direct appraisal.*

Table 3-3 also shows 56 percent of the AAEV damages are attributed to the residential damage category and 23 percent to the commercial category, followed by post-disaster costs at 10 percent and vehicles at 9 percent, with the remaining categories accounting for about 4 percent combined. The total AAEV damages for the WOP conditions in Hunting Bayou are estimated at $22.4 million at 2001 prices and at the 2001 5.625 federal discount rate. See *Exhibit 3-3*, which identifies the AAEV damage areas.

Exhibit 3-2:
Existing Conditions AEP Floodplains

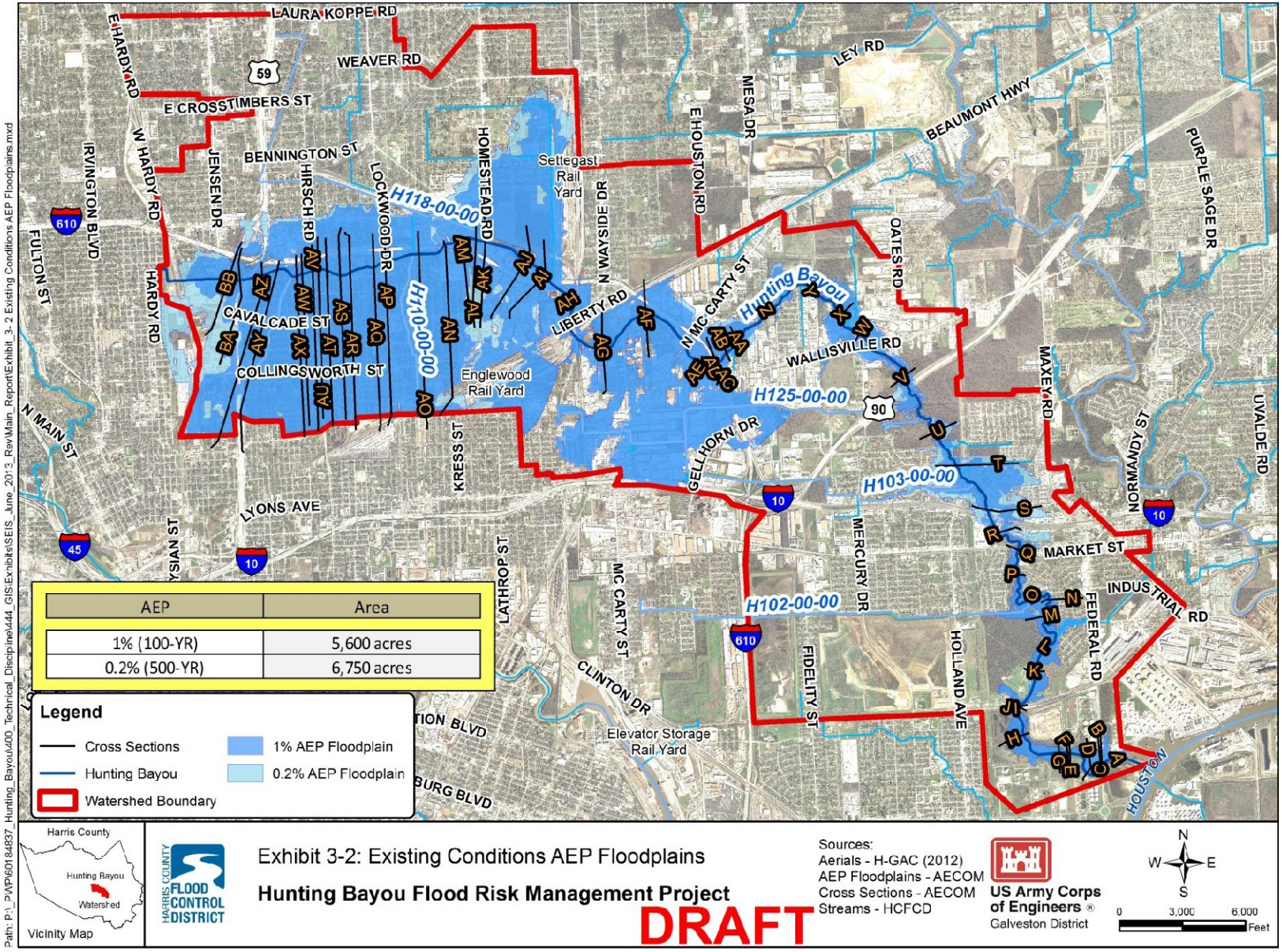
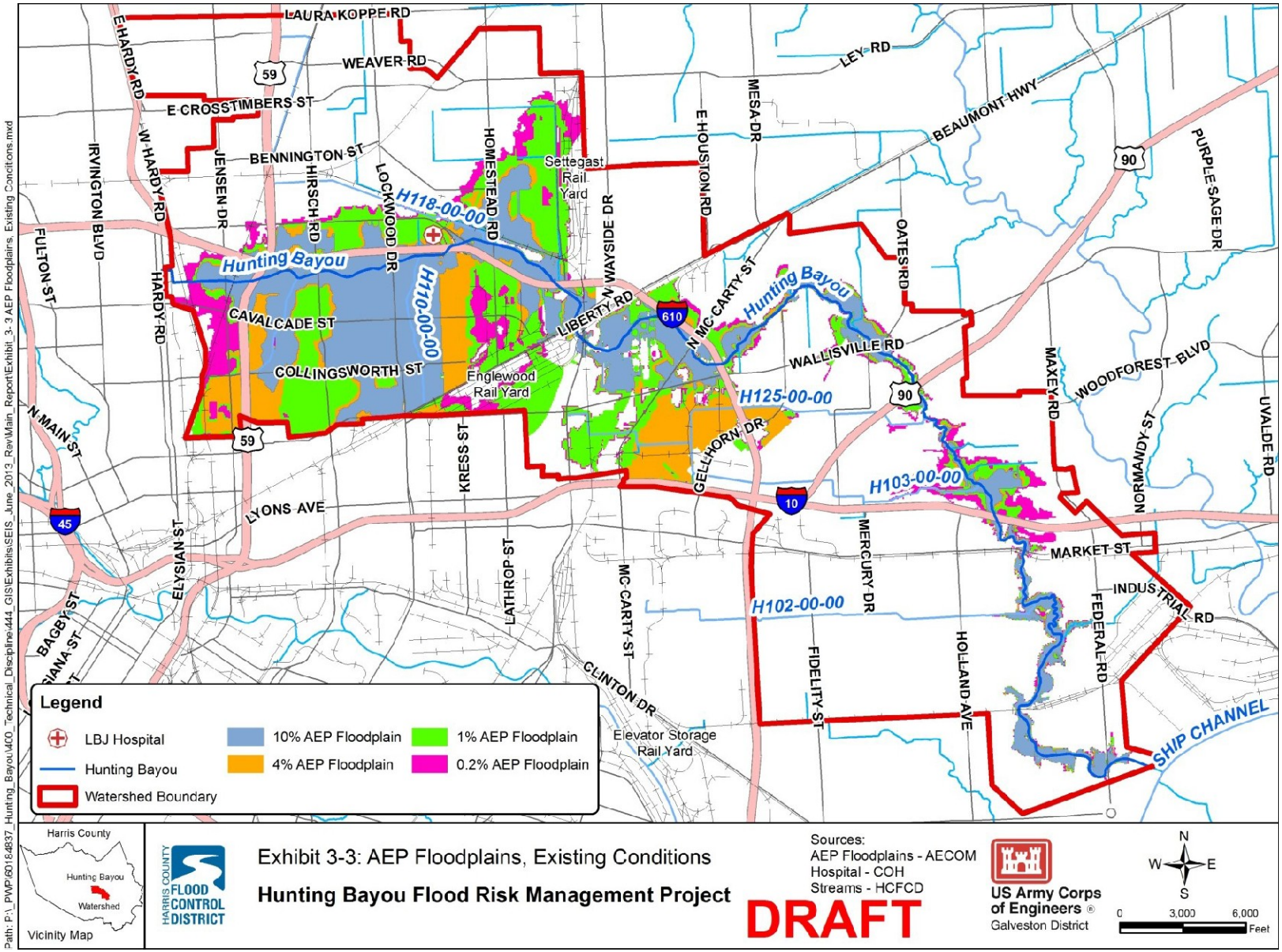


Exhibit 3-3:
AEP Floodplains, Existing Conditions



3.9 Flood Damages and Plan Reevaluation

The HCFCD has determined less environmentally intrusive options to the 1990 Authorized Plan are available, which can selectively address critical flooding areas; thus, the HCFCD supports the 1990 Authorized Plan for Hunting Bayou with specific design changes as evaluated in the report in light of current conditions which have occurred since the original authorization.

Since three-quarters of the WOP condition damages were located in four economic reaches AI through AZ of Hunting Bayou's upper stream segment, the measures' evaluation and optimization process should begin in the floodplain's upper stream segment and then proceed toward the mouth of Hunting Bayou. Opportunities for reevaluating and discovering a highly efficient FRM remedy were more likely in the upper stream segment. For all measures and combined measures evaluation, the Hydrologic Engineering Center Flood Damage Analysis (HEC-FDA) model was used to compute AAEVs for flood damages reduced. Cost estimates developed for each evaluation exercise were also subsequently annualized to compute AAEV annual net excess benefits and benefit/cost ratios (BCRs) at consistent price levels.

3.9.1 Reevaluation and Evaluation for Upper Stream Segment Components

Within the upper stream segment, the following management measures were initially formulated and evaluated based on their compatibility to reduce flood risk and for opportunities within the floodplain for engineering performance.

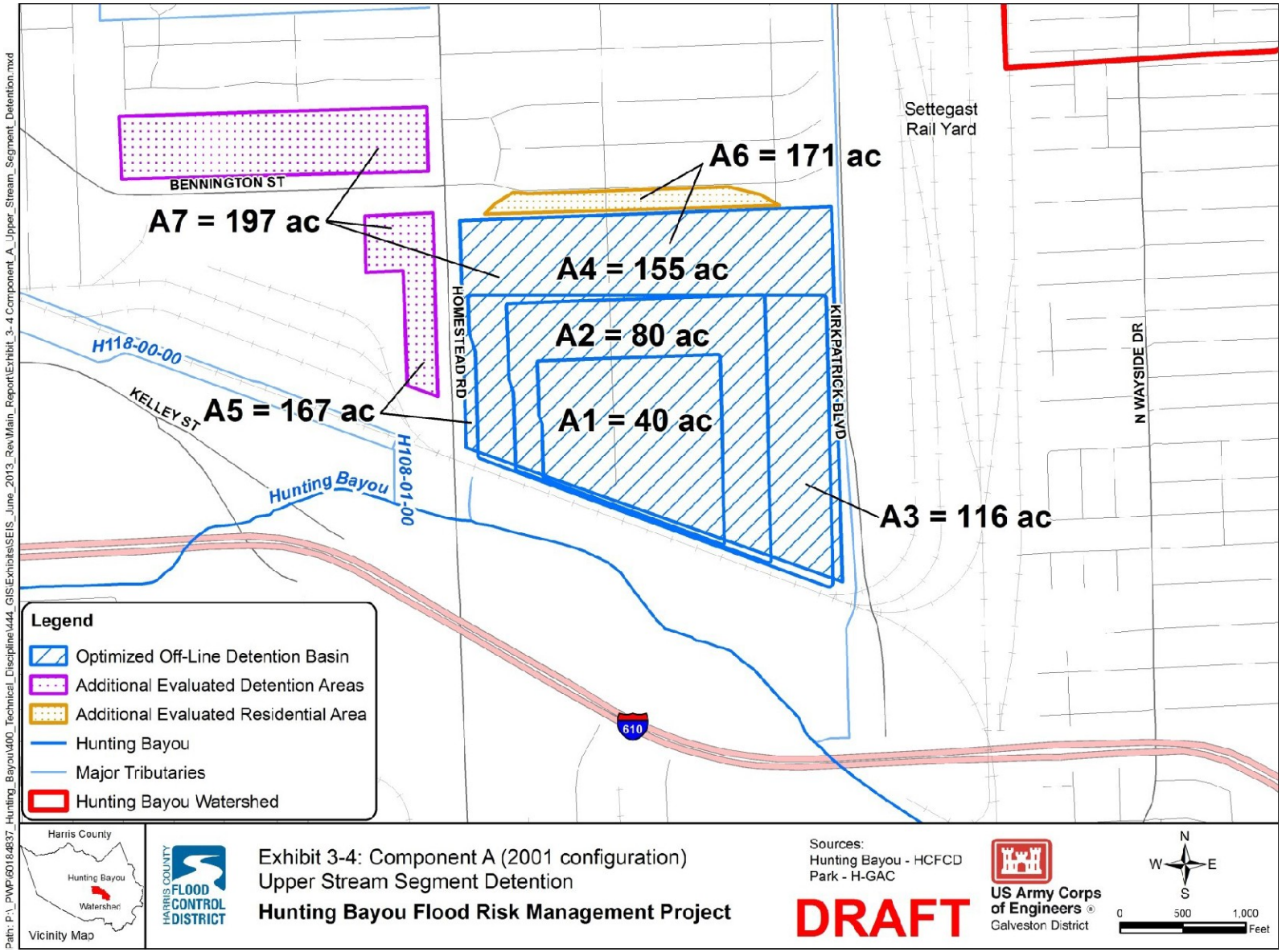
- Detention (Component A)
- Channel modifications with and without replacing highway and/or railroad bridges (Component B)
- Buyouts followed with recreational features (Component C)
- Flood proofing (Component D)
- Buyouts followed with detention along tributary H110-00-00 (Component X)

The top economically performing scales for each component in terms of AAEV net excess benefits are shown in the tables that follow.

3.9.1.1 Component A – Upper Stream Segment Detention

Component A consisted of offline detention storage located upstream from the second IH 610 crossing in Reach AI. This component reduced flood discharges downstream from the basin, which in turn provided FRM benefits to Hunting Bayou's middle stream segment. The reduction in discharges also lowered the tailwater elevations at the basin, which resulted in minor flood reduction upstream from the basin. *Exhibit 3-4* displays Component A.

Exhibit 3-4:
Component A (2001 Configuration) Upper Stream Segment Detention



Seven detention basin sizes shown in *Table 3-4* were evaluated for Component A, and the optimal size was determined based on net economic benefits. Components A1 through A7 were all offline basins located proximate to Homestead Road. Component A1 used 26 percent, Component A2 used 52 percent, and Component A3 used 75 percent of the undeveloped railroad tract located between Homestead Road and the second IH 610 crossing, while Component A4 used the entire tract. Component A5 used the entire tract in addition to 12 acres located on an undeveloped tract to the west. Component A6 also used the entire tract, but extended to the north into the Homestead subdivision. Component A7 consisted of the basins used in Component A5 in addition to 30 acres located on a second undeveloped tract to the west.

The economic performance for Component A sizing is presented in *Table 3-5*. Component A3, which uses the entire tract area, provided the maximum $4.612 million annual net benefit and had a 2.50 BCR. In no case are WSELs increased by Components A1 to A7 along Hunting Bayou.

3.9.1.2 Component X – Combined Detention Storage and Nonstructural Buyout

Component X consisted of a combination of nonstructural and structural measures. Since many structures identified for buyout in the upper reach (Component C) were located on contiguous parcels along Tributary H110-00-00, it was determined detention storage located in this area should be investigated. *Exhibit 3-5* displays Component X.

Table 3-4:
Upper Stream Segment Detention Characteristics Comparison

Component ID	Basin Surface Area (acre)	Detention Volume (acre-feet)	Lots Impacted	Living Units Impacted
Homestead Site				
A1	40	560	1	0
A2	80	1,130	1	0
A3	116	1,780	1	0
A4	155	2,380	1	0
A5	167	2,540	2	0
A6	171	2,620	66	65
A7	197	2,930	3	0
H110 Detention Site				
X1	39	312	99	169
X2	69	547	168	329
X3	100	767	261	516
X4	128	966	359	682
X5	159	1,220	446	837
X6	218	1,660	594	1,040

Table 3-5:
Economic Performance of Components A and X

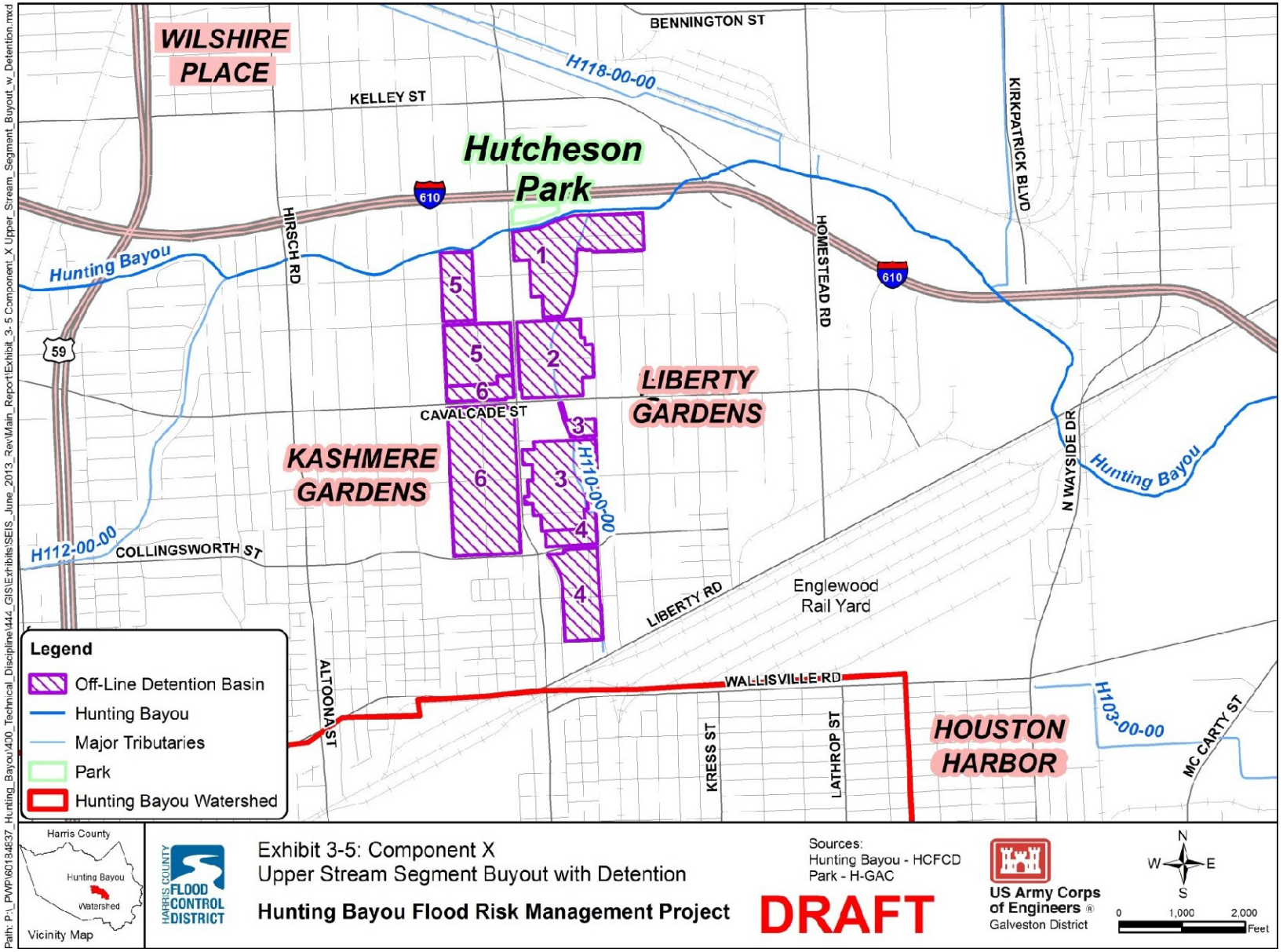
Component	AAEV Project Cost	AAEV Damage Reduction Benefits	AAEV Net Excess Benefits	BCR
A1	$1.260	$2.603	$1.343	2.07
A2	$2.297	$5.376	$3.079	2.34
A3	**$3.075**	**$7.687**	**$4.612**	**2.50**
A4	$4.339	$8.898	$4.559	2.05
A5	$4.700	$9.030	$4.330	1.92
A6	$5.067	$9.097	$4.030	1.80
A7	$5.626	$9.403	$3.777	1.67
X1	$0.893	$4.142	$3.249	4.64
X2	$1.578	$7.158	$5.580	4.54
X3	$2.463	$9.044	$6.581	3.67
X4	$3.118	$10.962	$7.844	3.52
X5	**$3.839**	**$12.205**	**$8.366**	**3.18**
X6	$6.178	$13.602	$7.424	2.20

Based on 2001 price levels and 5.625 percent discount rate.
All dollar values in millions.

Six interconnected offline detention basins were placed along Tributary H110-00-00. Their sizes are shown in *Table 3-4*. These basins are separated by the crossings at Rand Street, Cavalcade Street and Marcus Street. Of the 874 parcels identified for buyout in the upper reach, 365 were located within the limits of the six detention basins. In addition, many residential structures not identified in the buyout as well as commercial structures would require acquisition due to their location within the proposed basin limits.

The economic performance for Component X is presented in *Table 3-5*. It can be seen Component X5, which uses 159 acres and impacts 837 residential units, provided the maximum $8.366 million annual net benefit and has a 3.18 BCR. In no case were WSELs increased by Components X1 through X6 along Hunting Bayou. Although carried forward in the analysis due to its FRM contribution and the net excess benefits it produced, Component X violated a principal study constraint by requiring a very high population displacement level to achieve its optimal performance.

Exhibit 3-5:
Component X Upper Stream Segment Buyout with Detention



3.9.1.3 Component X-A – Combinations of Component X and Component A

Combinations for the X- and A-components were evaluated to determine if the two detention measures could produce higher annual net benefits when combined and functioned in unison. Various configurations for Component X-A were tested for economic performance.

To test a comprehensive array of detention combinations, the detention layout from each site was held constant while the other site was varied until an optimum combination was determined. To illustrate this approach and the interrelationship, results are arranged as a matrix shown on the next page in *Table 3-6*. The engineering analysis indicated these sites do not perform independently. Their performances are hydraulically linked, and the performance for each influences the other in a symbiotic effect. The 40-acre Homestead site basin (A1) and the 159-acre H110 Detention Site basin (X5) combination produced $8.3 million annual net benefits and was identified as the best performing detention combination for components A and X. Component X-A as presented in *Table 3-7* (see next page) and uses 199 total acres and impacts 837 residential units. In no case were WSELs increased by Components X-A along Hunting Bayou.

3.9.1.4 Component B – Upper Stream Segment Earthen Trapezoidal Channel Modifications (US 59 to Englewood Railroad Yard [ERRY])

The next measure optimized in Hunting Bayou's upstream segment was the Component B channel modification which included widening and bridge replacement. Component B was initially developed to determine the net benefits attributable to channel modifications as a stand-alone component. Channel modifications were chosen for optimization to determine the optimum channel size, length and configuration. A bypass channel component was also incorporated into the optimization process as a variation of channel modification. *Exhibit 3-6* displays Component B.

The channel modification component consisted of channel enlargement through the upper segment and continued through ERRY to reduce damages in the upstream residential area. The channel enlargement was then extended downstream to Herman Brown Park. Each channel modification component included 30-acres of inline detention and the cost to replace all the bridges along the project length, except where indicated, during the bridge replacement analysis. Effects from replacing bridge crossings were evaluated independently from the channel modification effects.

Optimization for channel length, cross-section size and geometry and bridge replacements are presented in *Appendix 5 – Economics Analysis.*

Table 3-6:
Annual Net Benefits of Detention Components A and X in Combination* ($millions)

			H110 Detention Site					
			X1	X2	X3	X4	X5	X6
		Basin Size	39 ac	69 ac	100 ac	128 ac	159 ac	218 ac
Homestead Road Site	A1	40 ac	$6.7	$6.7	$7.7	$7.9	**$8.3**	$7.2
	A2	80 ac	$5.3	$6.7	$7.6	$7.7	$7.8	$6.1
	A3	116 ac	$6.1	$6.9	$7.7	$7.4	$7.2	$5.4
	A4	155 ac	$5.8	$6.6	$7.0	$6.7	$6.4	$4.7

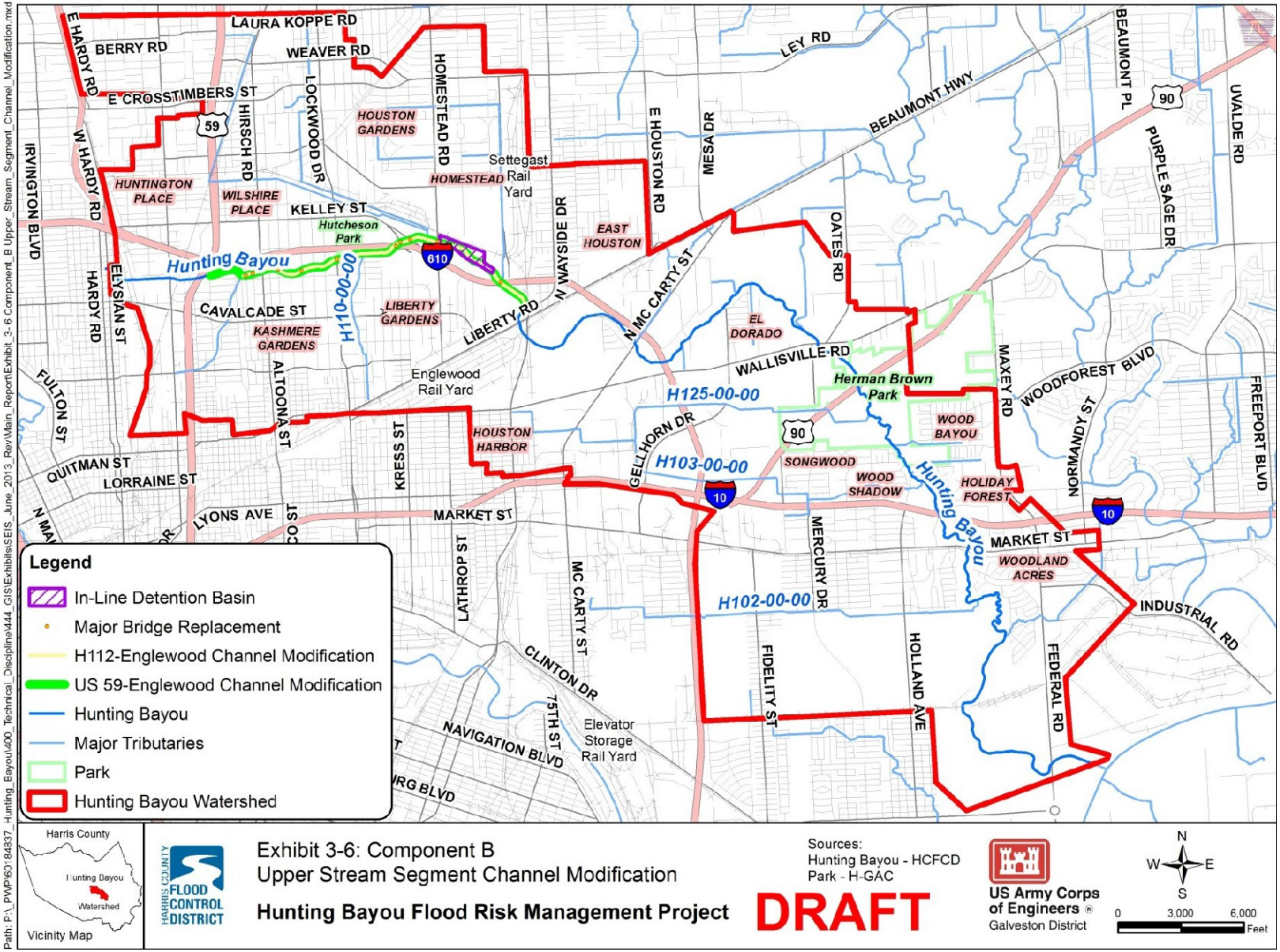
** Rounding is for presentation of results only and was performed after calculations.*
Based on 2001 price levels and 5.625 percent discount rate.

Table 3-7:
Economic Performance of Component X-A

Component	AAEV Project Cost	AAEV Damage Reduction Benefits	AAEV Net Excess Benefits	BCR
X1-A1	$2.178	$6.373	$4.195	2.93
X1-A2	$3.216	$8.553	$5.337	2.66
X1-A3	$3.994	$10.052	$6.058	2.52
X1-A4	$4.996	$10.828	$5.832	2.17
X2-A1	$3.216	$9.912	$6.696	3.08
X2-A2	$3.920	$10.639	$6.719	2.71
X2-A3	$4.830	$11.773	$6.943	2.44
X2-A4	$5.720	$12.286	$6.566	2.15
X3-A1	$3.722	$11.379	$7.657	3.06
X3-A2	$4.760	$12.396	$7.636	2.60
X3-A3	$5.691	$13.368	$7.677	2.35
X3-A4	$6.581	$13.545	$6.964	2.06
X4-A1	$4.498	$12.388	$7.890	2.75
X4-A2	$5.722	$13.415	$7.693	2.34
X4-A3	$6.544	$13.966	$7.422	2.13
X4-A4	$7.672	$14.367	$6.695	1.87
X5-A1	**$5.349**	**$13.652**	**$8.303**	**2.55**
X5-A2	$6.596	$14.382	$7.786	2.18
X5-A3	$7.630	$14.862	$7.232	1.95
X5-A4	$8.572	$15.005	$6.433	1.75
X6-A1	$7.718	$14.879	$7.161	1.93
X6-A2	$9.098	$15.220	$6.122	1.67
X6-A3	$9.969	$15.361	$5.392	1.54
X6-A4	$10.939	$15.630	$4.691	1.43

Note: All dollar values in millions.
Based on 2001 price levels and 5.625 percent discount rate.

Exhibit 3-6:
Component B Upper Stream Segment Channel Modification



3.9.1.4.1 Channel Length

Three channel lengths were analyzed for their flood damage reduction benefits. The lengths were chosen based on their proximity to the highly concentrated damage areas in the watershed's upper segment. The analysis results indicated Component B60 from US 59 to ERRY had the greatest AAEV net excess benefits.

3.9.1.4.2 Channel Cross-Section Size

An analysis similar to that performed for channel length was conducted to determine the optimum channel cross section. The channel lining and geometry were held constant using a grass-lined, 3:1 side slope trapezoidal geometry. This geometry is considered the most efficient and maximizes project benefits by minimizing channel construction costs. Bottom widths were allowed to vary from 40 feet (B40) to 140 feet (B140). The analysis indicated a peak in net excess benefits between 60 feet (B60) and at 100 feet (B100) with net excess benefits falling within a relative range of 2 percentage points among the top performing channel cross-section sizes.

At this point in the analysis, evaluation of even larger channel cross-section sizes was stopped and the smaller channel cross section size, B60, was identified as the preferred cross-section size. The rationale for this decision was based on the economic efficiency in producing virtually the same net excess benefit outputs for the lowest investment. Also the smaller channel width size addressed the study objective to minimize population displacements necessary to achieve FRM benefits.

3.9.1.4.3 Channel Geometry

Two channel configurations with the same flow capacity as B60 (the best performing earthen channel) were evaluated. The two configurations were a concrete-lined section from Homestead to US 59 and a channel with a terrace on one side of a 7 to 9-foot deep pilot channel. These channel components provided favorable net benefits, but performed less successfully than most grass-lined channel sizes.

3.9.1.4.4 Bridge Replacement

During Component B's analysis, evaluated the effects of the 22 bridges crossing Hunting Bayou from US 59 through ERRY to determine if channel modifications could be avoided in lieu of bridge modifications. Evaluated bridges were selected based on the degree of hydraulic impacts created. To isolate the bridges' impacts, four Upper Reach bridge replacement options were evaluated.

1. Bridge Option 1 – Replace IH 610 bridge (second crossing) only.
2. Bridge Option 2 – Replace most upstream railroad bridge only.
3. Bridge Option 3 – Replace IH 610 bridge (second crossing) and most upstream railroad bridge.
4. Bridge Option 4 – Replace all Upper Reach bridges.

Component B was optimized on bottom-width, channel modification length and number of modified bridges needed to produce the most economically efficient (maximized net excess benefits produced) composition. The best performing option was Bridge Option 4 with a $6.4 million reduction in annual damages. The estimated cost for Bridge Option 4 was

$44.3 million, while B-60, including the bridge option, was estimated to cost $91.4 million. Therefore, the bridge modification costs contributed 48 percent to the total channel modification costs. These results indicated the channel modifications were the predominant action for flood damage reduction, but bridge modifications are a necessary addition to channel modification performance.

The low chord elevation requirement above the base flood elevation is based on local construction rules set forth in COH code of ordinances, Chapter 19, Section 19-43 (c) (2) which states:

> The bottom of the lowest horizontal structural member of the bridge, excluding the pilings or columns, will be elevated at least 18 inches above the base flood level. If the city engineer determines that construction to this elevation is not practical based upon the application of sound engineering principles to the proposed construction, the elevation geometry, the attendant roadway geometry, and the necessity for the bridge to be built or reconstructed in the proposed location, the city engineer may approve deviation from this standard.

Consequently, all bridge modifications would be elevated to the BFE plus 18 inches to conform to COH ordinance.

3.9.1.5 Component B60 Optimized

Component B60 consisted of approximately 20,100 feet (3.8 miles) of earthen trapezoidal channel modifications, from just downstream from US 59 to approximately 1,500 feet downstream from the ERRY and bridge replacements. At this point in the optimization, in-line detention storage was utilized between Homestead Road and the second crossing of IH 610. As shown in *Table 3-8*, Component B60 had the highest annual net benefits. However, Component B60 caused a slight increase in WSELs downstream from the project limits, resulting in approximately $0.1 million in increased annual damages below the project limits. This component was carried forward for further evaluation even though it violated the study objective of "no adverse impact" because it had the potential for being paired with other components that could mitigate for the induced damages and because it addressed the federal objective of maximizing net excess benefits.

Table 3-8:
Economic Performance of Component B with In-line Detention Storage

Component	Description	AAEV Project Cost	AAEV Damage Reduction	AAEV Net Excess Benefit	B/C Ratio
B40	Upper Reach Trapezoidal 40-Ft BW Earthen Channel Modification – US 59 to Englewood Railroad Yard	$5.21	$14.80	$9.59	2.84
B60	Upper Reach Trapezoidal 60-Ft BW Earthen Channel Modification – US 59 to Englewood Railroad Yard	$5.50	$15.49	$9.99	2.82
B70	Upper Reach Trapezoidal 70-Ft BW Earthen Channel Modification – US 59 to Englewood Railroad Yard	$5.75	$15.59	$9.84	2.71
B60-2	Upper Reach 60-Ft BW Trapezoidal Earthen Channel Modification – Englewood Railroad Yard to H112-00-00	$5.56	$15.00	$9.44	2.7
B60-3	Upper Reach Trapezoidal 60-Ft BW Earthen Channel Modification – Wallisville Road to US 59	$8.27	$16.61	$8.34	2.01
B60-4	Upper Reach Trapezoidal 60-Ft BW Earthen Channel Modification – Englewood Railroad Yard to US 59 (with Railroad Bypass)	$6.87	$15.83	$8.96	2.31

Based on 2001 price levels and 5.625 percent discount rate.
All dollar values in millions.

Although Component B60 yielded positive net excess benefits as shown in *Table 3-8*, it also resulted in $0.1 million in increased annual damages downstream from the project terminus due to increased conveyance capacity. Channel modifications alone would not achieve the planning objective of alleviating the flooding problem since some flood risk would be shifted downstream. Based on opinions expressed at public meetings; however, Component B60 was carried forward as a potential component of any NED plan because it minimized population displacements.

3.9.1.6 Component C – Upper Stream Segment Buyout

Component C was a nonstructural component that consisted buying out residential and commercial properties in the upper portion of the watershed (damage reaches AH, AI, AL, AP and AZ). The nonstructural analysis was performed using the WOP condition HEC-FDA results. *Exhibit 3-7* displays Component C.

HEC-FDA output includes damage results at each individual structure in the watershed database for all eight storm frequencies. Damages were integrated over these frequencies to determine the AAEV damage for each structure. Since the structure selected for the buyout would be removed from the floodplain, the AAEV damage was then considered to be the AAEV benefit. Therefore, in cases where the annual damages exceeded an annualized value of the structure, the structure was considered to be a potential part of a nonstructural plan.

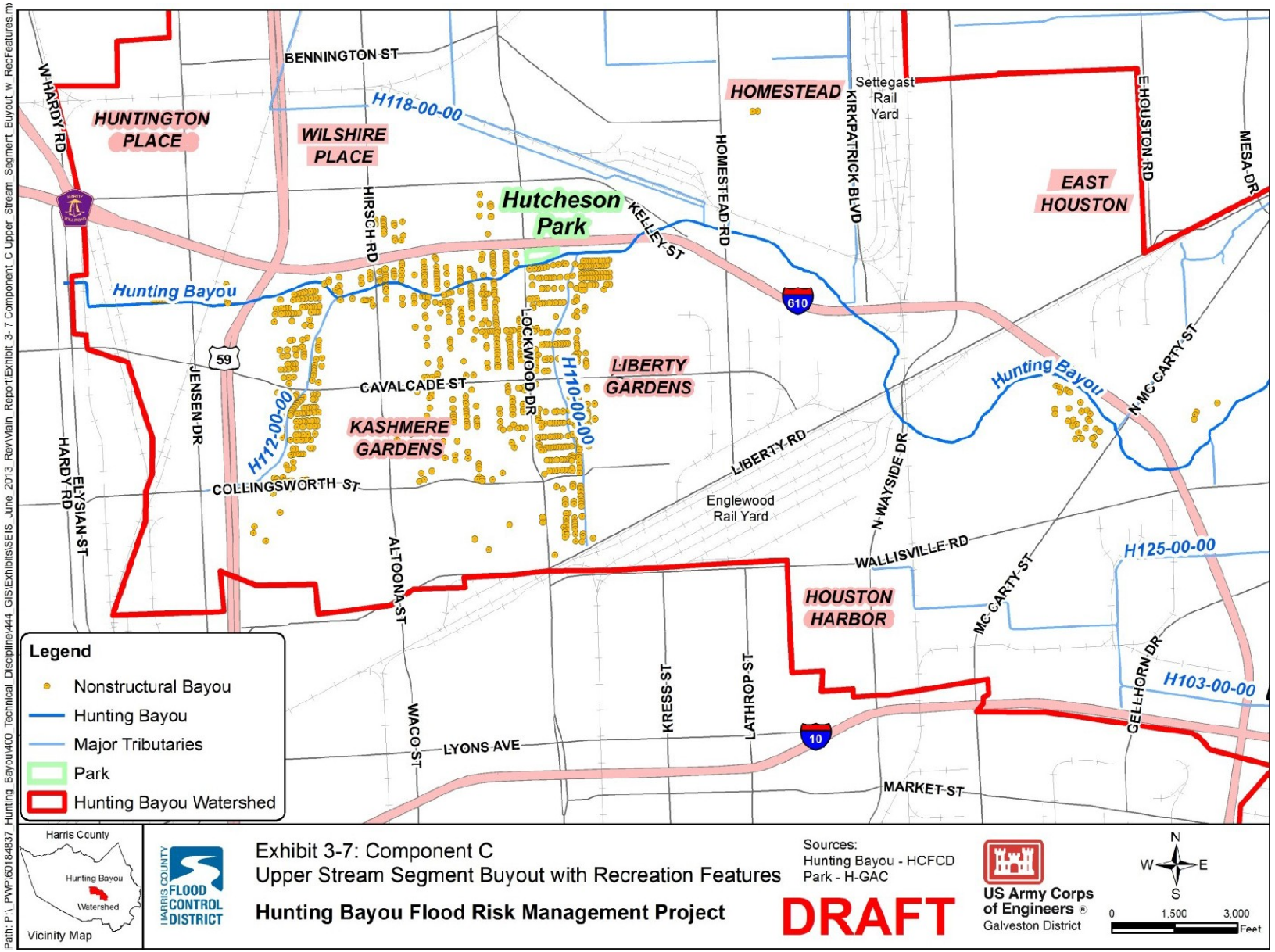
All of the structures having positive net benefits were selected for the buyout. A total of 842 residential structures and 32 commercial structures were identified to have a positive net benefit, which equates to an approximate 25 percent (4-year) floodplain buyout. Two of these structures were located in damage reach AL with the remainder being located in reaches AP and AZ. Component C has an annual $3.762 million net benefit and a 2.06 BCR.

3.9.1.6.1 Recreation Benefit Analysis

WRDA 1990 Section 101(a)(21) authorized flood control and recreation features for Hunting Bayou. While that authorization is still in effect, the non-federal sponsor, HCFCD, declines to exercise recreation authority at this time to focus efforts on FRM. During plan reevaluation in 2001, a recreational plan was developed and evaluated in conjunction with reusing vacated land associated with buyout Component C in the upper stream segment. Recreational features supported general urban park activities and included picnic tables, hike/bike trails and other amenities within the channel ROW. The potential for recreation benefits from reusing the land to be vacated by the buyout was investigated to make the buyout plan more socially acceptable and economically competitive.

The recreation analysis associated with Component C. The planning efforts resulted in the proposed facilities shown in *Appendix 5* - Exhibit 1 of Attachment A5-10, Memo for Independent Technical Review, 2 Jun 2005 (available for review upon request). These facilities would have provided approximately 167,820 annual user days for a variety of urban park activities. The corresponding General Recreation Value was $4.23, giving the proposed facilities an estimated $709,874 FY 2001 annual recreational value. The net benefit was calculated to be $414,302 annually (FY 2001) with a 2.4 BCR. The net recreation benefits when combined with the flood damage reduction benefits resulted in a total $4.31 million estimated AAEV net excess benefits (FY 2001) for Component C. Thus, this component had a significantly lower net benefit than other top performing components.

Exhibit 3-7:
Component C Upper Stream Segment Buyout with Recreation Features



While the non-federal sponsor, HCFCD, is not pursuing recreational opportunities at this time, another organization, the Houston Parks Board, is pursuing grants not affiliated with this project with which to construct trails along the Hunting Bayou ROW. The Houston Parks and Recreation Department, in partnership with the Houston Parks Board's Bayou Greenways master plan, has received funding for one mile of new trail construction along Hunting Bayou. The project will connect with 1.5 miles of existing trails and provide a continuous path between Mickey Leland Park and Hutcheson Park.

3.9.1.7 Component D – Upper Stream Segment Flood Proofing

Component D was a nonstructural component that consisted of flood proofing structures by raising-in-place in the upper portion of the watershed (damage reaches AH, AI, AL, AP and AZ). The nonstructural analysis was performed using the WOP condition HEC-FDA model results.

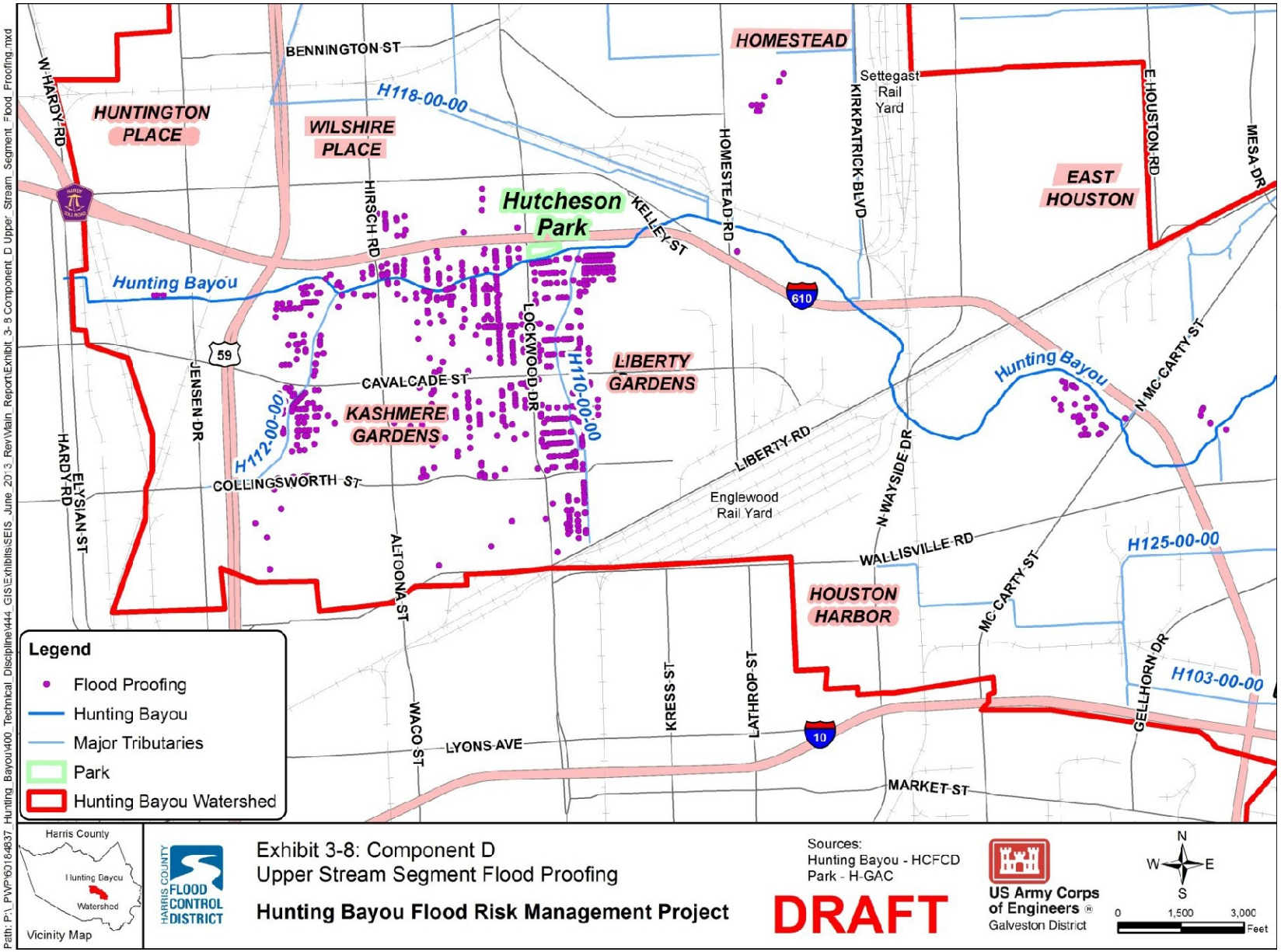
The process used to identify structures to be flood proofed was similar to that used for the buyout. Damages from HEC-FDA output were integrated over the eight storm frequencies to determine AAEV damage for each structure. It was assumed that the structure would be raised above the 0.2 percent flood levels such that no further damages to the structure would occur after it was flood proofed and to provide the maximum benefit to the elevation activity.

Therefore, the AAEV damage reduced was then considered to be the AAEV benefit once the structure was flood proofed. In cases where the AAEV damages reduced exceeded an annualized cost for flood proofing the structure, the structure was considered to be a potential part of a nonstructural flood proofing plan.

All structures having positive AAEV net excess benefits were selected for flood proofing. This methodology was developed and employed throughout the study because it ensures the optimum floodplain is determined and net excess benefits are maximized. *Appendix 5 – Economics Analysis* describes the flood proofing analysis.

A total of 896 structures (870 residential, 24 commercial, and 2 public) were identified to have a positive AAEV net excess benefits, which equates to an approximate 25 percent (4-year) floodplain. Two of these structures are located in damage reach AI, six in reach AL, with the remainder in reaches AP and AZ. Component D has an annual net $2.452 million benefit and a 2.05 BCR. *Exhibit 3-8* displays Component D.

Exhibit 3-8:
Component D Upper Stream Segment Flood Proofing



3.9.1.8 Results of Upper Stream Segment Component Evaluation

Four types of components were evaluated in the upper reaches of Hunting Bayou: detention (A, X and X-A combinations), channel modifications (B), buyout (C), and flood proofing (D). As shown in *Table 3-9,* channel modification (with attendant bridge replacements) proved to be the best performing upper stream segment component and was optimized at the B60 scale. Components A through D and X all exhibited a positive net benefit, indicating they were potential add-ons to Component B60 in the process of developing FRM alternatives.

Table 3-9:
Economic Performance of Optimized Components A, X, X-A, B, C, and D

Component	AAEV Project Cost	AAEV Damage Reduction	AAEV Net Excess Benefit	BCR
A3	$3.075	$7.687	$4.612	2.50
X5	$3.839	$12.205	$8.366	3.18
X5-A1	$5.349	$13.652	$8.303	2.55
B60	**$5.501**	**$15.489**	**$9.988**	**2.82**
C*	$3.551	$7.313	$3.762	2.06
D	$2.337	$4.789	$2.452	2.05

Based on 2001 price levels and 5.625 percent discount rate.
All dollar values are in millions.
**Net excess benefits with added recreation for Component C = $4.31 M.*

3.9.2 Reevaluation of Middle Stream Segment Components

The middle stream segment of Hunting Bayou is defined by the southern boundary of Herman Brown Park and the downstream end of the ERRY. Within this area, the land use is primarily industrial including large tank farms and warehouse buildings, with a few isolated pockets of residential subdivisions. Although the WOP condition damages are minimal through this reach, there is concern related to Herman Brown Park. There is a strong desire by the non-federal sponsor, HCFCD, and other community groups to avoid building a structural component through the park due to its environmental sensitivity.

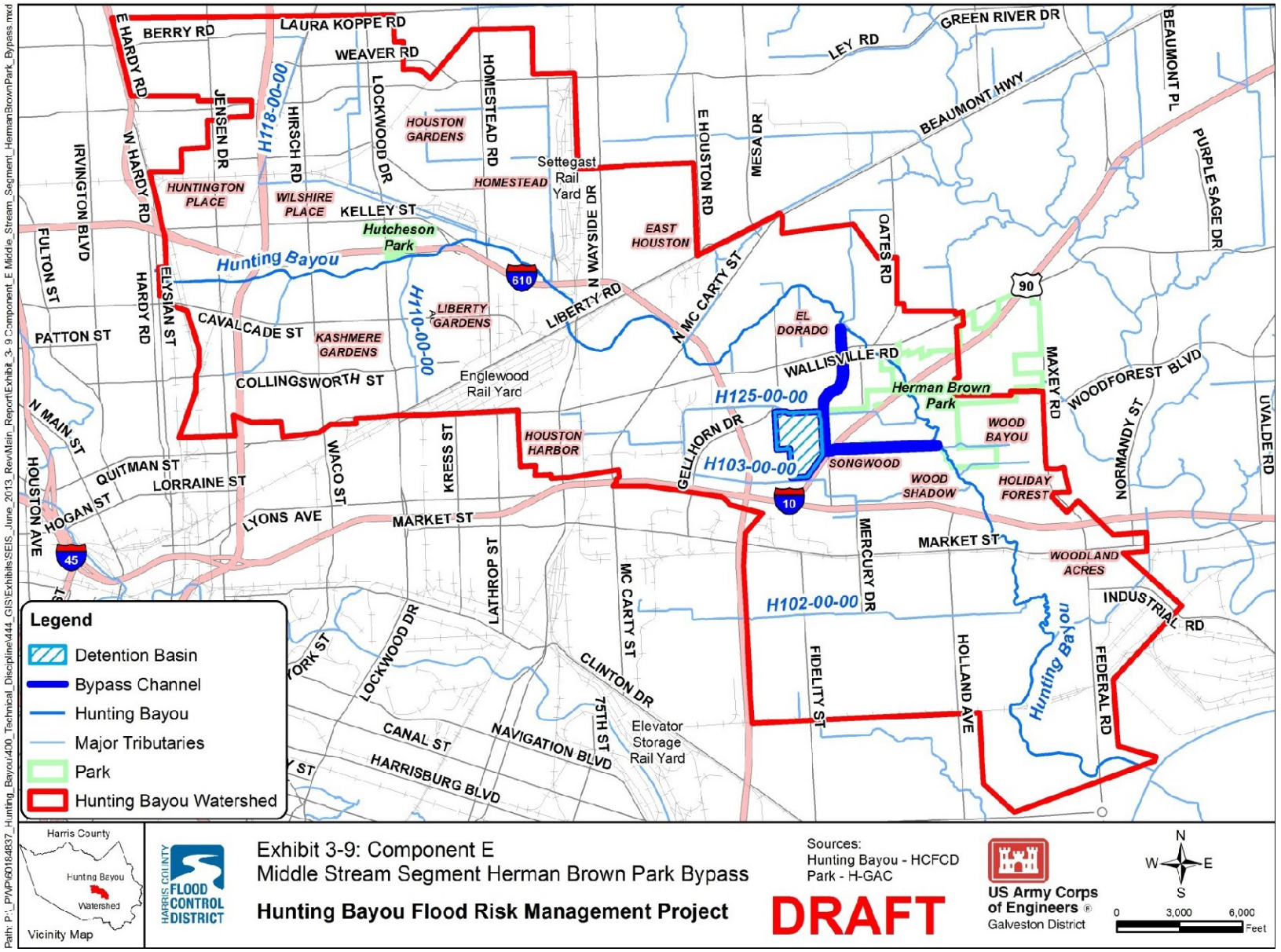
Within the middle segment, the following management measures were formulated and evaluated:

- Herman Brown Park Bypass (Component E)
- Buyouts (Component F)
- Flood Proofing (Component G)

3.9.2.1 Component E – Herman Brown Park Bypass

Component E consisted of a bypass channel approximately 11,700 feet (2.2 miles) in length around Herman Brown Park. Initially, two different channel sizes were evaluated, hereafter referenced as Components E1 and E2, with no detention. Based on the timing of the hydrographs between the bypass channel and Hunting Bayou for Components E1 and E2, it was determined that detention may have a positive effect on the overall performance. Therefore, a third run was made, Component E3, consisting of the E2 bypass channel with an offline detention basin located to the west of Herman Brown Park. Exhibit 3-9 shows the results of Components E through G.

Exhibit 3-9:
Component E Middle Stream Segment Herman Brown Park Bypass



3.9.2.2 Component F – Middle Stream Segment Buyout

Component F was similar to Component C in that it consisted of residential property buyouts in the middle portion of the watershed (economic damage reaches V, X, Z, AE, AF and AG). The nonstructural analysis was performed using output from the WOP condition HEC-FDA model.

Only residential and commercial structures with positive AAEV net excess benefit for acquisition were considered for buyout. A total of 37 residential and 2 commercial structures were identified to have positive AAEV net excess benefits in the middle reach, which equates to an approximate 25 percent (4-year) floodplain buyout. The majority of the structures (27) were in damage reach AF. Component F had AAEV net excess benefits of $0.122 million and a 1.84 BCR. *Exhibit 3-10* displays Component F.

WRDA 1990 Section 101(a)(21) authorized flood control and recreation features for Hunting Bayou. While that authorization is still in effect, the non-federal sponsor, HCFCD, declines to exercise recreation authority at this time to focus efforts on FRM. During plan reevaluation in 2001, a recreational plan was developed and evaluated in conjunction with reusing vacated land associated with buyout. Recreational features supported general urban park activities and included picnic tables, hike/bike trails and other amenities within the channel ROW. However, because the population calculated for the practical service areas was too small and because of the lack of suitable parcels for recreation facilities, recreation benefits were not explored further. While the non-federal sponsor, HCFCD, is not pursuing recreational opportunities at this time, another organization, the Houston Parks Board, is pursuing grants not affiliated with this project with which to construct trails along the Hunting Bayou ROW.

3.9.2.3 Component G – Middle Stream Segment Flood Proofing

Component G is the middle stream segment version of Component D. The analysis was performed using output from the WOP condition HEC-FDA model.

Forty-one structures (38 residential and 3 commercial) were identified to have positive AAEV net excess benefits, which equates to an approximate 25 percent (4-year) floodplain. The majority of these structures (26) are in damage reach AF. Component G has AAEV net excess benefits of $0.137 million and a 2.35 BCR. *Exhibit 3-11* displays Component G. *Table 3-10* shows the results of Components E through G.

Results of Middle Stream Segment Component Evaluation shows the nonstructural Components F and G exhibit positive AAEV net excess benefits, but Component E2 has the highest AAEV net excess benefits of the middle stream segment components. Since the annual net benefits of Components E, F and G are very low compared to the upper stream segment components; these components were carried forward as potential add-ons to the upper stream segment components.

Exhibit 3-10:
Component F Middle Stream Segment Buyouts

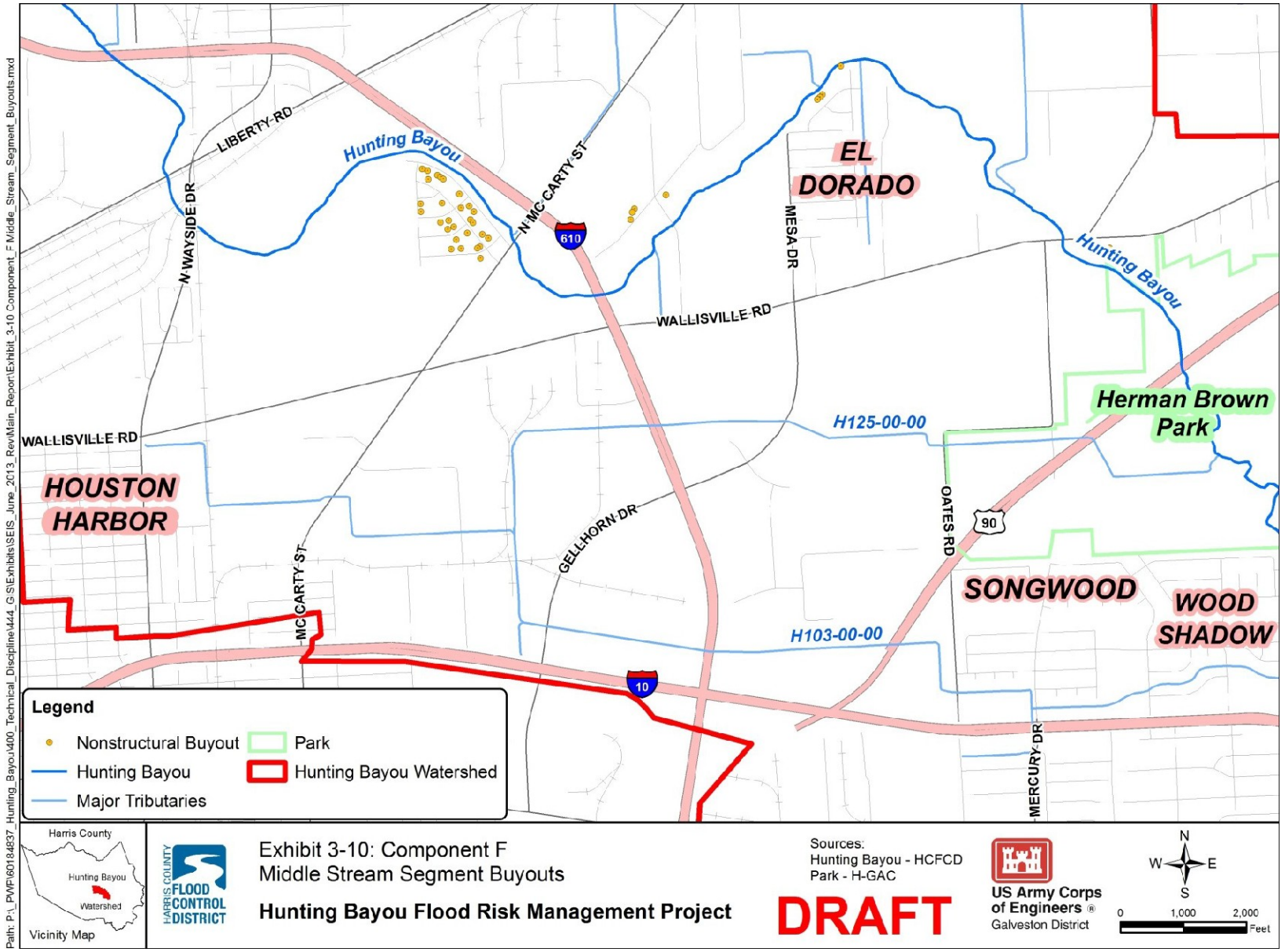


Exhibit 3-11:
Component G Middle Stream Segment Flood Proofing

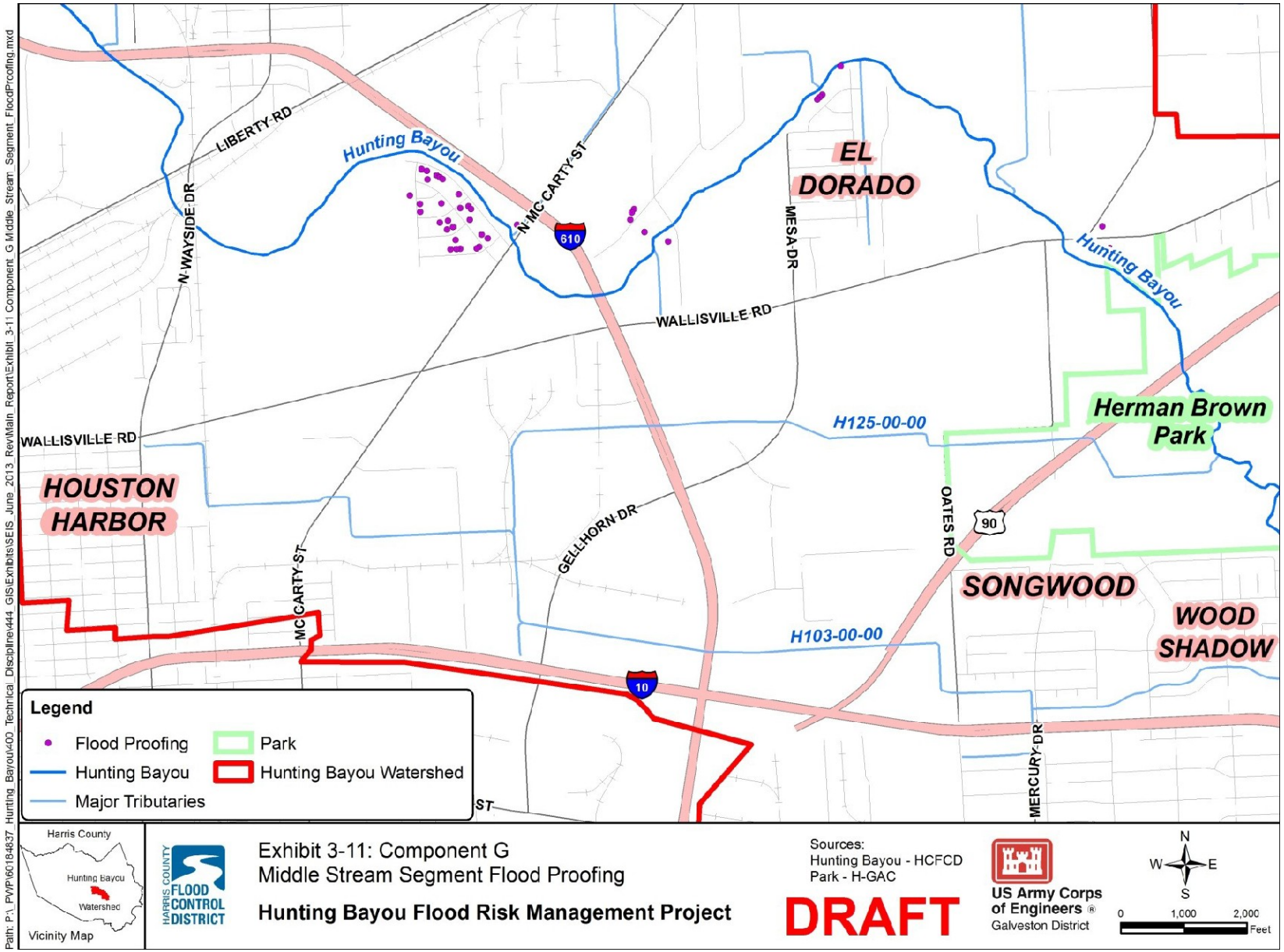


Table 3-10:
Economic Performance of Components E Through G

Component	AAEV Project Cost	AAEV Damage Reduction	AAEV Net Excess Benefit	BCR
E1	$1.298	$1.756	$0.458	1.35
E2	**$1.488**	**$1.985**	**$0.497**	**1.33**
E3	$5.550	$3.522	($2.028)	0.63
F	$0.144	$0.266	$0.122	1.85
G	$0.102	$0.239	$0.137	2.34

Based on 2001 price levels and 5.625 percent discount rate.
Note: All dollar values in millions.

3.9.3 Reevaluation of Lower Stream Segment Components

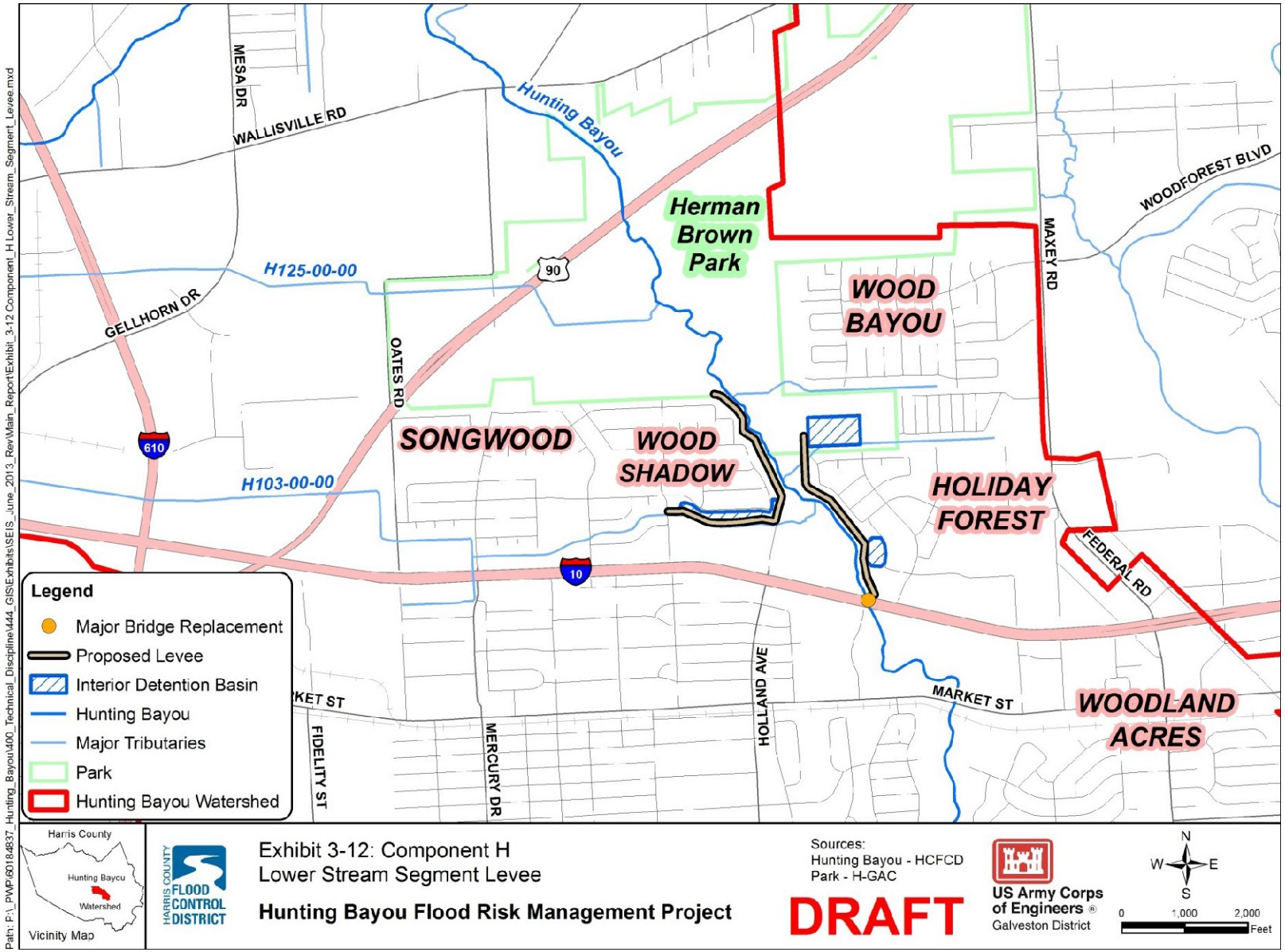
The lower stream segment of Hunting Bayou extended from just downstream from Herman Brown Park to the mouth of the bayou. The flooding in this stream segment is not as widespread as in the upper stream segment; however, the flooding depths are more severe, most notably in the residential subdivisions located just upstream from IH 10. Within the lower stream segment, the following management measures were formulated and evaluated:

- Levee (Component H)
- Channel Modifications (Component I)
- Detention (Component J)
- Buyouts (Component K)
- Flood Proofing (Component L)

3.9.3.1 Component H – Lower Stream Segment Levee

Component H included optimizing the levee height and interior drainage facilities separately before combining the two into a complete system. *Appendix 5 – Economics Analysis* describes the optimization process for levee height and interior drainage. *Exhibit 3-12* displays Component H.

Exhibit 3-12:
Component H Lower Stream Segment Levee



The results for the three levee designs are shown in *Table 3-11*. Even though all three levee designs resulted in negative net benefits, the 0.4 percent levee design resulted in the highest net benefits and was included as the levee portion of Component H. The levee was considered to be in place for the purpose of optimizing the interior facilities.

Table 3-11:
Economic Performance of Component H

Component H	AAEV Project Costs	AAEV Damage Reduction Benefits	AAEV Net Excess Benefits	BCR
2% AEP Levee	$1.23	$0.09	($1.14)	0.07
1% AEP Levee	$1.25	$0.14	($1.12)	0.11
0.4% AEP Levee	$1.27	$0.16	($1.11)	0.13
West Interior Area				
25-acre-feet	$0.38	$0.71	$0.33	1.87
30-acre-feet	**$0.42**	**$0.78**	**$0.36**	**1.86**
35-acre-feet	$0.44	$0.79	$0.35	1.79
Southeast Interior Area				
25-acre-feet	$0.15	$0.25	$0.10	1.70
30-acre-feet	**$0.16**	**$0.26**	**$0.11**	**1.69**
35-acre-feet	$0.16	$0.27	$0.11	1.65
Northeast Interior Area				
85-acre-feet	$0.29	$1.00	$0.72	3.51
90-acre-feet	**$0.29**	**$1.02**	**$0.73**	**3.48**
95-acre-feet	$0.31	$1.03	$0.72	3.36
H-Optimal	**$2.13**	**$2.21**	**$0.07**	**1.03**

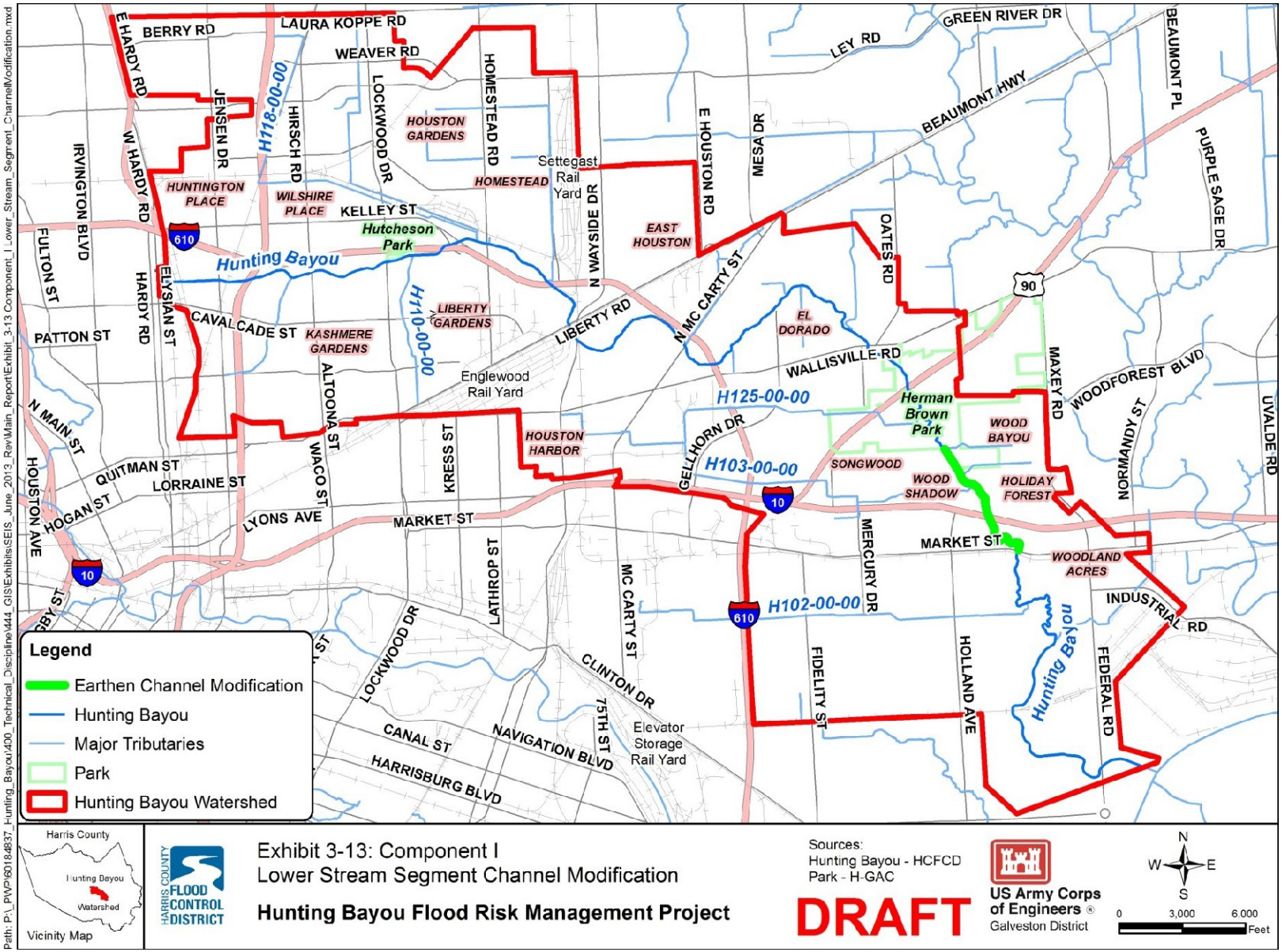
prices in $millions, 2001 price level, 6.375 percent discount rate

The west and southwest interior areas optimized with detention basins of 30-acre-feet; the northeast interior areas optimized with a detention basin of 90-acre-feet. The optimized levees and the three optimized interior drainage systems were then combined and evaluated as Component H (optimal).

3.9.3.2 Component I – Lower Stream Segment Earthen Trapezoidal Channel Modifications

Component I consisted of approximately 6,500 feet (1.2 miles) of earthen trapezoidal channel modifications, from just downstream from Herman Brown Park to just downstream from Market Street. Included in the channel modifications was a realignment of Hunting Bayou between IH 10 and Market Street to reduce the number of existing bends and, subsequently, the amount of head loss through this reach. Component I provided flood protection to the primarily residential areas located just upstream from IH 10. *Exhibit 3-13* displays Component I.

Exhibit 3-13:
Component I Lower Stream Segment Channel Modification



A total of three channel sizes were evaluated for this component, with bottom widths of 80 feet, 100 feet, and 120 feet. The optimum channel size was determined to be an 80-foot bottom-width channel, based on AAEV net excess benefits. The channel in its WOP condition is similar in size to that of a 60-foot bottom-width channel. For that reason, a size smaller than 80 feet was not evaluated.

3.9.3.3 Component J – Lower Stream Segment Detention

Component J consisted of an offline detention basin of approximately 194 acre-feet located just upstream from IH 10 on the eastern side of Hunting Bayou. This component reduced discharges downstream from the basin, leading to FRM benefits in the reaches downstream from IH 10 and also lowers tailwater elevations at the basin, which results in minor flood elevation reductions upstream from the basin. *Exhibit 3-14* displays Component J.

3.9.3.4 Component K – Lower Stream Segment Buyout

Component K was the lower stream segment version of Components C and F. It consisted of buying out residential and commercial properties in the watershed's lower portion (damage reaches D through U). The nonstructural analysis was performed using the WOP conditions HEC-FDA model results. *Exhibit 3-15* displays Component K.

Only structures that had positive AAEV net excess benefits for acquisition were considered for buyout. A total of 62 structures (all residential) was identified to have a positive net benefit in the lower reach, which equates to an approximate 14 percent (7-year) floodplain buyout. The majority of the structures (56) are located in damage reach T-Left. Component K has an annual $0.727million net benefit and a 3.23 BCR.

Section 101(a)(21) of WRDA 1990 authorized flood control and recreation features for Hunting Bayou. While that authorization is still in effect, the non-federal sponsor, HCFCD, declines to exercise recreation authority at this time to focus efforts on FRM. During plan reevaluation in 2001, a recreational plan was developed and evaluated in conjunction with reusing vacated land associated with buyout Component K in the lower stream segment. Recreational features supported general urban park activities and included picnic tables, hike/bike trails and other amenities within the channel ROW. The recreation benefits associated with the nonstructural component was developed to make the economic performance of Component K more competitive. Details of this analysis are available for review upon request in *Appendix 5* - Attachment A5-9, Memorandum for Record to Agency Technical Review, 14 Jan 2005. This analysis resulted in identification of a potential service area defined by Lafferty Road in the north to Loop 610 in the south and Maxey Road in the east to Hunting Bayou in the west. No recreational facilities were available in this service area, and the planning effort using the buyout parcels identified some walking trails, playgrounds and other small park amenities. The recreation benefit was estimated to be $483,433 annually (FY 2001), providing a net annual benefit of $426,559 with an 8.5 BCR. This increases the total annual net benefit to approximately $730,000 (FY 2001) which is still significantly lower than the best performing plans. The component was not carried forward due to poor economic performance with low net excess benefits. While the non-federal sponsor, HCFCD, is not pursuing recreational opportunities at this time, another organization, the Houston Parks Board, is pursuing grants not affiliated with this project with which to construct trails along the Hunting Bayou ROW.

Exhibit 3-14:
Component J Lower Stream Segment Detention

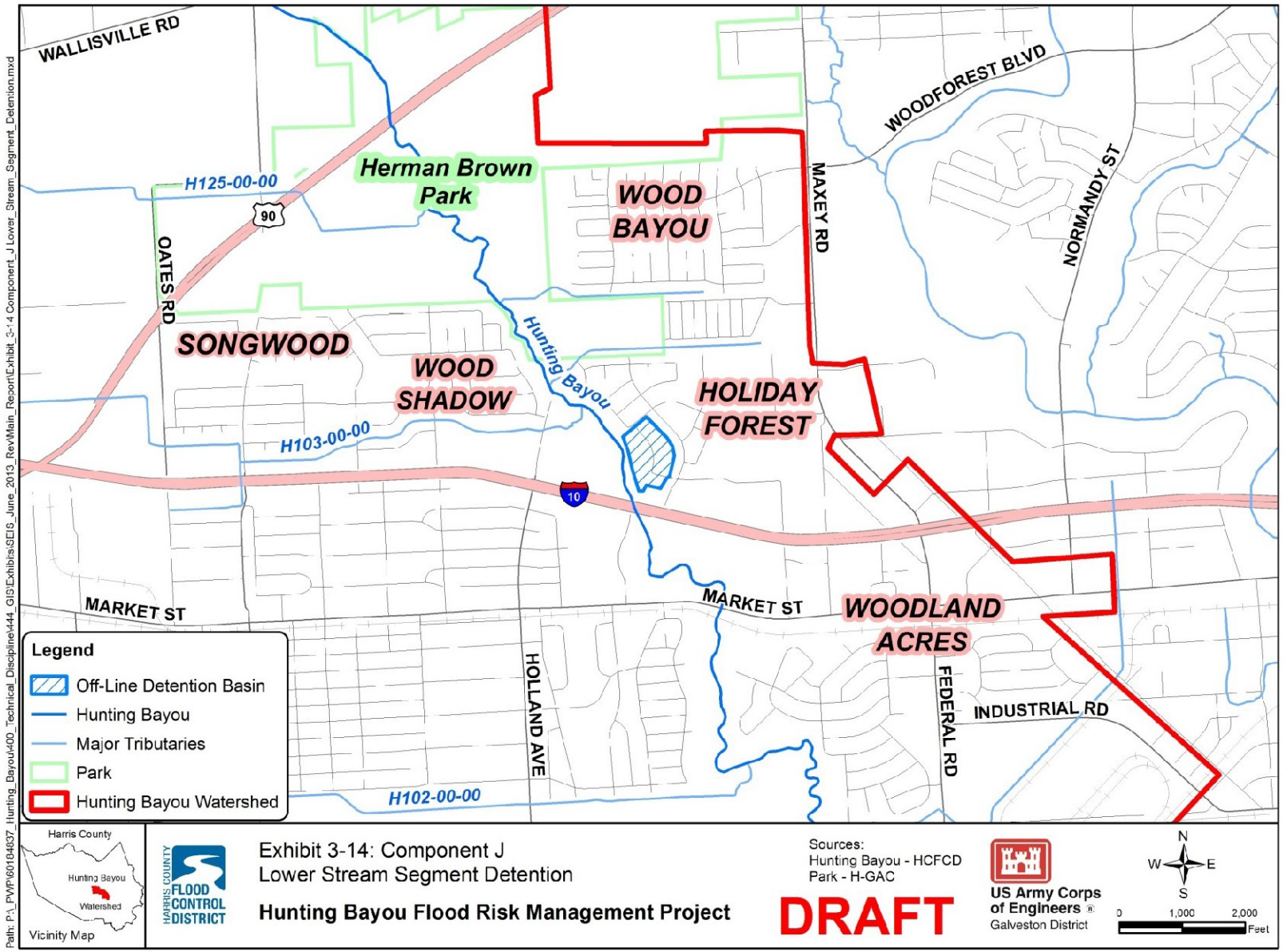
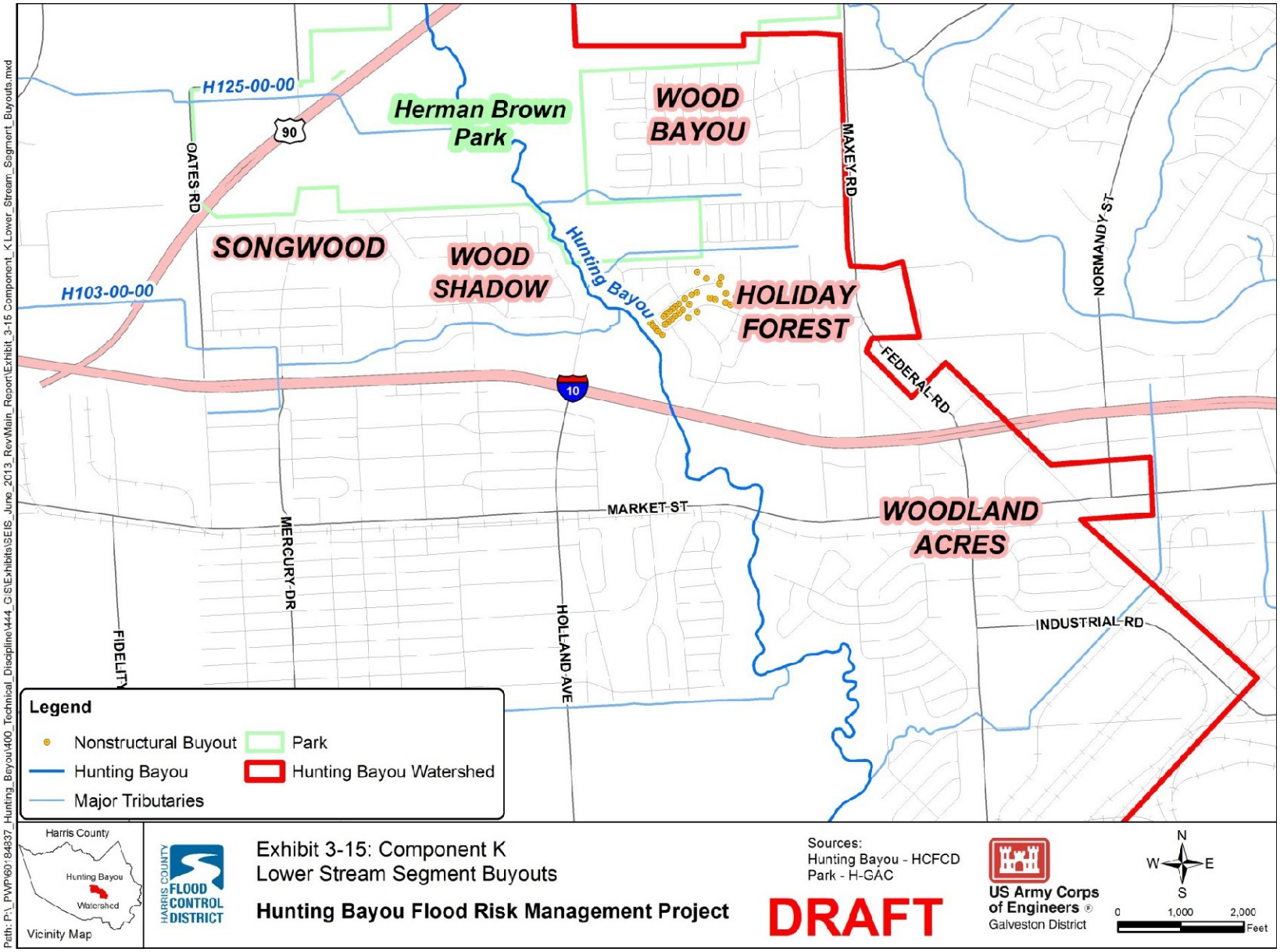


Exhibit 3-15:
Component K Lower Stream Segment Buyouts



3.9.3.5 Component L – Lower Stream Segment Flood Proofing

Component L was the lower stream segment version of Components D and G. The nonstructural analysis was performed using the WOP condition HEC-FDA model results. *Exhibit 3-16* displays Component L.

A total of 102 structures (all residential) were identified to have positive AAEV net excess benefits, which equated to an approximate 11 percent (9-year) floodplain. The majority of these structures (93) were located in damage reach T-Left. Component L had an annual net benefit of $0.361 million and a 2.06 BCR.

3.9.3.6 Results of Lower Stream Segment Component Evaluation

Five separate components were evaluated in the lower stream segment of Hunting Bayou: levees with interior drainage facilities (H), channel modifications (I), detention (J), buyout (K) and flood proofing (L). *Table 3-12* compares the economic performance for these components.

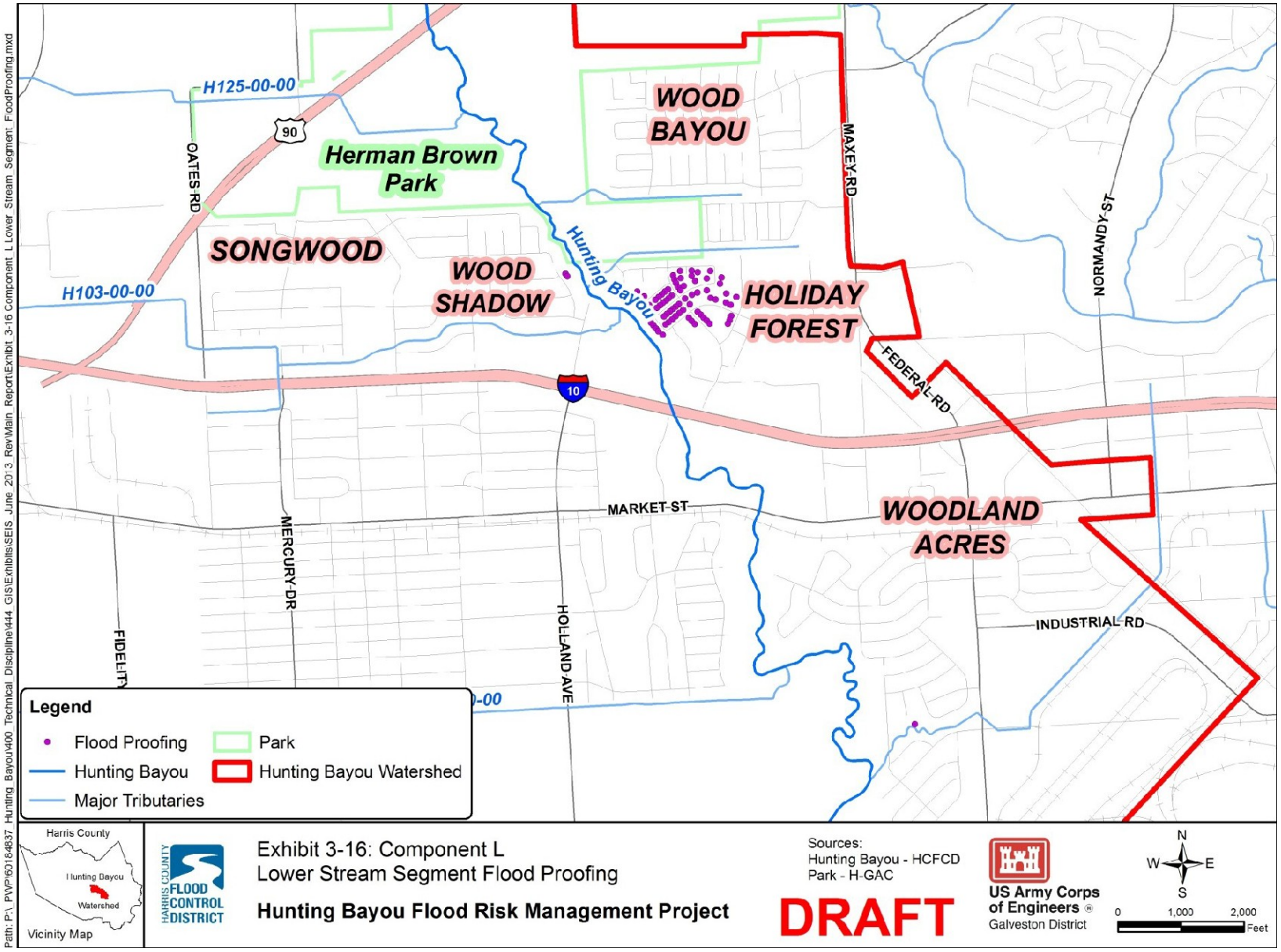
Table 3-12:
Economic Performance of Components H Through L

Component	AAEV Project Costs	AAEV Damage Reduction Benefits	AAEV Net Excess Benefits	BCR
H (Optimal)	$2.009	$2.079	$0.070	1.03
I (80' BW)	$1.883	$2.070	$0.187	1.10
J	$0.845	$0.279	($0.566)	0.33
K	**$0.326**	**$1.053**	**$0.727**	**3.23**
L	$0.342	$0.703	$0.361	2.06

Based on 2001 price levels and 5.625 percent discount rate.
Note: All dollar values in millions.

The table shows the only component that did not have positive net benefits was Component J (detention). Components H, I, K and L all had comparable annual net benefits, but could not approach the AAEV net excess benefit economic performance of the upper stream segment components. However, these four components were carried forward as potential additions to the upper stream segment components.

Exhibit 3-16:
Component L Lower Stream Segment Flood Proofing



3.9.4 Summary of All Stream Segment Optimized Components

Table 3-13 summarizes and ranks the optimized scale for all stream segment components. At this point, these stand-alone components are compared for their potential to be paired with other components in developing FRM alternatives.

Table 3-13:
Economic Performance of All Optimized Stream Segment Components

Component	AAEV Project Cost	AAEV Damage Reduction	AAEV Net Excess Benefit	BCR	Rank by AAEV Net Excess Benefits
A4	$4.34	$8.90	$4.56	2.05	4
X5	$3.84	$12.21	$8.37	3.18	2
X5-A1	$5.35	$13.65	$8.30	2.55	3
B60	**$5.50**	**$15.49**	**$9.99**	**2.82**	**1**
C	$3.55	$7.31	$3.76	2.06	5
D	$2.34	$4.79	$2.45	2.05	6
E1	$1.30	$1.76	$0.46	1.35	9
E2	$1.49	$1.99	$0.50	1.33	8
E3	$5.55	$3.52	($2.03)	0.63	16
F	$0.14	$0.27	$0.12	1.85	13
G	$0.10	$0.24	$0.14	2.34	12
H (Optimal)	$2.01	$2.08	$0.07	1.03	14
I (80' BW)	$1.88	$2.07	$0.19	1.1	11
J	$0.85	$0.28	($0.57)	0.33	15
K	$0.33	$1.05	$0.73	3.23	7
L	$0.34	$0.70	$0.36	2.06	10

Color code corresponds to upper, middle and lower stream segments
Based on 2001 price levels and 5.625 percent discount rate.
Note: All dollar values are in millions.

This comparison demonstrates the best economically performing components are concentrated in the upper stream segment. Damages are concentrated in the upper stream segment and offer opportunities for efficient FRM. Component B60, the 60-ft bottom width channel modification in the upper stream segment produced the highest net excess benefits of all the other optimized components considered and was carried forward as the anchor component with which other components would be added to test for economic efficiency.

3.10 Component Combinations–

Of the 16 components previously evaluated in the upper, middle, and lower stream segments, the best performing components were all upper stream segment components. Component B60 (channel modifications) yielded the highest annual net benefits, thus making it the anchor component to which other components were added, evaluated, and optimized in an attempt to further reduce flood damages and to further increase the overall AAEV net excess benefits of the plan.

Component A (Homestead site detention) was added to the B60 channel modification to create Alternative B60-A. Several variations of this combination were evaluated in which the detention basin's size was varied to determine the optimal combination. *Table 3-14* provides the scale of detention used in the optimization exercise. *Exhibit 3-16* displays the economic results from the evaluation process.

Table 3-14:
Added Detention Increment to Alternative Reevaluation

Component ID	Basin Surface Area (acre)	Detention Volume (acre-feet)	Lots Impacted	Living Units Impacted
Homestead Site				
A1	40	560	1	0
A2	80	1,130	1	0
A3	116	1,780	1	0
A4	155	2,380	1	0

In addition, buyout (Component C) and flood proofing (Component D) were combined with the anchor component and compared to the optimal combination of detention and channel modifications. The optimization of these alternatives is discussed in detail in the following sections.

3.10.1 Alternative B60-A – Detention with Optimal Upstream Earthen Trapezoidal Channel Modifications (US 59 to Englewood Railroad Yard [ERRY])

Alternative B60-A consists of upper reach detention (Component A) in combination with the optimal upstream channel modifications, Component B60. This alternative provides FRM to the upper Hunting Bayou watershed, where the majority of the WOP conditions damages are located. When combined with Component B60, the optimal detention basin is 116 acres in size and is located between Homestead Road and the second crossing of IH 610.

3.10.2 Alternative B50Con-A3 – Optimal Detention with Upstream Concrete Trapezoidal Channel Modifications (US 59 to Englewood Railroad Yard [ERRY])

Alternative B50Con-A3 is similar to Alternative B60-A3 in that it consists of channel modifications from US 59 to just downstream from the ERRY. The major difference is that upstream from the in-line detention basin, the proposed channel under Alternative B50Con-A3 consists of concrete-lined side slopes with an earthen bottom.

The earthen channel modeled in the upper stream segment in Alternative B60-A3 resulted in a significant number of real estate acquisitions. Concrete side slopes allow for steeper slopes providing a narrower top width. The purpose of analyzing the concrete-lined channel in Alternative B50Con-A3 was to determine whether the savings in real estate acquisitions would offset the increased cost of construction of a concrete channel.

Much like Alternative B60-A3, Alternative B50Con-A3 also has a positive incremental AAEV net excess benefits when compared to Component B60, but the total AAEV net excess benefits

are less than that for Alternative B60-A3. Thus, an earthen channel is more cost-effective than a concrete-lined channel in the upper stream segment of Hunting Bayou.

3.10.3 Alternative BTerrace-A3 – Optimal Detention with Upstream Earthen Terrace Channel Modifications (US 59 to Englewood Railroad Yard [ERRY])

Alternative BTerrace-A3 is similar to Alternative B60-A3, except for the design cross-section from just upstream from the third crossing of IH 610 in Hutcheson Park to Tributary H112-00-00. The terrace channel geometry would produce additional benefits for the local community, such as space for the development of recreational opportunities and enhanced aesthetics, with minimal additional cost. The terrace varies in width but was configured to provide approximately the same level of service as the optimal trapezoid section (60-foot bottom width).

Alternative BTerrace-A3 was shown to have positive incremental AAEV net excess benefits but the overall AAEV net excess benefits are approximately $0.67 million less than Alternative B60-A3.

3.10.4 Alternative B60-Buyout – Optimal Channel Modifications with Residual Buyout of the Floodplain

Alternative B60-C consists of the optimal channel modifications (Component B60) in combination with a residual buyout of structures throughout the Hunting Bayou watershed. The nonstructural analysis was performed in HEC-FDA using the Component B60 With Project conditions hydrology.

Only residential and commercial structures with positive AAEV net excess benefits for acquisition were considered for buyout. A total of 71 structures (all residential) were identified to have a positive net benefit with the channel modifications in place, which equates to an approximate 14 percent (7-year) floodplain buyout. Forty-three of these structures are located in the lower stream segment, 24 in the middle stream segment and only four in the upper stream segment. Alternative B60-Buyout had an annual $9.06 million net benefit and a 2.56 BCR.

Recreational benefits were investigated for the residual buyout land. The majority of contiguous parcels involved in this component are in the middle reach and lower reach. Recreational benefits were not explored for the middle stream segment parcels for the same reasons as described in the component evaluation of Component F, the middle stream segment buyout measure, since less of the same set of parcels were involved in this alternative. The lower stream segment parcels involve essentially the same parcels as Component K, the lower stream segment buyout measure. The same recreational facilities were proposed for this alternative, producing $426,560 in AAEV net excess benefits (FY 2001). With this recreational component, the total AAEV net excess benefits of B60-C is $9.49 million (FY 2001).

3.10.5 Alternative B60-Flood Proofing – Optimal Channel Modifications with Residual Flood Proofing within the Floodplain

Alternative B60-Flood Proofing consists of the optimal channel modifications (Component B60) in combination with residual flood proofing of structures throughout the Hunting Bayou

watershed. The nonstructural analysis was performed in HEC-FDA using the Component B60 With Project conditions.

Only residential and commercial structures with positive AAEV net excess benefits for acquisition were considered for flood proofing. A total of 118 structures (116 residential and 2 commercial) were identified to have positive AAEV net excess benefits, which equates to an approximate 14 percent (7-year) floodplain. Only four of these structures were identified in the upper stream segment and 31 in the middle stream segment. The remaining 83 structures are in the lower stream segment. Alternative B60-Flood Proofing has $8.871 million AAEV net excess benefits and a 2.51 BCR.

3.10.6 Alternative Size Combinations for Earthen Channel and Homestead Road Site Detention

Several alternatives were examined that consisted of alternate sizes of the trapezoidal earthen channel modifications described for Component B60 combined with various sizes of the Homestead Site detention. During review of initial results for some these alternatives, it was determined an optimum storage may be achieved by combining a smaller capacity channel than the best-performing channel (B60) with a larger detention basin than that used (A3) in the best-performing combination with the optimized channel (B60-A3), and vice versa. In other words, the same or similar storage as provided by B60-A3 may be provided by alternative size combinations of channel modifications and detention. This optimum storage should provide similar FRM and potentially greater AAEV net excess benefits than B60-A3. Alternative ways for providing this optimum storage might achieve higher AAEV net excess benefits by reducing costs of achieving this optimum storage.

Thus by combining smaller channels with larger detention or larger channels with smaller detention, the plan reevaluation process considered alternate ways of providing the FRM provided by B60-A3. Also, to achieve a more complete analysis of this reevaluation thought process, smaller channels with smaller detention were also examined, in case there was a more rapid decrease in cost of detention (due to smaller size) than the decrease in FRM benefit, which would result in higher AAEV net excess benefits.

The following paragraphs describe these alternatives.

- A smaller alternate channel width component (B40) was combined with A3 and modeled, to ensure that a combination of an alternative channel width to the B60 size was evaluated. The channel modifications use a maximum 40-foot bottom width earthen cross section and cover the same extent as B60.

- A 50-foot bottom width earthen channel was also modeled, in combination with detention ranging from 40 acres to 155 acres (Alternatives B50-A1, B50-A2, B50-A3 and B50-A4). The channel modifications cover the same reach as B60.

- To test the possibility that a larger channel in combination with smaller detention than was used in B60-A3 (the best-performing upper stream segment channel-Homestead Site detention alternative at this point), could perform better, Alternative B70-A2 was modeled. The channel component is the same as the 70-foot bottom width channel component previously tested in the component analysis and the detention is the 80-acre component, A2.

3.10.7 Optimization of Combined Components

All FRM measures evaluated in the component analysis were carried forward for further analysis and optimization to develop a potential NED Plan. The top performers for producing AAEV net excess benefits are shown in *Table 3-15*. The optimized B60 component was compared against component combinations. The combinations which produced greater AAEV net excess benefits than the stand-alone B60 component are bolded in *Table 3-15*. With so little variation in performance, it is reasonable to conclude a channel modification and detention basin combination was the optimized alternative for Hunting Bayou. Four channel modification and detention combinations, highlighted in *Table 3-15*, produce greater AAEV net excess benefits than Component B60 alone. These alternatives' economic performances fall within 2 percentage points of AAEV net excess benefits, and represent scale refinements to the channel modification/detention basin alternative. B50-A1 was promoted to the Final Array of Alternatives because it reasonably maximized net excess benefits at least cost. The B50-A1 combination of channel modification, bridge replacement, and detention storage reduced AAEV damages by 75 percent in the Hunting Bayou watershed. Damages residual to the implementation of B50-A1 were distributed within the floodplain in a way that made the addition of other structural components unlikely to be economically efficient. The expectation was that, if the structural alternative B50-A1 was identified as the NED Plan, further nonstructural FRM opportunities could be investigated during final plan refinement.

Table 3-15:
Top Performing Channel and Homestead* Detention Combinations

Alternative ID	Description	AAEV Project Cost	AAEV Damage Reduction	AAEV Net Benefit	BCR
B60	60' Channel	$5.50	$15.49	**$9.99**	2.82
B60-Buyout	60" Channel with Residual Buyout	$5.82	$14.88	$9.06	2.56
B60-Flood Proofing	60"Channel with Residual Flood Proofing	$5.88	$14.75	$8.87	2.51
B50-A1	**RR Site (40 Ac) + 50' Channel**	**$6.78**	**$16.99**	**$10.21**	**2.51**
B60-A1	**RR Site (40 ac) + 60' Channel**	**$6.99**	**$17.18**	**$10.19**	**2.46**
B60-A2	**RR Site (80 Ac) + 60' Channel**	**$8.32**	**$18.33**	**$10.00**	**2.2**
B70-A2	RR Site (80 Ac) + 70' Channel	$8.58	$18.44	$9.86	2.15
B40-A3	40' Channel + RR Site (116 ac)	$8.92	$18.69	$9.77	2.1
B50-A3	RR* Site (116 Ac) + 50' Channel	$9.22	$19.05	$9.83	2.07
B60-A3	RR Site (116 ac) + 60' Channel	$9.44	$19.12	$9.69	2.03
B50Con-A3	Upper Reach Concrete + RR Site (116 ac)	$9.69	$19.13	$9.45	1.98
BTerrace-A3	Upper Reach Terrace + RR Site (116 ac)	$10.13	$19.15	$9.01	1.89
B50-A4	RR Site (155 Ac) + 50' Channel	$10.48	$19.46	$8.97	1.86
B60-A4	RR Site (155 ac) + 60' Channel	$10.71	$19.50	$8.79	1.82
B50-A2	**RR Site (80 Ac) + 50' Channel**	**$18.21**	**$8.11**	**$10.10**	**2.25**

Based on 2001 price levels and 5.625 percent discount rate.
**RR Site is detention vacant property between Homestead Road and Settegast Railroad Yard.*
All dollar values are in millions.