HUNTING BAYOU FLOOD RISK MANAGEMENT, HARRIS COUNTY, TEXAS

DRAFT GENERAL REEVALUATION REPORT

APPENDIX 5
ECONOMIC ANALYSIS

June 2014

HARRIS COUNTY FLOOD CONTROL DISTRICT

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1.0 INTRODUCTION

This appendix provides a description of the investigations, procedures, and analyses conducted for the economic analysis for the Integrated General Reevaluation Report and Environmental Assessment (GRR/EA) for flood risk management (FRM) on Hunting Bayou, Texas. The scope of this report spans over 14 years and includes economic analyses of both the Without Project (WOP) condition and a variety of With Project conditions, resulting in the identification of a plan that reasonably maximizes National Economic Development (NED) benefits consistent with protecting the Nation's environment while reflecting community constraints and obligations. The Tentatively Selected Plan (TSP) is compared against the plan that was proposed in 1988 and authorized by Congress in WRDA of 1990.

From an economic perspective, this reevaluation constitutes a significant update to the 1988 Feasibility Report on Buffalo Bayou and Tributaries. The 1990 Authorized Plan consisted of an earthen channel extending from the confluence of Hunting Bayou with the Houston Ship Channel upstream to the vicinity of US 59 and provided protection from a 4 percent annual exceedance probability (AEP) storm under future development conditions. With present local drainage conditions in the watershed, the plan would provide protection from a flood greater than a 40-year flood or a flood with a 2.5 percent AEP. The GRR/EA discusses the rationale for pursuing this reevaluation at this time.

The benefit/cost ratio (BCR) for the Authorized Plan was 10.2 with the 8.625 percent discount rate for fiscal year (FY) 1988. To update the economic performance of the Authorized Plan, the plan is compared to current conditions within the Hunting Bayou economic study area over the same period of analysis as other plans considered.

1.1 General Reevaluation

The economic analysis for the GRR/EA was conducted in accordance with the following policies and guidelines for water resources planning studies:

- U.S. Army Corps of Engineers, ER 1105-2-100, "Planning Guidance Notebook," 22 April 2000
- U.S. Army Corps of Engineers, ER 1105-2-101, "Risk Analysis for Flood Damage Reduction Studies," 3 January 2006
- U.S. Army Corps of Engineers, Institute for Water Resources, National Economic Procedures Manual—Urban Flood Damage, March 1988
- U.S. Army Corps of Engineers, Economic Guidance Memorandum 01-03, "Generic Depth-Damage Relationships", 4 December 2000
- U.S. Army Corps of Engineers, Economic Guidance Memorandum 09-04, "Generic Depth-Damage Relationships for Vehicles, 22 June 2009
- U.S. Army Corps of Engineers, New Orleans District, Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-To-Structure Value Ratios in Support of the

Jefferson and Orleans Flood Control Feasibility Studies, prepared by Gulf Engineers and Consultants (GEC), Inc., June 1996

- Gulf Engineers and Consultants, Final Report on Non-Structural Damages, Technical Memorandum, 26 October 1998.

The study period for the Hunting Bayou GRR/EA spanned 14 years and entailed three significant approaches to economic model development and execution. Within this report, these approaches are presented in their order of occurrence followed by the data that were developed as a result. With each model update, the data upon which they rely are described and displayed. The model years of note are 2001, 2009, and 2013.

1.2 Period of Analysis, Interest Rate, and Price Level

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.

Over the 14-year course of study, different price levels and different interest rates that were current when the analyses were performed are displayed in this appendix. In order to avoid confusion in the presentation of alternative screening results and to remain true to the results of the plan reevaluation, the interest rate and price level applicable at the time the analysis was conducted are reported where appropriate. Tables include notations of the applicable interest rate and price level of the outputs presented. Throughout the period of analysis, benefits and costs were consistently compared at similar prices and discount rates. The final array of alternative plan benefits and costs is presented at 2Q2013 prices and at the FY14 discount rate of 3.50 percent in order to demonstrate project viability and federal interest.

A chronology of the Hunting Bayou plan reevaluation analyses is presented below. The activities associated with each iteration are discussed in the corresponding sections of this document.

1998-2001: 2001 price level, FY01 discount rate of 5.625 percent

- study began and structure inventory compiled;
- structure inventory replacement cost new less deprecation (RCNLD) values determined;
- ancillary damage categories determined;
- uncertainty estimates and depth-damage curves incorporated into the analysis;
- component identification and optimization occurred during this time;
- alternatives evaluation occurred at this time;
- preliminary NED Plan identified

2004-2006: 2004 price level, FY06 discount rate of 5.125 percent

- structure inventory RCNLD values updated;
- ancillary damage categories updated.

2009: Feb 2009, FY10 discount rate of 4.375 percent

- structure inventory RCNLD values updated;
- ancillary damage categories updated;
- single-family structure/content depth-damage curves conformed to guidance;

- vehicle damage estimation techniques conformed to guidance;
- refinement of NED alternative plan occurred at this time.

2013: 2Q13 price level (Jan 2013), FY14 discount rate of 3.50 percent

- verification and update of structure inventory;
- update of structure RCNLD values;
- verification of uncertainty parameters;
- verification of depth-damage curves;
- update of ancillary damage values;
- compliance with City of Houston (COH) elevation ordinance of BFE+1 foot for new development and substantial redevelopment;
- update of H&H model (result of DQC review);
- calculation of advance bridge replacement benefit;
- identification of NED Plan/TSP under current conditions.

1.3 Study Area

The Hunting Bayou watershed is composed of roughly 30 square miles located approximately 5 miles northeast of downtown Houston, in Harris County, Texas (*Exhibit A5-1*). The entire watershed was the study area for the economic analysis, until the final update in 2013, with particular attention given to the portion of the Hunting Bayou watershed estimated to be influenced by a 0.2 AEP flood event. The 0.2 AEP floodplain area was field surveyed for development, although the original structure inventory included all structures in the watershed in 2001.

1.3.1 Land Use

The watershed is a highly developed mix of residential, commercial, and industrial land use. Land use within the Hunting Bayou watershed was determined from parcel data obtained from Harris County Appraisal District (HCAD) real property records. The 1998 land use distribution in the watershed is presented in *Table A5-1*. *Exhibit A5-2* presents a map of land use for the watershed as of 2010. Development has occurred over many decades to the extent that some neighborhoods are culturally significant for their historic value and relevance to the social fabric of the community at large.

Table A5-1:
Distribution of Land Use in the Hunting Bayou Watershed, 1998

Land Use Area (acres)	Area (acres)	Percent of Total Developed Area
Single-family residential	3,990	21.00
Multi-family residential	290	2.00
Commercial	600	3.00
Office	50	0.30
Industrial	2,820	15.00
Institutional	1,110	6.00
Parks	660	3.00
Agricultural	30	0.20
Utilities	560	3.00
Undeveloped	5,730	30.00
Other	3,160	17.00
Total	**19,000**	**100.00**

1.3.2 Population at Risk

Vulnerable populations with respect to flood hazards are those persons who lack the physical or emotional ability and/or the economic resources to cope with or respond to a flood threat and, therefore, are at a higher risk to suffer adverse consequences of a flood event. The Hazards and Vulnerability Research Institute, University of South Carolina, has identified demographic characteristics that are indicators of higher levels of social vulnerability. Included among these indicators are age, race and ethnicity, and socioeconomic status. Younger and older persons as well as minority and low-income groups are more likely to be vulnerable to a flood threat because they are more likely to lack the ability or resources to respond independently to secure their safety. Institutional or governmental assistance is more likely to be required to aid this population segment during emergency evacuations and post-disaster recovery. Other social characteristics indicate social vulnerability such as gender or health, but this analysis is confined to age, ethnicity, and poverty.

Social characteristics that suggest population vulnerability are in evidence within the Hunting Bayou study area based on 2010 Bureau of the Census data. The population within the 0.2 percent AEP floodplain is estimated to be 15,500 persons, 96 percent of which have a minority status as either Hispanic and/or black American. In contrast, Harris County has a minority population that is 60 percent Hispanic and/or black American.

The population living within the 0.2 percent AEP floodplain has a relatively higher dependency ratio—the proportion of younger (less than 18 years of age) and older (62 years and older)persons to persons in the working ages(18 to 61 years)—when compared with Harris County overall. The Hunting Bayou floodplain population has a dependency ratio of 0.72:1.00 meaning that for every 100 persons residing in the floodplain in the working ages, there are 72 other residents that are either younger than 18 years of age or are 62 years or older. By comparison, Harris County has a dependency ratio of 0.63:1.00.

Slightly over 17 percent of the residents in Harris County live below the poverty level. The poverty rate within the Hunting Bayou study area averages 30.4 percent of the population. These indicators suggest that the population of the Hunting Bayou 0.2 percent AEP floodplain is at a higher risk for adverse consequences from a flood hazard or other disaster than the general population of Harris County.

1.4 Economic Reaches

Reaches are the primary economic subunits of analysis. Geomorphic conditions, land use, man-made physical barriers, type or level of existing protection, and consistency of the water surface profile are criteria used in designating reaches. The economic reaches along Hunting Bayou were delineated according to the following principles:

1. Beginning and ending stations for each reach were defined such that each reach had relatively consistent hydrology;

2. Each reach had similar flows at every cross-section with relatively small variations in the water surface profiles; and

3. Index locations, the point to which all damages within a reach were aggregated, were located at the cross-section with the highest concentration of structures in the reach.

The stream was divided into 23 economic reaches with representative index stations for modeling purposes, based on the criteria described. Structures within the economic study area were assigned to the nearest stream cross-section between Station 21+40 and Station 767+52. Each structure was associated with the left or right bank of the stream. Section letters from the then-current FEMA flood insurance study were used to identify each economic reach. The economic reaches are presented as follows in *Table A5-2*. A map of the reach delineations is found at *Exhibit A5-3*.

**Table A5-2:
Economic Damage Reach Delineations**

Economic Reach*	Beginning Station	Ending Station	Bank	Index Station	Description
D	2140	6110	Both	4062	Confluent to upstream from COH Water Plant
H	6111	9930	Both	9888	Upstream from COH Water Plant to PTRA Railroad
L	9931	13551	Both	13551	PTRA Railroad to Woodland Acres Subdivision
M	13552	17139	Both	16284	Through Woodland Acres Subdivision
O	17140	18385	Both	18335	Woodland Acres Subdivision to Jacinto City Limits
P	18386	22389	Both	20985	Jacinto City Limits to Market Street
R-Left	22390	25706	Left	25706	Market Street to IH 10
R-Right	22390	25706	Right	25706	Market Street to IH 10
T-Left	25707	28512	Left	25812	IH 10 to downstream from Herman Brown Park
T-Right	25707	28512	Right	28512	IH 10 to downstream from Herman Brown Park
U-Left	28513	32049	Left	30749	Downstream from Herman Brown Park to Herman Brown Park
U-Right	28513	32049	Right	30749	Downstream from Herman Brown Park to Herman Brown Park
V	32050	37029	Both	34658	Herman Brown Park to Wallisville Road
X	37030	41700	Both	41700	Wallisville Road to El Dorado Subdivision
Z	41701	46183	Both	44208	El Dorado Subdivision to Manitou Road
AE	46184	49831	Both	48479	Manitou Road to McCarty Road
AF	49832	53772	Both	52267	McCarty Road to Texaco Tank Farm
AG	53773	56554	Both	54950	Texaco Tank Farm to Englewood Railroad Yard (ERRY)
AH	56555	59445	Both	58305	ERRY to IH 610 (Second Crossing)
AI	59446	62067	Both	61162	IH 610 (Second Crossing) to downstream from Homestead Road
AL	62068	66172	Both	65654	Downstream from Homestead Road to Hutcheson Park
AP	66173	72006	Both	70462	Hutcheson Park to Hirsch Road
AZ	72007	76752	Both	76752	Hirsch Road to upstream watershed boundary

**Cell color corresponds to Lower, Middle and Upper Stream Segment aggregations.*

2.0 ANALYTICAL METHOD, MODEL, AND DAMAGE CATEGORIES, 2001

2.1 Analytical Method

Damages prevented to economic assets within the economic study area are based on a comparison of the future most-likely WOP conditions in the absence of federal action to a variety of alternative With Project conditions. Benefit categories investigated for FRM projects consist primarily of inundation reduction to economic assets within the most likely future WOP 0.2 percent AEP floodplain. The Hunting Bayou GRR/EA considered inundation reduction to structures and contents; inundation reduction to utilities, vehicles, and roads; and reduction in post-disaster losses sustained by individuals following flood events, such as temporary relocation and reoccupation costs. Reduction in administrative costs to the National Flood Insurance Administration (NFIA) is another benefit category applicable to removing structures from the regulatory NFIA floodplain. Lastly, advance bridge replacement is calculated as an NED benefit.

2.2 Analytical Model

The Hydrologic Engineering Center Flood Damage Analysis (HEC-FDA) computer program, Version 1.2, March 2000, was used in the economic analysis for the 2001 model execution to integrate hydrology and hydraulics (H&H) data with economic damage analysis for creation of average annual equivalent economic damages. As described in Section 11 of this Appendix, the certified version 1.2.4 was used in the final 2013 iteration. Please refer to that section for additional information.

2.3 Damage Categories

For the initial model development and early component screening and plan reevaluation, damage categories and occupancy types used to estimate inundation damages to structures and contents were based on a USACE New Orleans District (NOD) study entitled "Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-To-Structure Value Ratios in Support of the Jefferson and Orleans Flood Control Feasibility Studies," prepared by GEC, Inc., June 1996. The depth-percent damage relationships established in the NOD study are applied to the Hunting Bayou study due to similarities in structure type and construction practices in New Orleans and Houston. The damage categories used for this study are discussed in more detail below.

2.3.1 Damages to Residential Structures and Contents

The NOD study served as the source for the single-family residential, multi-family, and mobile home depth-percent damage functions with uncertainty. At the time of the Hunting Bayou federal study initiation in 1998, the NOD study provided depth-percent damage curves for residential structures and contents at a time when no other curves that expressed uncertainty were available. It was not until 4 Dec 2000 that the single-family residential generic depth-percent damages curves in EGM 01-03 were published. The NOD curves were thought to better reflect the building characteristics and damage potential of housing construction in the Harris County, Texas area. (The generic curves were adopted for use in the plan reevaluation iterative update in 2009).

Residential structure damages include inundation losses for single-family dwellings classified as one-story on pier or slab; two-story on pier or slab; mobile home; and multi-family residences classified as metal frame structures, masonry bearing wall structures, or wood- or steel-frame structures. Separate depth-percent damage relationships based on the NOD study were applied to the residential inventory, based on the classification of each structure. Content damages were calculated using separate depth-percent damage relationships for single-family classifications of one-story, two-story or mobile home, and for multi-family.

Content-to-structure values ratios (CSVRs) for all residential structures were taken from the NOD study. Rather than use the recommendations directly from the NOD study which was based on a minimal sampling effort, the team economist recommended using ratios defined by the Flood Insurance Administration (FIA). These CSVRs were 63 percent for one-story homes and 53 percent for two-story homes. Attachment A5-2, 6 June 2005, which is available upon request, summarizes the analysis that led to using the FIA CSVR data. Refer to Section 11 for a discussion on the depth-damage functions and CSVRs used in the final 2013 reevaluation.

2.3.2 Damages to Commercial Structures and Contents

Commercial damages include losses to properties used in commerce, industry, business trade, servicing, or entertainment. Separate depth-damage relationships were used to assess inundation damages to commercial structures and contents, based on depth-percent damage relationships derived in the NOD study. Commercial structures were classified by three different exterior construction types, each with a unique depth-percent damage relationship with uncertainty. The three exterior construction types are metal frame walls, masonry walls, and wood- and steel-frame.

Contents for commercial properties were classified into six separate damage categories with unique stochastic depth-percent damage relationships. The six commercial content categories are eating and recreation; groceries and gas stations; professional businesses; repairs and home use; retail and personal services; and warehouse and contractor services. Content values for the six commercial content categories were adopted from CSVRs developed for the NOD study. The CSVRs also are expressed as values with associated uncertainty.

2.3.3 Damages to Public Structures and Contents

Public damages include damages to public facilities such as public buildings, parks, and other facilities, including equipment and furnishings owned or operated by federal, state, county, and local governmental entities. Since most public structures are tax exempt entities, HCAD did not report structure values for several public properties. All those properties were field inspected and a Marshall & Swift (M&S) value estimate performed. Separate depth-percent damage relationships were used to assess inundation damages to public structures and contents. The damage relationships and CSVRs were borrowed from the NOD study and are expressed stochastically.

2.3.4 Lyndon B. Johnson (LBJ) General Hospital

The LBJ Hospital is a major Level 3 Trauma Center hospital located within the 0.2 percent AEP floodplain of Hunting Bayou. The hospital opened in 1989 and is owned and operated by the Harris County Hospital District, a tax-supported public entity. The hospital is a full-service general hospital for indigent patients in Harris County, Texas. The LBJ Hospital is a partner of the University of Texas – Houston Medical School system and has 328 beds. Although a Level 3 trauma center does not have the full availability of specialists, the hospital does have resources for emergency resuscitation, surgery and intensive care for most trauma patients.

The LBJ Hospital is a major hospital in the Hunting Bayou study area. Therefore, a replacement cost new less depreciation was performed by licensed appraisers. An extensive list of contents and physical characteristics was supplied by the Harris County Hospital District specifically for development of structure and content values.

2.3.5 Ancillary Damage Categories

Ancillary damages are those that are not specifically related to physical damage to structures and their contents and include damages to vehicles, public utilities, roads, and post-disaster costs to the flooded household. Unit values applied to ancillary damages were based on previous studies in other watersheds in Harris County. In an attempt to obtain more recent values that were site-specific to the Hunting Bayou watershed, a study was undertaken by GEC, Inc. in October 1998 to validate vehicle, utility, and road damage as well as post-disaster costs. Public agencies, including government agencies at all levels, commercial, and non-profit organizations were contacted regarding historical flooding events in the Houston area. The GEC study determined that because of the sparse data, the figures from previous USACE studies in Harris County, updated to current price levels, were the best estimates available.

2.3.5.1 Income Elasticity Adjustments

The investigations performed by GEC were primarily based on data from a 1997 USACE study of Cypress Creek, Texas. Housing values and average incomes in the Cypress Creek watershed are substantially higher than those in the economically disadvantaged Hunting Bayou watershed. In order to apply the data from the Cypress Creek study to Hunting Bayou, adjustments were made to the vehicle values and road costs in the Cypress Creek report, based on the differences in household incomes of the two watersheds.

Average incomes were determined according to census blocks for both the Cypress Creek and Hunting Bayou watersheds. The average income in the Hunting Bayou watershed was determined to be 31 percent of that in the Cypress Creek watershed. These “income elasticity” adjustments were then applied to unit costs for roads and vehicles, under the assumption that the average vehicle value would be directly proportional to income.

Since the utility values and post-disaster costs are more likely to be similar in both watersheds, damages in these categories were not adjusted.

2.3.5.2 Vehicles

The nature of development within Harris County is such that streets are graded lower than the surrounding land in order to function as tertiary drainage from the surrounding urban development. Due to the dual function of roadways for transportation and drainage, vehicles are especially vulnerable to damage from flooding. In a 1989 Houston residential flood survey, the Institute for Water Resources (IWR) found that, on average, each flooded household lost one vehicle to flooding, exceeding $7,500 per vehicle. Flood damage to vehicles includes the labor and parts to dry out and replace materials, as necessary, whenever a vehicle is inundated. The vehicle damage per flooded household value was adjusted to a 2001 value of $10,452 by applying the relative percentage increase in the Consumer Price Index (CPI) over the time period. This value was then adjusted according to the income elasticity described above, resulting in an average vehicle damage value of $3,240.

Vehicles were put into the structure inventory database within HEC-FDA as a "simulated structure," so that the model could compute the vehicle damages with uncertainty. A ratio of one vehicle to one living unit was assumed for each residential type of dwelling. The number of living units was available from the HCAD database. In this way, multi-family structures were assigned the appropriate number of vehicles to correspond with their living units. Single-family residential and mobile homes were assigned one vehicle each. In cases where data on living units were missing or inconsistent with the structure type, field verification was performed to determine the number of living units. In subsequent iterative updates of this analysis, Economic Guidance Memorandum (EGM) 09-04 (22 June 2009) was implemented in response to the vehicle damage category.

2.3.5.3 Public Utilities

Public utility damages include losses to electrical transformers and transmission lines, telephone company lines and switch boxes, and water and gas pipelines. Damages were developed by the Institute for Water Resources (IWR) following Tropical Storm Claudette which flooded Harris and Galveston Counties, in July, 1979. IWR estimated unit damages to public utilities at $77 per flooded structure. This average damage value per structure flooded was updated to a February 2009 value of $220 by applying the relative percentage increase in the Consumer Price Index-All Urban Consumers (CPI-U) over that time period. Utility damages were calculated outside the HEC-FDA program using the distribution of flooded structures by reach within the eight AEP floodplains and applying the unit damage value of $220.

2.3.5.4 Roads

Road damages include repair costs for roads, bridges, street signals, and street lighting. In order to compute road damages using HEC-FDA, road miles were distributed to all structures in the watershed, according to each economic reach, using a Texas Department of Transportation (TxDOT) GIS map of road miles. A different ratio of road miles per structure was developed for each economic reach.

An investigation performed by GEC was based on data from a 1997 USACE study of Cypress Creek, Harris County, Texas. Housing costs and average incomes in the Cypress Creek watershed are substantially higher than those in the economically disadvantaged Hunting Bayou watershed. To apply the data from the Cypress Creek study to Hunting Bayou, adjustments were made to the costs in the Cypress Creek report, based on the differences in household incomes of the two watersheds.

Although difficult to quantify, it was necessary to make some adjustments to the Cypress Creek road costs, since Hunting Bayou has a smaller percentage of curb and gutter streets and more roadside ditch systems. Also, since the development in Hunting Bayou is generally older than that in Cypress Creek, in many cases the streets are narrower and in worse condition. All these considerations indicate an overall lower unit road cost for Hunting Bayou. Therefore, a modified income elasticity adjustment was made for the unit road cost to account for the comparatively worse road conditions.

A dollar value of damage per road mile presented in the GEC, Inc. study was obtained from the Cypress Creek study ($8,500 per mile) and then adjusted for income elasticity as described to

$5,568 per mile. This value was then adjusted to a year 2001 price level using the CPI, which equaled $6,496 per damaged mile. The dollars of damage per road mile were then distributed to each structure in the watershed by economic reach. When the water surface elevation (WSEL) exceeded the road elevation, 100 percent of the damage would be applied to that portion of the road represented by the structure. On average, this value equates to $117 of road damages per flooded structure. *Table A5-3* shows the road mile distribution by economic reach used in the HEC-FDA analysis.

Table A5-3:
Road Damages Computation for Input into HEC-FDA

	Road Miles			Road Miles Per	Damage Value	Road Damage	Total Road Value
Economic Reach	**Length (feet)**	**Length (miles)**	**Total Structures**	**Structure (mile/structure)**	**Per Road Mile ($/mile)***	**Per Structure ($/structure)**	**Per Economic Reach ($)**
AZ	584,130	110.63	6,486	0.0171	$6,496	$110.81	$718,692
AP	380,159	72.00	5,159	0.0140	$6,496	$90.66	$467,734
AL	114,391	21.66	1,100	0.0197	$6,496	$127.95	$140,743
AI	71,448	13.53	437	0.0310	$6,496	$201.16	$87,906
AH	20,667	3.91	65	0.0602	$6,496	$391.19	$25,428
AG	114,404	21.67	1,108	0.0196	$6,496	$127.04	$140,758
AF	86,640	16.41	537	0.0306	$6,496	$198.51	$106,599
AE	63,451	12.02	102	0.1178	$6,496	$765.38	$78,068
Z	46,272	8.76	458	0.0191	$6,496	$124.31	$56,932
X	31,080	5.89	134	0.0439	$6,496	$285.37	$38,240
V	13,589	2.57	36	0.0715	$6,496	$464.41	$16,719
U	40,586	7.69	557	0.0138	$6,496	$89.65	$49,935
T	103,967	19.69	1,115	0.0177	$6,496	$114.72	$127,917
R	141,086	26.72	971	0.0275	$6,496	$178.77	$173,587
P	104,867	19.86	1,735	0.0114	$6,496	$74.37	$129,025
O	48,565	9.20	955	0.0096	$6,496	$62.57	$59,753
M	45,558	8.63	521	0.0166	$6,496	$107.59	$56,053
L	35,074	6.64	251	0.0265	$6,496	$171.93	$43,153
H	3,195	0.61	1	0.6052	$6,496	$3,931.40	$3,931
D	12,078	2.29	0	-	$6,496	-	-
Total	**2,061,206**	**390.38**	**21,728**				
Average Miles per Structure			0.0180				
Average Road Damage per Flooded Structure			$116.72				

Based on 2001 value determined for this study by GEC, Inc.

2.3.5.5 Post Disaster Costs

IWR's 1990 survey of flood victims within the Cypress Creek and Greens Bayou watersheds in Harris County revealed other costs associated with flooding which were not otherwise quantified. These costs include lodging, travel, food, vandalism, looting and medical costs, costs for clean up, and costs for moving and storing furniture all associated directly with the flood experience. On average these types of costs exceeded $5,700 as reported by surveyed households. The distribution of residences by flood elevation was used with the unit damage value to assess the post disaster costs associated with flooding.

2.4 Savings in National Flood Insurance Program (NFIP) Costs

Benefits can be derived from a reduction in administrative costs to the NFIP if an insured structure is removed from the 1 percent AEP floodplain with implementation of a proposed plan. According to EGM 03-03, 11 Apr 2003, the average cost of administering a flood insurance policy was estimated to be $133 for Fiscal Year 2003.

Based on information provided by FEMA on flood insurance policyholders, fewer than 400 flood insurance policyholders were enrolled in the NFIP in Hunting Bayou's 1 percent floodplain in 2001. With 4,100 single-family homes in the 1 percent floodplain, this represents less than ten percent participation in the study area. The low participation rate can be partially attributed to the demographic profile of this area. Lower income areas have lower insurance participation due to lower rates of home ownership and less disposable income to spend on insurance. The annual cost of administering policies for these structures is estimated to be less than $53,200 total. This figure represents the maximum benefit that can be accrued in this category by any candidate plan and was therefore not pursued further for benefit calculation.

2.5 Advance Bridge Replacement

It is USACE policy to allow NED benefit calculation for the advance replacement of bridges as a consequence of constructing civil works projects. Two aspects of advance bridge replacement are considered as benefits to the nation: 1) extending the useful life of an existing bridge; and 2) reduced Operation and Maintenance costs associated with replacing an older bridge with a newer one, the assumption being that a newer bridge will require less investment in repair and rehabilitation over the 50-year period of analysis as opposed to the existing bridge. Because of the nature of the Hunting Bayou watershed and its level of development, replacement of bridges could constitute a significant cost to a federal project.

3.0 INITIAL DATA COLLECTION, VERIFICATION AND UPDATES

A Geographic Information System (GIS) was used for the Hunting Bayou watershed to assist in the data collection, manipulation, and evaluation process. The Environmental Systems Research Institute (ESRI) ArcGIS platform contains HCAD parcel base maps with an associated HCAD property database that contains numerous data elements or attributes of each parcel record.

3.1 Survey of Existing Economic Assets

The initial structure inventory of existing development performed in 1998 encompassed the entire watershed of Hunting Bayou. Mapping data sources included:

1. New aerial survey with 1-foot elevation resolution for the lower reaches of the watershed.

2. Set of planimetric maps that included 2-foot interval contours obtained from the COH Monumentation and Mapping Program. These maps were digitized and used to complete the remaining areas within the 0.2 percent AEP floodplain.

3. USGS Digital Elevation Models (DEMs) based on 5-foot contour mapping data were used to supplement the remaining area of the watershed, outside of the 0.2 percent AEP floodplain. A Digital Terrain Model (DTM) was created using topographic data sources.

All of these geographic data sources were related digitally, using ESRI ArcGIS. Economic work maps were generated as necessary, although most work was done directly using the GIS.

The primary source of economic information was the Harris County Appraisal District's (HCAD) 1998 database of structure values and GIS files that depict parcel and address locations. Three data sets were obtained from HCAD: Appraised Value (AV) data, Personal Property (PP) data, and Computer-Assisted Mass Appraisal (CAMA) data. Combined, these three data sets provided valuable information about property location, number of stories, foundation type, structure type, land use category (occupancy type), age of the structure, and the replacement cost new less depreciation (RCNLD) value for the structures. The structure data associated by HCAD account number were subsequently assigned a unique numerical identification (structure name) for each parcel.

The HCAD account number is not always a unique value. In cases where multiple structures are on the same parcel, the same HCAD account number is used for all of these structures. Afield in the HCAD data set called "NUMCRD" (number of cards) indicates these cases. Therefore, a 15-digit ID was constructed from the 13-digit HCAD account number plus the last two digits of the "NUMCRD" field, resulting in a unique ID for each structure for input into the HEC-FDA model.

The stream station nearest to each structure was determined by spatially relating structures to cross-sections in ESRI ArcGIS. Structures were assigned to either the left or right bank of the stream.

Using the DTM that was developed for the project, a ground elevation was assigned to each structure in the watershed. The vertical datum used for the assignment of ground elevations was the National Geodetic Vertical Datum (NGVD) of 1929, 1973 adjustment, which is the same datum used in the hydraulic analysis for Hunting Bayou.

A field survey of all structures within the 0.2 percent AEP floodplain was performed to determine a first-floor correction for each structure in the study area. The first-floor correction was visually estimated from the ground elevation at each structure. The field survey was also used to obtain pertinent structure data, including land use and the number of living units in each structure. The average slab heights for both residential and non-residential structures were computed and applied to all structures outside the 0.2 percent AEP floodplain.

3.2 Structure and Content Values

Several sources and methods were employed in the estimation of values for structures and contents within the study area.

3.2.1 Structure Values

USACE guidance states the correct measure of structure values for estimating inundation reduction benefits when depth-damage functions are used is replacement cost new less depreciation (RCNLD). The RCNLD appraisal method entails initially valuing a structure on its full replacement cost and then applying a depreciation factor to that structure that reflects its physical condition. Estimated values for residential, commercial, and public properties identified in the structure inventory are based on the 1998 HCAD RCNLD values and were subsequently adjusted to 2001 values.

3.2.1.1 Residential Structure Values

HCAD property data for residential properties were developed using a cost approach consistent with ER 1105-2-100. The cost approach is the foundation of the property tax appraisal system for HCAD, which assesses the improvement value using estimates of what it would cost to replace the improvements (structures) and then subtracts an amount for accrued depreciation. The cost approach provides a structure value consistent with the required (RCNLD) value.

3.2.1.2 Non-residential Structure Values

For non-residential structures, HCAD uses a number of different valuation methods including the Cost Approach, Income Approach, and Market Approach. Sampling was also performed to validate the use of HCAD data using the M&S Commercial Cost Estimator Program.

In order to achieve higher accuracy, a field survey form and M&S Commercial Estimator Worksheet were prepared for each of the surveyed structures. The size of each structure was obtained from the field survey. Building class was also established based on the M&S cost groups, depending on type of framing wall, floor and roof structure, and fireproofing. This information was used to obtain a unit cost for the structure. The basic cost estimate was refined according to the quality of construction by qualifying the level of workmanship, quality of materials, and quantity of components relative to a typical structure in its class. A replacement cost for the structure was estimated from the unit cost and building size. The effective age or remaining life of the structure was then estimated to determine percent depreciation based on M&S depreciation tables. The RCNLD value was obtained by subtracting percent depreciation from replacement cost.

An appraisal for the LBJ Hospital was performed by Arthur Andersen, LLP, in 1998 to obtain the structure and content values based on the RCNLD value. Direct estimation techniques were also employed to obtain structure values for five schools. Direct estimation techniques were warranted for these public properties since the HCAD does not typically evaluate tax-exempt properties.

3.2.2 Content Values

Contents data were available for commercial properties only on a limited basis within the HCAD personal property database. In cases in which a business owner owns multiple properties, this value may include contents values for multiple structures, not just the structure itself, resulting in inaccurate contents values. Therefore, content-to-structure value ratios (CSVR) were used to determine the content values in almost all cases. In one case, the results from actual content surveys received from a business owner were put into the structure inventory database.

CSVRs for all structures without surveys were taken from the USACE New Orleans District (NOD) study entitled "Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-To-Structure Value Ratios in Support of the Jefferson and Orleans Flood Control Feasibility Studies," prepared by Gulf Engineers and Consultants (GEC), Inc., June 1996.

The NOD study was deemed applicable to this study due to the relative proximity of the Hunting Bayou and New Orleans study areas and their close similarities in construction type, economies, and incomes as well as the nature of the flood experience. The NOD study was reviewed and analyzed by a University of Houston economist for its applicability to the Hunting Bayou watershed.

3.3 Field Sampling

Based on the HCAD data set, there were nearly 22,000 structures within the geographic boundary of the Hunting Bayou watershed in 1998. Of these, about 6,500 were located within the limits of the 0.2 percent AEP floodplain. Of the structures located within the regulatory 0.2 percent floodplain, 90 percent are single-family residential (SFR) buildings, 2 percent were multi-family residential (MFR) buildings, and 8 percent were non-residential buildings.

A 100 percent field survey was performed for all structures located within the regulatory 0.2 percent AEP floodplain to verify their existence. In addition, the survey verified the structure as either residential or non-residential and further described the type of land use. In accordance with ER 1105-2-100, a stratified sample of properties in the study area was surveyed to validate the structure values obtained from HCAD. The use of sampling also provided a quantifiable measure of the uncertainty in the estimated values. The sample design was based on the inventory of structures by structure type and by the total number of structures in each reach.

A stratified pilot sample of 570 structures was randomly selected for the appraisals using the M&S Residential and Commercial Estimator programs. The sample distribution included 482 single-family residential structures, 32 multi-family residential structures and 56 commercial structures. A statistical evaluation of the pilot sample and HCAD structure values was performed to determine the level of precision based on a 90 percent confidence interval level and to test the mean relationship between the sample and HCAD structure values.

The sampling procedure consisted of a drive-by evaluation of structure square footage, exterior, floors, foundation, and extent of depreciation. The field survey data was then put into M&S's Residential Estimator software to estimate the RCNLD value. Attachments A5-1 through A5-8, 6 June 2005, describe the procedures and results of the methodology described and are available upon request.

The final 2013 reevaluation verified and updated the floodplain inventory to ensure the values represented the most recent data available. Refer to Section 11 for discussion and details on approach, assumptions and methodology.

4.0 RISK AND UNCERTAINTY PARAMETERS

The analytical method incorporates descriptions of uncertainty within key parameters and functions into project benefit and performance analyses. ER 1105-2-101, 3 January 2006, states uncertainty for urban areas will be expressed in the following economic variables: depth-percent damage relationships; structure values; content values; and structure first-floor elevations. These elements of analysis are described below along with the method by which uncertainty is expressed.

4.1 Uncertainty in Depth-Percent Damage Relationships

The depth-damage functions produced for the NOD by GEC, Inc. in 1996 were deemed appropriate to the Hunting Bayou study area because of similar flooding characteristics and construction techniques within Louisiana and Texas. The NOD study was developed by employing expert elicitation as a credible source for estimating inundation depth-percent damage to structures and contents and for estimating content-value-to-structure-value relationships. These depth-damage relationships and CSVRs were created with an expert elicitation technique and incorporate uncertainty in their estimates.

4.1.1 Single-Family Detached Residential Structure Depth-Damage Curves

Prior to 2009, the estimate of single-family residential damages for the Hunting Bayou GRR/EA was based on the NOD study. In this study, single-family residential structures are differentiated as pier-and-beam or slab-on-grade construction and as either one-story or two-story structures to which corresponding depth-damage curves were applied.

4.1.2 Mobile Home and Multifamily Structure Depth-Damage Curves

Mobile home and multifamily structure depth-damage relationships were also taken from the NOD study. CSVRs were also adopted from the NOD study.

4.1.3 Commercial, Public, and Industrial Structure Depth-Damage Curves

Commercial, public and industrial depth-damage functions for this analysis were also adopted from the referenced NOD study. Structure depth-damage functions pertain to three generalized exterior construction types: metal frame walls, masonry-bearing walls, and wood- and steel-frame construction. Contents for nonresidential properties were classified into six separate content categories, each with unique depth-percent damage relationships expressed with uncertainty. The seven commercial content categories are eating and recreation; groceries and gas stations; public and semi-public; professional businesses; repairs and home use; retail and personal services; and warehouse and contractor services.

4.1.4 Lyndon B. Johnson (LBJ) Hospital Structure Depth-Damage Curves

A depth-percent damage curve for LBJ Hospital was taken from the USACE Galveston District depth-percent damage curves for hospitals. Uncertainty was estimated for this curve by averaging the uncertainty percentages for the other commercial damage categories.

4.2 Uncertainty in Estimation of Structure Values

USACE guidance states the correct measure of structure values for estimating inundation reduction benefits when depth-damage functions are used is RCNLD. RCNLD values are calculated by HCAD appraisers during the derivation of property appraised values. Estimated values for residential and nonresidential properties identified in the structure inventory were initially based on the 1998 Harris County Appraisal District's (HCAD) replacement cost new less depreciation (RCNLD) values. HCAD property data for residential properties are developed using a cost approach consistent with ER 1105-2-100. The cost approach is the foundation of the property tax appraisal system for HCAD, which assesses the improvement value using estimates of what it would cost to replace the improvements (structures) and then subtracts an amount for accrued depreciation. HCAD guidance reads, in part:

> *"In the cost approach method, the value of the land is determined separate from the value of the improvements on-the-land. The improvements are valued by first determining the replacement cost new (RCN) and adjusting for the depreciated amount of cost new…. Depreciation is expressed as a percent of replacement cost new." ("Commercial Comparable Property Analysis: Cost Approach," Harris County Appraisal District, August 11, 2010).*

Sampling was performed by an independent agent to validate the use of the HCAD data and to establish uncertainty for structure value estimates using the M&S Cost Estimator Program. The M&S cost approach is based on the M&S construction cost model with depreciated replacement cost obtained by using the following formula:

Depreciated Replacement Cost = Size X Unit Construction Cost X (1 - % Depreciation)

A reasonable estimate of percent depreciation is determined from the effective age or estimated remaining life of the structure.

4.2.1 Uncertainty in Single-family Residential Structure Values

Uncertainty in single-family residential structure values was based on a randomly selected sample of 482 structures within the inventory. Statistical techniques were applied by an independent real estate expert to derive uncertainty in the structure value estimates. Comparisons were made between HCAD values of the random sample and values obtained using M&S. Sample values were computed using both structure attributes from the HCAD database and from field surveys and then compared with the HCAD RCNLD values. This effort helped to establish the structure value estimate and its uncertainty. The uncertainty was calculated to be 34 percent for the single-family residential sample with a normal distribution assumed. Subsequently, an independent investigation was conducted by a certified master appraiser to validate the results of the sampling effort. A total of 80 structures from the original sample were reappraised in order to update the RCNLD values to 2001 price levels.

4.2.2 Uncertainty in Structure Values Other Than Single-family Residential

The structure inventory of non- single-family residential structures within the 0.2 percent AEP floodplain served as the population from which 88 structures were randomly selected. Among these structures are multi-family residences for consistency with the NOD study which included these structures among its commercial structure inventory. The sampling was further subdivided based on land-use code in order to obtain a stratified sample of the various commercial and industrial properties within the floodplain. The HCAD RCNLD values of the non-single-family residential structure sample were compared with M&S derived RCNLD values computed with field surveyed data. The level of precision of the sample was determined to be 11.7 percent of the mean ratio at the 90 percent confidence level. The value estimate uncertainty was computed to be 67 percent.

4.2.3 Uncertainty in Lyndon B. Johnson (LBJ) Hospital Structure Value

The structure value for the LBJ Hospital was derived from an appraisal by a master appraisal firm. The uncertainty associated with this appraisal was estimated by the firm to be 10 percent of the true value.

4.3 Uncertainty in Estimation of Content Values

4.3.1 Uncertainty in Single-family Residential Content Values

The economic analysis performed in 2001 adopted the CSVRs produced by the NOD study for single family one-story structures and pier or slab and two-story structures on pier or slab. These CSVRs are expressed with uncertainty.

4.3.2 Uncertainty in Content Values Other Than Single-Family Residential

The economic analysis performed in 2001 adopted the CSVRs produced by the NOD study for mobile homes, multifamily residential structures and the seven commercial content damage categories: eating and recreation; groceries and gas stations; public and semi-public, professional businesses; repairs and home use; retail and personal services; and warehouse and contractor services. CSVRs specific to use were developed with uncertainty by the NOD study.

4.3.3 Uncertainty in Hospital Content Values

Based on the direct dollar valuation of this unique property of its structure and contents, the CSVR was computed to be 27 percent. The uncertainty associated with this appraisal was estimated by the firm to be 10 percent of the mean value.

4.4 Uncertainty in Structure Elevation

A sample was also performed of 452 structures in the 0.2 percent AEP floodplain to verify the accuracy of the structure elevation estimation method. Precision survey equipment was used to measure ground elevation and first floor elevation for each structure. The standard deviation of the difference between the approximate elevation and elevation by precision survey for all the surveyed structures was 1.14 feet. This error estimate was used in the HEC-FDA model to generate a normal probability density function to describe the uncertainty in estimating first-floor elevations for structures in both the residential and non-residential categories.

Table A5-4 displays the uncertainty parameters and their values applied to the Hunting Bayou GRR/EA in 2001.

Table A5-4:
Economic Uncertainty Error Types and Values for Key Variables, 2001

Damage Category/ Occupancy Type	Depth-Damage Function		Structure Value		CSVR		First Floor Stage	
	Structure Error Type	Content Error Type	Error Type	Standard Deviation (%)	Mean (%)	Standard Deviation (%)	Error Type	Standard Deviation (feet)
1-Story Single-Family	Triangular	Triangular	Normal	34.0	63.0	34.0	Normal	1.14
2-Story Single-Family	Triangular	Triangular	Normal	34.0	53.0	34.0	Normal	1.14
Mobile Home	Triangular	Triangular	Normal	34.0	50.0	34.0	Normal	1.14
Multi-Family Residences	Triangular	Triangular	Normal	51.0	53.0	51.0	Normal	1.14
Eating & Recreation	Triangular	Triangular	Normal	67.0	98.0	67.0	Normal	1.14
Groceries & Gas Stations	Triangular	Triangular	Normal	67.0	170.0	67.0	Normal	1.14
Professional Businesses	Triangular	Triangular	Normal	67.0	89.0	67.0	Normal	1.14
Public & Semi Public	Triangular	Triangular	Normal	67.0	42.0	67.0	Normal	1.14
Repairs & Home Use	Triangular	Triangular	Normal	67.0	121.0	67.0	Normal	1.14
Retail & Personal Services	Triangular	Triangular	Normal	67.0	107.0	67.0	Normal	1.14
Warehouse & Contractor Services	Triangular	Triangular	Normal	67.0	153.0	67.0	Normal	1.14
LBJ Hospital	Triangular	Triangular	Normal	10.0	31.1	10.0	Normal	1.14
*Vehicles	Triangular	N/A	Normal	51.0	N/A	N/A	Normal	1.14
*Utilities	Triangular	N/A	Normal	51.0	N/A	N/A	Normal	1.14
*Emergency/Post Disaster	Triangular	N/A	Normal	51.0	N/A	N/A	Normal	1.14
*Roads	Triangular	N/A	Normal	51.0	N/A	N/A	Normal	1.14

**Vehicles, utilities, emergency, and road costs were included as "simulated structures" within HEC-FDA*

4.5 Critical Uncertainty Parameters

The Hunting Bayou watershed is characterized by flat terrain which makes the estimation of elevation the most critical uncertainty parameter for HEC-FDA modeling. The necessity for elevation data is owed to HEC-FDA's modeling framework of implementing function relationships such as exceedance-discharge, stage-discharge, and stage-damage, for integrating expected annual damages. Elevation parameters are more influential on damages in flat watersheds, such as Hunting Bayou, where a small rise in WSEL can exacerbate the inundated area and damages. Moreover, the magnitude of structural inundation damages depends largely on a reasonable estimation of the flood stage and the elevation of the flood threshold of a floodplain structure. Accurate estimation of flood stage and structure first floor elevation in flat terrains is highly sensitive and may exceed the limitations of state-of-the-art techniques for ground elevation estimation and flood inundation.

4.5.1 Flood Stage Uncertainty

As outlined in Table 5-2 in EM 1110-2-1619, the minimum stage uncertainty to be used in an economic analysis is a function of the cross-section data and Manning's n-value reliability. For this study, the cross-sections are based on field surveys and a DTM. The Manning's n-value reliability is assumed to be fair since there is limited high water mark data on Hunting Bayou. Therefore, the modeling uncertainty used for this study is 0.7 foot according to Table 5-2 in EM 1110-2-1619. The stage-discharge uncertainty was computed using equations 5-1, 5-2, and 5-3 in EM 1110-2-1619. USGS stream gauge 08075770 (Hunting Bayou at IH-610) was used for calculation of the natural uncertainty. The stage-discharge uncertainty was calculated from the modeling uncertainty and the natural uncertainty and equals 0.7 per equation 5-6. The range for error is (+/-) 3 standard deviations or 4.2 feet, which is significant for an area as flat as the Hunting Bayou watershed.

The WSEL difference between the 2% and the 0.2% AEP event WSEL for the WOP condition ranges between 2.0 to 5.6 feet. In effect, the uncertainty band for any one event discharge encompasses the full range of event frequency median stages. When the HEC-FDA model samples stages for any probabilistic flood event, the samples can encompass almost the entire WSEL profile, from the 2 percent or the 0.2 percent event. The uncertainty associated with the flood stage is transferred to the stage at which damages begin accruing to floodplain structures.

4.5.2 Structure First Floor Elevation Uncertainty

The flat terrain makes estimating first-floor elevations for structures without basements, and the point at which damages accrue, equally sensitive. Obtaining highly accurate estimation of structure elevations may also exceed the ability of affordable techniques. This is especially true for Hunting Bayou, where the floodplain is broad and shallow, and thousands of structures were inventoried.

The structure inventory of existing development employed the following mapping data sources for estimation of ground elevation:

1. New aerial survey with 1-foot elevation resolution for the lower reaches of the watershed; and

2. Set of planimetric maps that included 2-foot interval contours obtained from the COH Monumentation and Mapping Program. These maps were digitized and used to complete the remaining areas within the 0.2 percent AEP floodplain.

A DTM was developed from these sources and ground elevations were assigned to each structure from the model. The National Geodetic Vertical Datum of 1929, 1973 adjustment, was used to assign ground elevations. This is the same datum used for Hunting Bayou's hydraulic analysis.

A field survey was performed for all structures within the 0.2 percent AEP floodplain to determine a first-floor correction for each structure in the study area. The first-floor correction was visually estimated from the ground elevation at each structure.

A sample of 452 structures in the 0.2 percent floodplain was used to verify the accuracy of the structure elevation estimation method. Precision survey equipment was used to measure ground elevation and first floor elevation for each structure in the sample. The standard deviation of the difference between the estimated structure elevation and structure elevation determined by precision survey for all the sample structures was calculated to be 1.14 feet. This error estimate was used in the HEC-FDA model to generate a normal probability density function to describe the uncertainty in estimating first-floor elevations for structures in both the residential and non-residential categories. Therefore the full range of error, which is +/- 3 standard deviations from the mean value, translates to 6.8 feet. This value constitutes the sampling range for a normal distribution for first-floor structure elevation within the HEC-FDA model.

The uncertainty from stage error and structure first floor elevation error reflect the uncertainty in the source data and the error associated with standard field data collection techniques exacerbated by flat terrain. The number of iterations for each stage ordinate in the stage damage function was increased to 1,000 in the Monte Carlo simulations in an effort to allow the resulting expected values to better reflect the error distributions.

5.0 FLOOD RISK REDUCTION MEASURES CONSIDERED

Structural and nonstructural measures were considered for FRM along Hunting Bayou. These measures can be adapted to address specific geomorphologic, political or socioeconomic issues and can be helpful alone or in combination with other measures.

5.1 Structural Measures

Structural measures consist of structures designed to control, divert, or exclude the flow of water from flood-prone areas to the extent necessary to reduce damages to property, hazard to life or public health, and general economic losses. The structural measures considered in the study were as follows.

- Complete channel modifications
- Bridge replacement
- Diversion
- Selected reach channel modifications with mitigation of water surface profile increases through selected detention
- Selected channel widening for in-line detention
- Detention only
- Levees

5.2 Nonstructural Measures

Nonstructural measures prevent flood damages by exclusion or removal of damageable properties from flood-prone areas. These measures do not affect the frequency or level of flooding within the floodplain; instead, they affect floodplain activities by altering the land use itself. The nonstructural measures considered in the various stages of the study included:

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

Implementation guidance for Section 219 of the Water Resources Development Act of 1999 for Nonstructural Flood Control Projects (22 January 2001) was followed in developing the methodology for evaluating nonstructural alternatives. Specifically, for benefit calculations, flood damage reduction benefits for evacuation projects were calculated as the total flood damages reduced.

5.2.1 Methodology for Determining Buyout Plan

Typically buyout alternatives are analyzed in terms of AEP floodplains (e.g., 0.50, 0.20, 0.10) using manual techniques to determine the best floodplain for the buyout. However, within these AEP floodplains, certain structures may not have positive net benefits for buyout but would be included simply because they are located within the floodplain.

For Hunting Bayou, HEC-FDA was used to determine the optimum buyout alternative. HEC-FDA output includes damage results at each individual structure in the database for eight different storm frequencies. Damages were then integrated over these frequencies to determine average annual equivalent damages for each structure. In cases where the annual damages exceeded an annualized value of the structure, the structure was selected for the buyout.

This methodology was developed rather than adopting the standard practice of selecting all structures within a standard floodplain because using this method ensures that only structures with positive net benefits are included and that the net benefits are maximized.

5.2.1.1 Real Estate Costs

In order to avoid double counting of the internalized portion of flood damages reduced, adjustments were made to the real estate costs used in the BCR calculation. In determining the value of floodplain land, comparable flood-free land costs were also determined and were used as proxy values when comparing total expected damages.

The steps used to determine comparable flood-free property costs are described below:

1. Determine Fair Market Value

   Market values for both structures and land were obtained from HCAD data. A sample of recent single-family residential property sales in the Hunting Bayou watershed was then compared to the HCAD data and indicated that the values for single-family residential properties should be inflated by 19 percent.

2. Determine Additional Costs

   Additional costs included relocation costs as provided by PL 91-646, the Uniform Relocation Assistance and Real Property Acquisitions Policies Act of 1970 (URA) and appraisal, survey, and administrative acquisition costs.

   Relocation

   A relocation cost of $3,500 per residential unit was used. This cost was applied to the number of living units in each residential structure. Relocation costs for commercial structures were assumed to be $3.50 per square foot of building area with a minimum cost of $3,500.

   Appraisal and Survey

   An appraisal and survey cost of $700 per structure was used for each structure.

   Administrative Acquisition

   An administrative acquisition cost of $1,900 per parcel was used.

3. Determine Flood-free Property Cost Adjustment

   A study conducted for the Hunting Bayou study area by Resource Economics in June 2000, compared land values inside and outside of the FEMA regulatory floodplain. The results of the study indicated that the value in dollars per square foot did not vary significantly whether or not the structure was located inside or outside the floodplain for most land use types. Therefore, no adjustment was made to account for the difference in land values between floodplain and non-floodplain land and no supplemental housing allowance was included as provided by the URA.

4. Determine Residual Land Benefit

   The land that would be evacuated through a nonstructural alternative will have some residual value. Since the land use of the evacuated land will be restricted to some type of park use or other green space, it was assumed to have a lower value than any of the other existing land uses. Based on the results of the June 2000 property value study, a value of $0.25 per square foot was used for residual land benefits.

6.0 THE WITHOUT PROJECT (WOP) CONDITION

6.1 No Action

A basic alternative in any FRM study is the No Action Alternative. This alternative assumes no action by the federal government to implement the project as recommended by this study. However, No Action 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 the expectation these activities and policies will continue over time. All these activities are expected to persist over the period of analysis to reduce flood hazards and to maintain the expectation of no increase in WSELs in the WOP condition over the 50-year period of analysis.

6.1.1 Ongoing Local Flood Risk Management (FRM) Practices, Policies and Programs

As part of their mission, the non-federal sponsor, Harris County Flood Control District (HCFCD) adopted policies and practices to the extent that new development must include measures to assure “no adverse impact” to the surrounding area’s water surface profiles for events up to and including at the 1 percent and 10 percent exceedance frequency. These policies and compliance requirements for development within Harris County are described in the non-federal sponsor, HCFCD, *Policy, Criteria, and Procedure Manual*, adopted October 2004 and updated December 2010. Because of 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 over the pre-development levels. *Because of this policy, the most likely future scenario for H&H is assumed to equal the current existing condition.* Even though the original 2001 reevaluation preceded this 2004 ordinance, the effect of it required an adjustment to the analysis whereby any projection of future WSEL changes were removed from economic damage models. The hydraulic modeling of future conditions was revised to equal the near term condition throughout this analysis. Other considerations for H&H are discussed in *Appendix 2 – Hydrology and Hydraulics*.

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 that 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 as well as to participants in their program.(see *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 the NFIP in the 1970s and comply with floodplain regulations to elevate new construction at or above the base flood elevation (BFE). Currently, COH policy requires new construction and substantial reconstruction first floor elevations within the 1 percent floodplain are built12 inches above the BFE. Both Harris County and the COH participate in the NFIP’s Community Rating System, which is a voluntary program for NFIP participating communities. The CRS has been developed to provide incentives in the form of insurance premium discounts for communities to go beyond the minimum floodplain management requirements to develop extra measures to provide extra protection from flooding. The extent of the premium discount is gauged upon 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 currently the largest city in the nation to achieve a Class 5 rating.

Harris County also maintains a "real time" flood warning system that 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 non-federal sponsor, 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, TxDOT, various river authorities and surrounding municipalities all contribute data for integration into the county-wide flood warning system.

6.2 Existing Economic Assets in the Without Project (WOP) Condition, 1998 Inventory, 2001 Price Level, FY 2004 Federal Discount Rate

Plan evaluations for this report are presented with the evaluation parameters that were current at the time of the evaluation in order to preserve the integrity of the process. Throughout the time of analysis, benefits and costs were consistently compared at similar prices and discount rates.

The structure inventory and the distribution of capital investment within Hunting Bayou's eight existing AEP floodplains are presented in *Table A5-5* and represent the 1998 structure inventory, 2001 price level and 2004 federal 5.625 percent discount rate. Based on these parameters, it was estimated 89 percent of the total structures in the estimated 0.2 percent annual probability floodplain were residential, which accounted for approximately $265 million in property value. The initial screening of measures and consequent plan reevaluation activities were based on this expression of the WOP condition for Hunting Bayou over the period of analysis.

6.3 Single Occurrence Damage

Damages expected to accrue from the various AEP events for the WOP conditions are displayed in *Table A5-7*. These values represent damages expected for individual events under the WOP hydrologic conditions and include structure, content, and nonstructural values. Values are based on 2001 price levels.

6.4 Average Annual Equivalent Damages (AAE)

AAE damages, computed with risk and uncertainty over the 50-year project life, are presented for the WOP conditions in *Table A5-7*. Approximately 78 percent of the AAE damages are concentrated in the four most upstream reaches: AZ, AP, AL, and AI, which extend from the second crossing of IH 610 to the upstream watershed boundary. In effect, over three-quarters of the flood damages within the Hunting Bayou watershed occur in the uppermost one-quarter of the stream length. Other areas of 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.

Table A5-7 also shows 56 percent of the AAE 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 AAE damages for the WOP conditions in Hunting Bayou are estimated at $22.4 million at 2001 prices and at the 2004 federal discount rate of 5.625 percent.

Refer to Section 11 (and following sections) for discussions of how the WOP condition was updated to reflect the most recent information available and to comply with new policy and guidance.

Table A5-5:
Distribution of the Economic Assets within the Without Project (WOP) Annual Exceedance Probability (AEP) Floodplain, Hunting Bayou, 1998 Inventory, 2001 Price Level

Damage Category	Annual Exceedance Probability (AEP) 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	-	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**

Residential content value assumed to be 50 percent of residential structure value.

Table A5-6:
Single Occurrence Damages by Annual Exceedance Probability (AEP) Event – Without Project (WOP)

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	$0	$451,498	$2,124,867	$3,609,802	$5,335,242	$7,317,216	$10,182,810	$11,535,649
Hospital	$0	$0	$0	$0	$0	$0	$0	$0
Public	$0	$320,727	$613,036	$1,035,896	$2,064,968	$2,386,577	$2,819,525	$3,132,517
Residential	$0	$5,556,453	$19,444,757	$32,174,631	$46,587,077	$61,306,624	$81,429,444	$89,119,353
Contents								
Commercial	$0	$856,000	$5,665,082	$10,642,582	$17,739,068	$26,554,641	$40,726,034	$47,315,072
Hospital	$0	$0	$0	$0	$0	$0	$0	$0
Public	$0	$57,000	$307,790	$598,521	$962,421	$1,171,164	$1,742,619	$2,034,949
Residential	$0	$2,276,000	$11,517,378	$21,189,156	$33,060,192	$46,126,437	$65,278,200	$73,245,432
Totals								
Commercial	$0	$1,307,498	$7,789,949	$14,252,384	$23,074,310	$33,871,857	$50,908,844	$58,850,721
Hospital	$0	$0	$0	$0	$0	$0	$0	$0
Public	$0	$377,727	$920,826	$1,634,417	$3,027,388	$3,557,740	$4,562,144	$5,167,466
Residential	$0	$7,832,453	$30,962,135	$53,363,787	$79,647,270	$107,433,061	$146,707,644	$162,364,785
Nonstructural								
Emergency Costs	$0	$3,220,548	$7,823,259	$11,253,885	$14,473,406	$14,919,656	$15,458,380	$15,877,316
Roads	$0	$153,634	$402,957	$618,438	$807,486	$832,446	$877,738	$910,886
Utilities	$0	$315,360	$765,949	$1,101,683	$1,416,882	$1,460,639	$1,513,336	$1,554,340
Vehicles	$0	$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	0.0%	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%	0.0%
Public	0.0%	2.6%	1.7%	1.8%	2.2%	2.0%	1.9%	1.9%
Residential	0.0%	54.6%	57.5%	58.7%	58.6%	60.0%	60.6%	60.4%
Emergency Costs	0.0%	22.5%	14.5%	12.4%	10.6%	8.3%	6.4%	5.9%
Roads	0.0%	1.1%	0.7%	0.7%	0.6%	0.5%	0.4%	0.3%
Utilities	0.0%	2.2%	1.4%	1.2%	1.0%	0.8%	0.6%	0.6%
Vehicles	0.0%	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%**

Table A5-7:
Distribution of Average Annual Equivalent Damages by Reach, Without Project (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 due to the uncertainty bands generated by the stochastic method of determining damages. Without uncertainty included in the average annual damage calculation, the AAEV damage to the LBJ Hospital would be zero. Uncertainty is applied to the LBJ Hospital structure value of $63 million, which was determined by direct appraisal.*

7.0 WITH PROJECT CONDITIONS FLOOD DAMAGES AND PLAN REEVALUATION

The process by which alternative flood reduction 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 that was identified through additional engineering, environmental, and economic planning analyses. The technical investigations followed the six-step planning process with consideration for the study objectives and constraints.

The initial investigation identified types of structural and non-structural flood risk reduction measures which were compatible with the flood situation, expected damages, opportunities for FRM, and surrounding topography. Effort was made to identify those types of FRM measures that were also socially desirable and implementable in keeping with the objectives and constraints of the study. An economic analysis then identified justifiable components that addressed project objectives as discussed in Section 4.6.2 of the GRR/EA. These components were evaluated in terms of average annual equivalent value (AAEV) net excess benefits to determine the optimum economic performance based on the federal objective. These measures were then screened with consideration given to technical, economic, social, and environmental impacts of each component.

The next step was alternative reevaluation, which entailed the systematic building of 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 of 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 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.

7.1 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 of most components to be formulated were determined. 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:

- the upper stream segment: from US 59 downstream to ERRY
- the middle stream segment: from ERRY downstream end 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 Houston Ship Channel

These stream segments incorporated economic reaches as noted in *Exhibit A5-3* and 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

It was recognized that three-quarters of the WOP condition damages were located in the upper one-quarter of the watershed in four economic reaches AI through AZ of Hunting Bayou's upper stream segment. Because of the concentration of damages upstream, the measures evaluation and optimization process should begin in the upper stream segment of the floodplain and then proceed toward the mouth of Hunting Bayou. Opportunities for reevaluation and discovery of a highly efficient FRM remedy would be more likely in the upper stream segment. For all measures and combined measures evaluation, the HEC-FDA model was used to compute AAEVs for flood damages reduced. In addition, cost estimates developed for each evaluation exercise were subsequently annualized to compute AAEV annual net excess benefits and BCRs at consistent price levels. The components that were evaluated are presented in *Exhibit A5-4* through *Exhibit A5-16* at the end of the appendix.

7.2 Reevaluation and Evaluation of 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 Replacement of 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 of each component in terms of AAEV net excess benefits are shown in the tables that follow.

7.2.1 Component A – Upper Stream Segment Detention

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

Seven detention basin sizes shown in *Table A5-8* were evaluated for Component A, and the optimal size was determined based on net economic benefits. Components A1 through A7 were all off-line 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 crossing of IH 610, 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 A5-8*. Component A3, which uses the entire tract area, provided the $4.612 million maximum annual net benefit and had a 2.50 BCR. In no case are WSELs increased by Components A1 to A7 along Hunting Bayou.

7.2.2 Component X – Combination of Detention Storage and Nonstructural Buyout

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

A total of six interconnected off-line detention basins were placed along Tributary H110-00-00. Their sizes are shown in *Table A5-8*. 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 A5-9*. It can be seen that Component X5, which utilizes 159 acres and impacts 837 residential units, provided the maximum annual net benefit of $8.366 million 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 contribution of FRM and the net excess benefits it produced, Component X violated a principal study constraint by requiring a very high level of population displacements in order to achieve its optimal performance.

Table A5-8: 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 A5-9: 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.

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

Combinations of 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 of Component X-A were tested for economic performance.

In order 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 in *Table A5-10*. The engineering analysis indicated that these sites are not independent in their performance. Their performances are hydraulically linked, and the performance of each influences the other in a symbiotic effect. The combination of the 40-acre Homestead site basin (A1) and the 159-acre H110 Detention Site basin (X5) produced annual net benefits of $8.3 million and was identified as the best performing detention combination for components A and X. Component X-A as presented in *Table A5-10* and *Table A5-11* utilizes 199 total acres and impacts 837 residential units. In no case were WSELs increased by Components X-A along Hunting Bayou.

Table A5-10:
Individual and Combined Annual Net Benefits of Detention Components A and X*
($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 A5-11:
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

Component	AAEV Project Cost	AAEV Damage Reduction Benefits	AAEV Net Excess Benefits	BCR
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.

7.2.4 Component B – Upper Stream Segment Earthen Trapezoidal Channel Modifications (US 59 to Englewood Railroad Yard)

The next measure optimized in the upstream segment of Hunting Bayou was 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.

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 of the channel modification components included in their design 30-acres of inline detention and the cost of replacing all of the bridges along the project length, except where indicated, during the bridge replacement analysis. Effects from replacing bridge crossings were evaluated independently of the effects of channel modifications.

7.2.4.1 Channel Length

The three channel lengths described below were analyzed for their flood damage reduction benefits. The lengths were chosen based on their proximity to the highly concentrated damage areas in the upper segment of the watershed.

- H112 to ERRY (B-60-2)
- US 59 to ERRY (B-60)
- US 59 to Wallisville Road (B60-3)

Four channel lengths were then analyzed to determine the optimized length of the B60 channel modifications: from US 59 to just downstream from ERRY (Component B60), from Tributary

H112-00-00 to just downstream from ERRY (Component B60-2), from US 59 to Wallisville Road (Component B60-3), and from US 59 to just downstream from ERRY with a bypass channel (Component B60-4). The economic performance of the various lengths of Component B60 is compared in *Table A5-12*.

A full-length channel alternative was not evaluated at this point in the plan reevaluation, because net excess benefits were shown to peak with the channel length from US 59 to ERRY (B-60). Net excess benefits decreased when the channel was extended downstream to Wallisville Road and also by including a short bypass channel around ERRY (B-60-4). The results of the analysis indicated Component B-60 from US 59 to ERRY had the greatest AAEV net excess benefits.

Table A5-12:
Component B – Channel Length Optimization*

Component ID	Component Description	Lots Impacted	Residential Units Impacted	AAEV ($1,000s)			BCR
				Damage Reduction Benefits	Cost	Net Excess Benefits	
B-60-2	Upper Reach Trapezoidal Earthen Channel Modification – ERRY to H112-00-00	61	35	$15,000	$5,600	$9,400	2.68
B-60	**Upper Reach Trapezoidal Earthen Channel Modification – US 59 to ERRY**	**94**	**66**	**$15,500**	**$5,500**	**$10,000**	**2.82**
B-60-3	Upper Reach Trapezoidal Earthen Channel Modification – Wallisville Road to US 59	139	66	$16,600	$8,300	$8,300	2.00
B-60-4	Upper Reach Trapezoidal Earthen Channel Modification – ERRY to US 59 (with Railroad Bypass)	125	69	$15,800	$6,900	$8,900	2.29

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

7.2.4.2 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 (B-40) to 140 feet (B-140). The analysis indicated a peak in net excess benefits between 60 feet (B-60) and at 100 feet (B-100), as shown in *Table A5-13*, 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, B-60, was identified as the preferred cross-section size. <u>The rationale for this decision was based on the economic efficiency in producing virtually the same net excess benefit outputs for the lowest investment</u>. Also the smaller channel width size addressed the study objective to minimize population displacements necessary to achieve FRM benefits.

7.2.4.3 Alternative Cross-Section Geometry

In addition to the earthen trapezoidal channel configuration discussed in the previous sections, two alternative cross-section geometries were examined in response to community concerns and consideration for more environmental and recreational opportunities. The alternative components were as follows.

1. B50-Concrete – A channel with a concrete-lined section from Homestead to US 59, sized to carry the same flows as B-60 (the best performing earthen channel). The concrete sides allow steeper slopes, reducing top width by 30 feet as compared to B60, thus requiring less ROW and residential displacements. Public meeting feedback included comments on minimizing acquisitions and relocations.

2. B-Terrace – A channel with equivalent capacity to B-60 consisting of a terrace on one side of a 7 to 9-foot-deep pilot channel. The terrace provides more area for environmental or recreational opportunities.

Table A5-13 includes the results for these two alternative cross-section geometries for comparison with the other channel modification components. These channel components provided favorable net benefits, but performed less successfully than most of the grass-lined channel sizes.

Table A5-13:
Upper Reach Grass-Lined Trapezoidal Channel*

Component ID	Channel Bottom Width (feet)	AAEV ($1,000s)			BCR
		Damage Reduction Benefits	Cost	Net Excess Benefits	
B-40	40	$14,800	$5,210	$9,590	2.84
B-60	**60**	**$15,490**	**$5,500**	**$9,990**	**2.82**
B-70	**70**	**$15,590**	**$5,740**	**$9,850**	**2.72**
B-80	**80**	**$15,990**	**$5,890**	**$10,100**	**2.71**
B-100	**100**	**$16,360**	**$6,470**	**$9,890**	**2.53**
B-120	120	$16,700	$7,140	$9,560	2.34
B-140	140	$17,040	$7,360	$9,680	2.32
B50-Concrete	50	$15,150	$5,900	$9,250	2.57
B-Terrace	10 (Pilot)	$15,880	$6,320	$9,560	2.51

**Rounding is for presentation of damage reduction and construction cost only.*
Based on 2001 price levels and 5.625 percent discount rate.

7.2.4.4 Bridge Replacement

During analysis of Component B, the effects of the 22 bridges crossing Hunting Bayou from US 59 through ERRY were evaluated to determine if channel modifications could be avoided in lieu of bridge modifications. The WOP condition water surface profile suggested that some bridges, particularly the second crossing of IH 610 and the most upstream bridge at the railroad yard, could be creating, or at least increasing, the backwater effect along the bayou. 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.

The analysis results are shown in *Table A5-14*. The best performing option was Bridge Option 4 with a reduction in annual damages of $6.4 Million.

The reduction in damages for the best performing channel modification component, B-60, was $15.49 million. Since B-60 included modifying all 22 bridges, an inference was made replacing or raising the bridges in the upper watershed accounted for $6.4 million, or 41 percent, of the flood damage reduction benefits attributable to B-60. The remaining 59 percent, or $8.7 million, in B-60 inundation damage reduction benefits, were attributable to the channel work itself.

The estimated cost for Bridge Option 4 was $44.3 Million, while B-60, including Bridge Option 4, was estimated to cost $91.4 million. Therefore, the bridge modification costs constituted 48 percent of the total channel modification costs. These results indicated that the channel modifications were the predominant action for flood damage reduction, but bridge modifications are a necessary addition to channel modification performance.

Consequently, all bridge modifications would be elevated to the BFE plus 1 foot to conform to COH ordinance. The low chord elevation requirement above the BFE is based on local construction rules set forth in Section 19-43 (c) (2) of Chapter 19 of the COH code of ordinances, 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 BFE. If the city engineer determines construction to this elevation is not practical based on applying 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.

Table A5-14:
Upper Reach Bridge Replacement*

Component ID	Component Description	AAEV ($1,000s)			BCR
		Damage Reduction Benefits	Costs	Net Excess Benefits	
Bridge 1	Existing Channel – Replace 610 Bridge (Second Crossing)	$2,190	$390	$1,800	5.62
Bridge 2	Existing Channel – Replace Upper Reach Railroad Bridge	$820	$150	$670	5.47
Bridge 3	Existing Channel – Replace Upper Reach Railroad Bridge and 610 Bridge	$3,290	$500	$2,790	6.58
Bridge 4	**Existing Channel – Replace all Upper Reach Bridges**	**$6,400**	**$2,660**	**$3,740**	2.41

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

7.2.4.5 Component B-60 Optimized

Component B-60 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 A5-15*, Component B-60 had the highest annual net benefits for the least cost. However, Component B-60 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 A5-15:
Economic Performance of Component B with In-line Detention Storage

Component	Description	AAEV Project Cost	AAEV Damage Reduction	AAEV Net Excess Benefit	BCR
B40	Upper Reach Trapezoidal 40-Ft BW Earthen Channel Modification – US 59 to ERRY	$5.21	$14.80	$9.59	2.84
B60	Upper Reach Trapezoidal 60-Ft BW Earthen Channel Modification – US 59 to ERRY	$5.50	$15.49	$9.99	2.82
B70	Upper Reach Trapezoidal 70-Ft BW Earthen Channel Modification – US 59 to ERRY	$5.75	$15.59	$9.84	2.71
B60-2	Upper Reach 60-Ft BW Trapezoidal Earthen Channel Modification – ERRY 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 – ERRY 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.

7.2.5 Component C – Upper Stream Segment Buyout

Component C was a nonstructural component that consisted of the buyout of 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.

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 net benefit of $3.762 million and a 2.06 BCR.

7.2.5.1 Recreation Benefit Analysis

The potential for recreation benefits from reuse of the land to be vacated by the buyout was investigated to make the buyout plan more socially acceptable and economically competitive. The Recreation Capacity Analysis (RCA) method contained in Appendix C of the Texas Parks and Wildlife Department (TPWD) 1995 Texas Outdoor Recreation Plan (TORP), Assessment and Policy Plan in conjunction with the Unit Day Value (UDV) method was used to estimate recreation project benefits. The 1995 TORP is available for review as Attachment 1 of Attachment A5-9, MFR to ATR, 14 Jan 2005.

The UDV method was chosen in accordance with the decision matrix contained in ER 1105-2-100 Appendix E, Figure E 10. To implement the evaluation procedure prescribed in ER 1105-2-100, Appendix E, Paragraph E-50.d., analyses were performed for all buyout components using the following steps.

7.2.5.1.1 Step 1 – Define the Study Area

The Hunting Bayou watershed was the overall study area. Service areas were defined within the study area for the populations that would realistically use proposed park facilities and were input into the RCA model. The study area was first divided into three areas corresponding to the upper, middle, and lower reaches. Service areas were then defined by identifying physical and traffic barriers that would potentially affect the usage of existing and proposed park facilities by area residents.

The Upper Stream Segment Buyout (Component C) service area was defined by Loop 610 in the north to Liberty Road in the south, Homestead Road in the east, and US 59 in the west. This service area was further divided to consider the major arterial roads that would function as barriers to local residential park use.

7.2.5.1.2 Step 2 – Estimate Recreation Resource

Existing park facilities like those proposed, were inventoried to estimate the available recreation resource and for subsequent use in the RCA model for determining facilities still needed. The updating and verifying of public park and School-Park (SPark) facilities was accomplished by using COH Parks Department information and previous inventories from the draft recreation plan and conducting a windshield survey of all the existing recreational facilities available in the service areas. The resulting inventory is available for review as Tables 1 and 2 of Attachment A5-10, Memo for ITR, 2 Jun 2005.

7.2.5.1.3 Step 3 – Forecast Potential Recreation Use in the Study Area

The TORP RCA was used to predict participation from the population served in the service area, which represents the potential recreational use. This was done for each category of activity. The categories of activities were chosen by investigating the comprehensive list of activities provided in the TORP, then considering the types of activities which already exist in the area or are planned for local park, and existing environmental, demographic and land use conditions, and available space. The activities assessed included general urban park activities like walking/jogging trails, softball/baseball fields, and playgrounds.

The appropriate U.S. Census Bureau population of each service area was then input into the model. The model proportions the service area population to a model-specific planning region population. The planning region population that maximizes recreational needs predicted by the model was chosen from among figures that assumed different migration patterns. The RCA analysis results for Component C are listed and available for review in Attachment 1 of Attachment A5-9, MFR to ATR, 14 Jan 2005. Column (5) of this reference shows the area participation, expressed as annual user occasions, predicted for each activity, which represents the potential recreation use.

7.2.5.1.4 Step 4 – Determine the Without Project (WOP) Condition

The WOP condition was determined by executing the model to compare the predicted needs against the existing resource to determined unfulfilled needs. This is reflected in the TORP procedures in which the current supply of activities planned is compared to the needs projected, and a shortfall in visit/use opportunities is calculated. Negative numbers suggested there was excess supply or the existing facilities are adequate to meet needs.

The facilities that were shown to be needed in the Component C service areas were trail miles, tennis courts, playgrounds, baseball fields and softball fields. Though the TORP results would be considered as a baseline of facility needs from which to plan and not an exact threshold. Facilities shown to be well in excess (negative result) of one facility would not be added, since it would strongly suggest adequate supply. As such, more picnic tables and basketball hoops would not be considered.

7.2.5.1.5 Step 5 – Forecast Recreation Use with Project in Place

The unfulfilled need predicted by the TORP served as a basis for planning. It was recognized the TORP should serve as a baseline from which the types and numbers of facilities would be based. The existing local master parks plans from both Harris County and COH were consulted to aid in planning appropriate facilities that would reflect local needs and input. The needs were examined considering the plans, the area demographics, the economic conditions, and the land constraints. Field visits were also conducted to help formulate a set of proposed facilities. A number of factors were used to guide the planning process, including:

- Considering geographical distribution and accessibility of facilities
- Providing facilities according to the parcel area availability
- Emphasizing extension of existing park facilities and using existing trails to link various planned facilities
- Configuring parks to avoid fragmentation and to maintain continuity.

COH and Harris County parks master plans both stressed development of greenway parks along bayous as a goal. Therefore, the overall concept used in planning facilities for Component C was to integrate facilities with an existing linear park hike and bike system.

The result of planning efforts was the proposed facilities are shown and available for review in Exhibit 1 of Attachment A5-10, Memo for ITR, 2 Jun 2005. These facilities would have provided approximately 167,820 annual user days for a variety of urban park activities.

7.2.5.1.6 Step 6 – Estimate Value of Use with Project in Place

The Unit Day Value (UDV) Method was applied using the annual days computed in the preceding step to estimate project benefits. The UDVs were chosen from the range identified in the USACE's Economic Guidance Memoranda (EGM) for FY 2001 and considering the quality of the proposed facilities.

Most of the ratings ranged in the average zone, because the recreational plan did not propose any new kinds of facilities in the area but instead focused on providing standard amenities required in urban parks. The point values for various criteria listed in this Table were summed with the Conversion of Points to Dollar Values Table from EGM01-01, to determine the General Recreation Value. The total point value was calculated to be 29 for Component C. The corresponding General Recreation Value was $4.23, giving the proposed facilities an estimated FY 2001 annual recreational value of $709,874.

7.2.5.1.7 Step 7 – Forecast Recreation Use Diminished With Project in Place

This step was not executed as the buyout plans do not impact existing parks.

7.2.5.1.8 Step 8 – Estimate Value of Recreation Use Diminished With Project in Place.

This step was not applicable as the previous step was not executed.

7.2.5.1.9 Step 9 – Compute Net Project Benefits

To compute net project benefits, a cost estimate was prepared for the proposed facilities, and subtracted from the estimated recreation benefits. The cost of recreation facilities was computed using the same unit costs employed in the Draft Hunting Bayou Recreation Plan (DHBRP). The unit costs of facilities were updated from FY 2000 to 2001 using the Consumer Price Index (CPI). The net benefit was calculated to be $414,302 annually (FY 2001) with a 2.4 BCR.

7.2.5.1.10 Conclusion of Recreation Benefit Analysis

The net recreation benefits when combined with the flood damage reduction benefits resulted in a total estimated AAEV net excess benefits of $4.31 million (FY 2001) for Component C. Thus, this component had a significantly lower net benefit than the top performing plans.

7.2.6 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 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 of the 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.

The unit costs for flood proofing were determined through soliciting cost estimates from several experienced local contractors. The unit costs are given below in *Table A5-16* for the three structure categories that were used. The costs are similar to those presented in a USACE case study on flood proofing, U.S. Army Corps of Engineers, Nashville District. *A Flood Proofing Success Story along Dry Creek at Goodlettsville, Tennessee*, National Nonstructural Flood Proofing Committee: April 1995.

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 benefit of $2.452 million and a 2.05 BCR.

Table A5-16:
Unit Costs for Flood Proofing, 2001

Cost Item	Residential Structures on Pier and Beam	Residential Structures on Slab	Non-Residential Structures
Raise structure ($/square foot)	$8.50	$20.00	$26.00
Additional cost to raise structure above 40 inches	$2,000	$2,000	$2,000
Repair and reconnect plumbing and other utilities	$5,000	$5,000	$5,000
Reconnect porches and/or construct stairs	$4,000	$4,000	$4,000
Repair interior damage (to sheetrock, etc.)	$1,000	$1,000	$1,000
Landscape and repair fences	$1,000	$1,000	$1,000
Administrative costs	$5,000	$5,000	$5,000

7.2.7 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 A5-17*, 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 that they were potential add-ons to Component B60 in the process of developing FRM alternatives.

Table A5-17:
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 in millions.
**Net excess benefits with added recreation for Component C = $4.31 M.*

7.3 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 because of 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)

7.3.1 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 bypass channel with an off-line detention basin located to the west of Herman Brown Park.

7.3.2 Component F – Middle Stream Segment Buyout

Component F was similar to Component C in that it consisted of the buyout of residential properties 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 that had 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 located in damage reach AF. Component F had AAEV net excess benefits of $0.122 million and a 1.84 BCR.

The potential for recreational benefits was investigated as was done for Component C. However, because the population calculated for the practical service areas was too small for model and because of the lack of suitable parcels for recreation facilities, recreation benefits were not explored further.

7.3.3 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.

A total of 41 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 located in damage reach AF. Component G has AAEV net excess benefits of $0.137 million and a 2.35 BCR.

7.3.4 Results of Middle Stream Segment Component Evaluation

Table A5-18 shows the non-structural Components F and G both 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.

Table A5-18:
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.

7.4 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)

7.4.1 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. The following sub-sections describe these optimization steps.

7.4.1.1 Optimization of Levee Height

The levee height was optimized assuming minimum internal drainage facilities in place. The minimum facilities provided protection to the interior areas for up to a 50 percent AEP storm event under gravity outlet conditions. For optimization purposes, three levee designs were analyzed that protected the interior areas from a spillover of Hunting Bayou for the 2, 1, and 0.4 percent AEP events. In accordance with ER 1105-2-101, freeboard was not considered in the analysis of the various levee heights. Eight storm frequencies were analyzed for each levee design to evaluate their effect on WSELs upstream and downstream from the levees. All levee designs increased WSELs upstream and downstream from the levees. By replacing the IH 10 bridge, the increases in WSELs were eliminated.

The results for the three levee designs are shown in *Table A5-19*. Even though all three levee designs resulted in negative net benefits, the 00.4 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 A5-19:
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

7.4.1.2 Optimization of Interior Drainage

As a result of the levees, there were three areas that required interior flood drainage facilities. One of these areas was located on the west side of Hunting Bayou, while the other two were located on the east side and were referenced as the southeast and northeast areas. The three areas were optimized separately to determine the optimum detention storage in combination with pumping that provided the highest AEP net excess benefits. The optimization of each of the three interior areas was performed by varying the size of the detention storage while holding the pumping rate constant. The lowest level of protection evaluated was with no detention and a functioning storm sewer system which, based on information from the COH, provided protection for about a 50 percent AEP storm event. For higher levels of protection, the gravity drains were assumed to be non-functional and were not included in the evaluation.

It was assumed for all plans involving detention and pumping, the pumping rate (outflow) from each interior area would be equal to the 50 percent AEP peak storm discharge. Pond depths were set at 15 feet while pond volumes were incrementally increased until AAEV net excess benefits peaked and began to decrease.

The pump sizes for each of the interior areas is as follows:

- Southeast Interior Area—three 20,000 gallons per minutes (gpm) pumps;
- Northeast Interior Area—four 20,000 gpm pumps; and
- West Interior Area—four 20,000 gpm pumps.

The capacities of each pump station were approximately equal to the 50 percent AEP discharge from each area.

The West and Southwest Interior Areas optimized with detention ponds of 30- acre-feet; the Northeast Interior Areas optimized with a detention pond of 90-acre-feet. The optimized levees and the three optimized interior drainage systems were then combined and evaluated as Component H (optimal).

7.4.2 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.

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.

7.4.3 Component J – Lower Stream Segment Detention

Component J consisted of an off-line 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.

7.4.4 Component K – Lower Stream Segment Buyout

Component K was the lower stream segment version of Components C and F. It consisted of the buyout of 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.

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. Most of the structures (56) are located in damage reach T-Left. Component K has $0.727million in AAEV annual net benefits and a 3.23 BCR.

Recreation benefits were investigated and facilities were proposed in the same manner as for Component C for the small number of parcels in this component. Details of this analysis are available for review in Attachment A5-9, MFR to ATR, 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 that of the best performing plans.

7.4.5 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.

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.

7.4.6 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). The economic performance of these components is compared in *Table A5-20.*

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. These four components were carried forward as potential additions to the upper stream segment components.

Table A5-20:
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.

7.5 Summary of All Stream Segment Optimized Components

The optimized scale of all stream segment components is summarized and ranked in *Table A5-21*. At this point, these stand-alone components are compared for their potential to be paired with other components in developing FRM alternatives.

Table A5-21:
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 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 reach segment produced the highest net excess benefits of all the other optimized components considered.

8.0 OPTIMIZATION OF COMBINED COMPONENTS

Of the 16 stand-alone components previously evaluated in the upper, middle, and lower stream segments, the best economically performing components were all upper stream segment components. Component B60 (channel modification only) 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 size was varied to determine the optimal combination. *Table A5-22* provides the scale of detention used in the optimization exercise. *Table A5-23* displays the economic results from the evaluation process.

In addition, residual buyout and residual flood proofing 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.

Table A5-22:
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

Table A5-23:
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 in millions.

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

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.

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

Alternative B50Con-A3 is similar to Alternative B60-A3 in that it consists of channel modifications from US 59 to just downstream from 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.

8.3 Alternative BTerrace-A3 – Optimal Detention With Upstream Earthen Terrace Channel Modifications (US 59 to Englewood Railroad Yard)

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.

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

Alternative B60-Buyout 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-C had an annual net benefit of $9.06 million 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 involved 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-Buyout is $9.49 Million (FY 2001).

8.5 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 4 of these structures were identified in the upper stream segment, and 31 in the middle stream segment. The remaining 83 structures are located in the lower stream segment. Alternative B60-Flood Proofing has AAEV net excess benefits of $8.871 million and a 2.51 BCR.

8.6 Alternative Size Combinations of 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 of these alternatives, it was determined optimum storage may be achieved by combining a smaller capacity channel than the best-performing channel (B60) with a larger detention basin than 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 of 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 to provide 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 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.

8.7 Results of Component Combinations

All top performing FRM measures evaluated in the component analysis were carried forward for further analysis and optimization for development of a potential NED Plan. Twenty-four variations of the combination of detention and channel modification were evaluated in addition to buyout and flood proofing as increments to the channel modification. The top performers for producing AAEV net excess benefits are shown in *Table A5-23*. The optimized B60 stand-alone component was compared against component combinations. Those combinations that produced greater AAEV net excess benefits than the stand-alone B60 component are highlighted in *Table A5-23*.

With so little variation in performance, it is reasonable to conclude that a combination of channel modification and detention basin was the optimized alternative for Hunting Bayou. Four channel modification and detention combinations, highlighted in *Table A5-23*, 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(40-acre) combination of channel modification, bridge replacement, and detention storage reduced AAEV damages by 75 percent for the watershed. Damages residual to implementing B50-A1 were distributed within the floodplain in a manner that restricted additional structural FRM components. A decision was made to wait until after the alternatives comparison to investigate additional nonstructural opportunities for FRM during the refinement of the channel modification, bridge replacement and detention storage combination.

9.0 ALTERNATIVES EVALUATION

The alternatives evaluation included combining one or more optimized components to form a plan that will exhibit positive AAEV net benefits and provide FRM to the study area. Detailed studies were performed based on available lands, property acquisitions, on-site environmental field investigations, and more refined engineering and economic data. Alternatives that were the best candidates for the NED Plan were subjected to further optimization. After the conclusion of the alternatives analysis, the alternative that maximizes AAEV net excess benefits is identified as the NED Plan.

Five alternatives were analyzed and are shown in *Exhibit A5-17* through *Exhibit A5-21* which demonstrates distinctly different methods by which FRM can be accomplished within the study area. Alternative 1 is a full earthen channel modification, from US 59 to the mouth of Hunting Bayou and represents the 1990 Authorized Plan. Alternative 2 is a nonstructural alternative consisting of a watershed-wide buyout of all residential and commercial properties with positive AAEV net excess benefits and represents the optimized scale of the buyout alternative. Alternative 3 is a nonstructural watershed-wide flood proofing of all residential and commercial properties with positive AAEV net excess benefits and represents the optimized scale of the raising-in-place alternative. Alternative 4 is the No Project Alternative. Alternative 5 is the same as B50-A1 which produced the greatest AAEV net excess benefits in the optimization exercise and represents the optimized structural alternative.

9.1 Alternative 1 – Full Earthen Channel Modification

In the 1988 USACE Feasibility Study, a full channelization plan was identified as the NED Plan for Hunting Bayou and authorized in WRDA of 1990. Thus, it was anticipated that a full channelization plan would also be a valid candidate for the NED Plan in this current study effort.

Alternative 1, a total reevaluation of the 1990 Authorized Plan, was developed using the most current hydrologic and economic information. It consists of earthen channel modifications from US 59 to the mouth of Hunting Bayou, a distance of approximately 72,900 feet (13.8 miles). Alternative 1 was optimized by analyzing four different channel designs, with bottom widths ranging from 35 feet to 150 feet near the mouth. A3, the scale with a 110-foot bottom width channel at the mouth of Hunting Bayou, replicates the 1990 Authorized Plan . These scales range in FRM from a less than a 10 percent to a 50 percent level of performance. *Table A5-24* shows the economic performance of the four bottom-width channel scales.

Table A5-24:
Economic Performance of Alternative 1

Channel Design	Total Project Cost	AAEV Project Cost	AAEV Damage Reduction Benefits	AAEV Net Excess Benefits	BCR
A1-35 BW	$210.691	$12.692	$19.801	$7.110	1.56
A2-65 BW	$236.949	$14.277	$21.875	$7.597	1.53
A3-110 BW	$341.583	$20.582	$22.401	$1.819	1.09
A4-150 BW	$421.341	$25.389	$22.414	($2.974)	0.88

2001 price level, discount rate of 5.625
Note: All dollar values in millions.

9.2 Alternative 2 – Nonstructural Buyout of Residences

Alternative 2, the nonstructural buyout alternative, identifies all residential and commercial structures that were shown to be cost-effective for buyout. Detailed output from the HEC-FDA WOP conditions model was used to compute the net benefits resulting from purchasing each of the structures in the study area. This alternative combines stand-alone components C, F and K. This alternative provides 4 percent FRM in the upper and middle stream segments and 14 percent FRM performance in the lower stream segment. A total of 974 structures (941 residential and 33 commercial) was identified to have a positive net benefit, which equates to an approximate 24 percent (4-year) floodplain buyout within the watershed. Alternative 2 represents the optimized scale for nonstructural buyouts. Alternative 2 has an annual net benefit of $4.360 million and a 2.15 BCR.

9.3 Alternative 3– Nonstructural Flood Proofing of Residences

Alternative 3, the nonstructural flood proofing alternative, identifies all structures that were shown to be cost-effective for flood proofing within the watershed. Detailed output from the HEC-FDA WOP conditions model was used to compute the net benefits resulting from raising each of the structures in the study area. This alternative is a combination of stand-alone components D, G and L. This alternative provides 4 percent FRM in the upper and middle stream segment and 11 percent FRM performance in the lower stream segment.

A total of 1,039 structures (1,010 residential, 27 commercial, and 2 public) were identified to have a positive AAEV net excess benefits, which equates to an approximate 25 percent (4-year) floodplain. Alternative 3 represents the optimized scale for nonstructural raising-in-place. Alternative 3 has AAEV net excess benefits of $2.950 million and a 2.06 BCR.

9.4 Alternative 4 – No Project Alternative

Alternative 4 is the No Project Alternative. Without the implementation of a flood damage reduction project in the Hunting Bayou study area, flood damages were calculated to be $22.42 million at 2001 prices and at the FY 2004 federal discount rate of 5.625 percent.

9.5 Alternative 5 – Upper Reach Channel Modification with a 50' Bottom Width and Homestead Detention

- Alternative 5 is the same as B50-A1 which is a combination of a 50' bottom width channel modification and a 40-acre detention basin at Homestead. Alternative 5 is the culmination of an optimization process detailed in Section 8 and represents the combination of best economically performing FRM components within the Hunting Bayou watershed. This alternative provides 10 percent FRM performance in the upper stream segment of the watershed. Alternative 5 has AAEV net excess benefits of $10.210 million and a 2.51 BCR. Alternative 5 represents the optimized scale for FRM among all the previous components tested and combined for economic efficiency.

9.6 Summary of Alternatives Analysis

A comparison of the economic performance of the five alternatives is shown in *Table A5-25*. From previous analysis of measures that maximize net excess benefits, the channel modification, bridge replacements and detention combination produced higher net benefits and was chosen to advance as the NED Plan with continued refinement of scale.

Table A5-25:
Economic Performance of Alternatives 1-5

Alternative	Component Description	AAEV Project Cost	AAEV Damage Reduction Benefit	AAEV Net Excess Benefit	BCR
1	Full Earth Channel (35'BW)	$12.692	($10.159)	($22.851)	-0.80
	Full Earth Channel (10-Year) (65' BW)	$14.277	$21.875	$7.598	1.53
	Full Earth Channel (25-Year) (110' BW) —1990 Authorized Plan	$20.582	$22.401	$1.819	1.09
	Full Earth Channel (50-Year) (150' 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	$2.781	$5.731	$2.950	2.06
4	No Project	-	$0.000	$0.000	0.00
5	**Upper Stream Segment 50' 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 in millions.

10.0 PRICE LEVEL AND DISCOUNT RATE UPDATE, 2004

Updates to economic inputs were performed for the top performing alternative scales, since more than three years passed from the date that structure values used in the FRM modeling and cost estimate price levels were derived,. In general, the price level for these economic inputs was updated from FY2001 to FY2004, and the federal discount rate of 5.125 percent for fiscal year 2006 was used. This section describes the processes used to update structure values and cost estimates:

10.1 Structure and Contents Value Update

The structure values were adjusted to 2004 price levels from 2001 by adjustment factors determined by a review appraiser using sales data. The same procedures were used to derive factors from 2004 sales data for a sample of the structure inventory. The review appraiser adjustment factors were used to bring 2001 structure RCNLD values to 2004 values in the structure inventory database. The following adjustment factors were determined for the listed damage structure categories:

- Single Family Residential – +5 percent
- Multi-family Residential – +11 percent
- Commercial and Public – +9 percent
- Industrial – +6 percent

For other damage categories, those described in Section 2, a price level adjustment was applied. For the 2004 update, vehicle, road, utility and emergency damage values were adjusted by using a 1.07 CPI-U ratio. Because content values were derived from CSVRs, no adjustments were made to content values.

11.0 ITERATIVE ECONOMIC UPDATE, 2009

During Hunting Bayou study advancement and update, a decision was made by the non-federal sponsor, HCFCD, to set aside the reevaluation of recreational features authorized by WRDA of 1990. The non-federal sponsor, HCFCD, will not exercise at this time the recreation authority granted by Congress. Also since the savings to the NFIP were of minimal consequence to overall plan reevaluation, that benefit category was dropped from further consideration.

11.1 Update of Without Project (WOP) Condition

In 2009 the Hunting Bayou economic analysis underwent another update and modification to bring the analysis up to current conditions. The structure inventory was updated and price level adjusted. Generic residential depth-damage curves and new generic vehicle depth-damage curves were incorporated into the certified version of the HEC-FDA model. Only those model parameters that were updated are discussed below. The remaining parameters were advanced from the previous economic models.

11.1.1 Analytical Model Update

The Hydrologic Engineering Center's Flood Damage Analysis (HEC-FDA) model version 1.2.4, released in November 2008, is certified by the U.S. Army Corps of Engineers as a Corporate Model and was used in this study for the 2009 and 2013 evaluation updates.

11.1.2 Update of Period of Analysis, Interest Rate, and Price Level

For this update, the period of analysis for comparing costs and benefits was updated to begin in 2019 and extends 50 years in the future to 2069, in accordance with ER 1105-2-100. A base year of 2019 was chosen as the year in which the project is anticipated to be completed and benefits are expected to begin to fully accrue. In this section, results are presented in February 2009 price levels. Field surveys and data collections were conducted during 1998 and 2004 and updated to February 2009 price levels. The limited update, which was based on available 2009 property tax records, was applied to the existing database. This ensured an update to 2009 price levels without wholesale indexing of property values.

The federal interest rate of 4.375 percent for fiscal year 2010, which extends over the period of October 1, 2009 through and including September 30, 2010, was applied to the model update.

11.1.3 Update of Structure Values

Estimated values for residential, commercial, and public properties identified in the structure inventory were originally established based on property values in 1998. During this reanalysis, an economic update was performed to determine property values at 2009 price levels. Content values were established on the basis of the structure values and the use of CSVRs.

11.1.3.1 Sampling

All of the values used in the update iterations were based on 1998 property values which were over time successively updated to 2001 price levels and subsequently to 2004 values. To provide a more current estimate of alternative flood damage reduction benefits, a price level update to

FY2009 was performed for the economic model update. Analysis and update of the structure inventory consisted of the following:

- A frequency analysis of changes to HEC-FDA structure values between 2004 and 2009 using Harris County Appraisal District (HCAD) data
- Random sampling of 50 residential, commercial, and public properties in the study area for costing using M&S Cost Estimating Programs
- Comparative statistical testing between 2004 HEC-FDA structure values and 2009 M&S depreciated replacement cost values (i.e., Student t-test)
- Update other costs (unit costs for vehicle, utilities, post-disaster costs, and road damage categories) to February 2009 price levels using an adjustment factor based on the Consumer Price Index (CPI).

An analysis was performed to determine the overall change in the HCAD data sets between 2004 and 2009 based on the 2004 HEC-FDA structure database. The majority of structures show increases in structure value between 0 and 20 percent. The median calculated indicates a value 12.09 percent increase. The mean change in value for the 33,236 properties analyzed was a 12.94 percent increase. This is based on a 1998 structure inventory that was compared and updated to 2004 and then updated to 2009 values. A M&S Cost Estimate of 50 randomly chosen study area properties shows that on average depreciated replacement costs values have increased by 12.0 percent. A Student t-test confirms the likelihood of a change in value for the 50-sample survey. This methodology is considered to be more accurate due to the age of the original database of 1998. Based on the 2009 M&S Cost Estimates compared to the HEC-FDA 2004 values, a recommended adjustment of all 2004 structure price levels by +12.00 percent to obtain RCNLD values at 2009 price levels. Unit costs for ancillary damage categories were inflated to 2009 price levels by +11.6 percent based on the CPI-U. The detailed methodology for the price level update is provided in Attachment 4, which is available upon request.

11.1.4 Update of Ancillary Damage Values

An update of ancillary damage values was accomplished by developing a factor of change using the CPI-U. For utilities, the average damage value per structure flooded was updated to a February 2009 value of $220. For roads, the average experienced repair cost per mile of inundated asphalt, concrete and dirt roads was updated to a February 2009 value of $11,918 per mile. For post disaster costs, the average cost incurred per flooded household was adjusted to a February 2009 value of $9,062 using the CPI-U.

11.1.5 Update of Single-Family Detached Residential Structure Depth-Damage Curves

The generic Economic Guidance Memorandum (EGM) 01-03, 4 Dec 2000 depth-damage curves for single-family residential structures without basements were applied to single family residences in the structure inventory based on number of stories. In this study, single-family residential structures are differentiated as pier-and-beam or slab-on-grade construction and as either one-story or two-story structures to which corresponding depth-damage curves were applied. That nomenclature is still present in the Structure Occupancy Types of the HEC-FDA model although those classifications now contain the depth-damage functions from EGM 01-03 as a consequence of the 2009 update.

Content damage curves for the single family residential structures without basements are provided in the EGM. The generic depth-damage functions for residential structures negate the need for uncertainty expressions in content values and content-to-structure ratios because the content damage is calculated as a percent of the structure value rather than as a percent of the content value.

Structure and content depth-percent damage curves and content values for mobile home and for multi-family residential units were maintained from the NOD study. Content values are proportionate to structure values with the use of CSVRs.

11.1.6 Update of Vehicle Damage Estimation

The vehicle damages were estimated using the current USACE guidance as outlined in Economic Guidance Memorandum (EGM) 09-04, Generic Depth-Damage Relationships for Vehicles dated June 22, 2009. This document provides guidance for the use of generic vehicle depth-damage curves for FRM. In order to estimate the number of vehicles by type, age, make and model, vehicle information based on motor vehicle registrations was purchased from the R.L. Polk Company by zip code. This source does not provide the average vehicle value for each classification.

The R.L. Polk vehicle registration data was extracted by zip codes assigned to the Hunting Bayou study area. All of the vehicles were classified into one of five categories designated in the EGM. The number of vehicles by make, model and age were analyzed by zip code along with a percentage of the total for each category which includes minivans, pickups, sedans, sports and sport utility vehicles (SUVs).

The average vehicle value was determined based on a random sample of 30 from each category of minivans, pickups, sedans, sports and SUVs per zip code. These 30 random samples of each category per zip code were given a value based on their make, model and age using Edmunds vehicle value estimator. The values from Edmunds are reported as Dealer Retail Values. The average vehicle value for each category was assigned to each zip code. The average vehicle value by category for the Hunting Bayou study area is shown in *Table A5-26* at the 2009 price level.

Table A5-26:
2009 Average Vehicle Values for the Hunting Bayou Study Area

Category	Average Value
Minivans	$5,584
Pickups	$10,110
Sedans	$7.743
Sports	$7,809
SUVs	$6,695

11.1.6.1 Vehicles Parked at Residential Locations

Damage attributable to vehicles parked at residential locations can be estimated based on the information described in addition to the number of vehicles per household and warning time to react to the flood threat. Data were downloaded from the U.S. Census Bureau using the select data tables which enables the use of zip codes to determine the number of occupied households, vehicles available per household and average number of vehicles per household. The average number of vehicles per household was determined to be 1.45 based on the entire study area as defined by the zip codes and the U.S. Census Bureau data.

The length of potential warning time and access to a safe evacuation route to a flood-free location was considered in estimating the percentage of vehicles which would likely remain in the flood prone location. The average number of vehicles per household for each record was reduced by the 50.5 percent which will move their vehicles to higher ground given a 6-hour warning period. The 6-hour warning period was based on the type of flooding experienced in the Hunting Bayou watershed and information provided by EGM 09-04.

Vehicle depth-damage functions were applied to the ground elevation for each residential structure record within the economic study area. The vehicle depth-damage curves for the minivans, pickups, sedans, sports and sport utility vehicles (SUVs) provided in the EGM were imported into the HEC-FDA model along with the structure inventory including the updated vehicle data based on the 5 categories as designated in the EGM.

11.1.6.2 Vehicles Parked at Nonresidential Locations

Properties that could potentially have vehicle damage at non-residential locations were identified by using Harris County Appraisal District (HCAD) land use codes. These properties were then viewed on an aerial map to verify that the land use code was correct. Phone interviews were conducted to determine the number of vehicles at each location, the types of vehicles (classification), the average value of the vehicles and the number of vehicles that would be moved if given a 6 hour warning period of a flood threat. Using the HCAD data, three used car lots were identified along with one new car dealership. Interviews were successful for three of the four properties. The fourth property identified was contacted several times with no message or other contact information available and was therefore, not included in the evaluation. Vehicles were assigned to the three commercial properties by distributing the total number of vehicles on each property into the classifications (sedan, sports car, SUV, pickup or minivan) based on the telephone interview along with an average vehicle value and applying the associated depth-percent damage curve.

The summary uncertainty parameters applied in the updated HEC-FDA model for 2009 are shown in *Table A5-27*.

Table A5-27:
Economic Uncertainty Error Types and Values for Key Variables, 2009 Update

Structure Occupancy Types	Depth-Damage Function Error Type		Structure Value		CSVR		First Floor Stage	
	Structure	Content	Error Type	St. Dev. (%)	Mean (%)	St. Dev. (%)	Error Type	St. Dev. (feet)
1-Story Single Family[1]	Normal	Normal	Normal	34	100	-	Normal	1.14
1-Story, Multi-Family Residences[1]	Normal	Normal	Normal	34	100	-	Normal	1.14
Multi-Story, Multi-Family Residences	Triangular	Triangular	Normal	67	37	14.3	Normal	1.14
2-Story Single-Family[1]	Normal	Normal	Normal	34	100	-	Normal	1.14
Mobile Home	Triangular	Triangular	Normal	34	60	24.1	Normal	1.14
Hospital	Triangular	Triangular	Normal	10	27	10	Normal	1.14
Vehicles*	Normal	None	None	-	-	-	None	-
Eating & Recreation[2]	Triangular	Triangular	Normal	67	114	48.2	Normal	1.14
Groceries & Gas Stations[2]	Triangular	Triangular	Normal	67	127	48.2	Normal	1.14
Public & Semi Public[2]	Triangular	Triangular	Normal	67	114	71.5	Normal	1.14
Professional Businesses[2]	Triangular	Triangular	Normal	67	43	13.8	Normal	1.14
Repairs & Home Use[2]	Triangular	Triangular	Normal	67	206	102	Normal	1.14
Retail & Personal Services[2]	Triangular	Triangular	Normal	67	142	93.2	Normal	1.14
Warehouse & Contractor Services[2]	Triangular	Triangular	Normal	67	168	98.3	Normal	1.14

** Calculated in accordance to EGM 09-04, Generic Depth-Damage Curve Relationships for Vehicles.*

*** Direct Depth-Dollar Damage functions used for Utilities, Post Disaster Costs, and Roads.*

[1] *Per EGM 01-03, for these residential structures, content values are assumed to be 50 percent of structure value because contents damage at half the rate of structure damage even though the requirement is to enter 100 percent in the CSVR menu in the HEC-FDA model. The standard deviation for the presumed CSVR is blank because the error in content damage is implied in the error of the structure value.*

[2] *The Structure Occupancy type is a combination of exterior construction (metal frame, masonry wall, or wood/steel frame construction) and land-use type (e.g., Eating & Recreation) data curves. Construction type curves are associated with the structure, while the land-use type curves are associated with the content. The exterior construction types are all represented with unique triangular error distributions for structure depth-percent damage.*

11.2 Determination of Existing Capital Investment within the Existing 0.2 Percent Annual Exceedance Probability (AEP) Floodplain

The structure inventory and the capital investment distribution within the eight existing AEP floodplains of Hunting Bayou based on the first floor elevations are presented in *Table A5-28*. It is estimated that over 89 percent of the total structures in the estimated 0.2 percent AEP floodplain are residential, which account for approximately $250 million of structure value. Total structure value in the 0.2 percent floodplain is approximately $559 million.

11.3 Determination of Flood Damages for Without Project (WOP) Condition

Flood damages were estimated for all properties within the 0.2 percent AEP floodplain of Hunting Bayou for the WOP condition. Damages from inundation are based on data obtained from the previously described field inventory of existing development. Damage estimates were computed for structures and contents for the various types of physical properties classified as residential, commercial and public. Damages were also computed for vehicles. Direct damage curves by reach were developed for utilities, roads, and post-disaster recovery costs.

11.3.1 Single Occurrence Damages

Damages expected to accrue from the various AEP events for the WOP condition are displayed in *Table A5-29*. These values represent damages expected for individual events under the WOP hydrologic and hydraulic conditions. Values are based on February 2009 price levels. As an example, total flood damages expected during a 1 percent AEP event is approximately $197 million. The flood damages expected during a 0.2 percent AEP event are approximately $303 million.

11.3.2 Average Annual Equivalent Damages With and Without Uncertainty

Average annual equivalent damages were calculated for WOP conditions. The AAEV was then recomputed within the HEC-FDA program without consideration of uncertainty. This produced a value of approximately $17.0 million as shown in *Table A5-30*.

Average annual equivalent damage computations in the HEC-FDA model with consideration of uncertainty resulted in AAEV values of $24.9 million.

11.3.3 Average Annual Equivalent Value (AAEV) Damages

AAEV damages by reach over the 50-year project life are shown in *Table A5-31*. These damages correspond to damages accruing from all damage categories earlier described and, because there is no expected change in the WSEL and the structure inventory over time, the AAEV damages are equivalent to expected annual damages.

Table A5-28:
Distribution of Capital Investment within Annual Exceedance Probability (AEP) Floodplains
Cumulative Totals based on Without Project (WOP) Condition
Dollar Values in $1,000's, February 2009 Price Levels

Property Type	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"
Residential Property								
Number of Structures	0	455	1,514	2,629	3,669	4,423	5,432	5,993
Single-Family	0	438	1,469	2,561	3,593	4,336	5,336	5,887
Multi-Family	0	17	45	66	74	84	93	101
Mobile Homes	0	0	0	2	2	3	3	5
Distribution	0.0%	7.6%	25.3%	43.9%	61.2%	73.8%	90.6%	100.0%
Structure Value	$0	$23,014	$70,571	$112,351	$151,848	$184,243	$229,254	$250,041
Content Value**	$0	$11,507	$35,286	$56,176	$75,924	$92,122	$114,627	$125,021
Total Value	$0	$34,521	$105,857	$168,527	$227,772	$276,365	$343,881	$375,062
Commercial Property								
Number of Structures	0	49	161	238	321	369	450	482
Distribution	0.0%	10.2%	33.4%	49.4%	66.6%	76.6%	93.4%	100.0%
Structure Value	$0	$5,658	$33,562	$61,876	$78,756	$102,519	$126,388	$150,598
Content Value**	$0	$7,309	$49,600	$96,540	$121,207	$150,108	$188,109	$225,779
Total Value	$0	$12,967	$83,162	$158,416	$199,963	$252,627	$314,497	$376,377
Public Property								
Number of Structures	0	8	25	41	54	55	63	65
Distribution	0.0%	12.3%	38.5%	63.1%	83.1%	84.6%	96.9%	100.0%
Structure Value	$0	$4,527	$6,004	$10,562	$18,880	$18,893	$20,443	$21,307
Content Value**	$0	$5,160	$6,845	$12,041	$21,524	$21,538	$23,305	$24,289
Total Value	$0	$9,687	$12,849	$22,603	$40,404	$40,431	$43,748	$45,596

Property Type	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"
Hospital Property								
Number of Structures	0	0	0	0	0	1	1	1
Distribution	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%	100.0%
Structure Value	$0	$0	$0	$0	$0	$137,000	$137,000	$137,000
Content Value**	$0	$0	$0	$0	$0	$36,990	$36,990	$36,990
Total Value	$0	$0	$0	$0	$0	$173,990	$173,990	$173,990
Total Property								
Number of Structures	0	512	1700	2908	4044	4848	5946	6541
Distribution	0.0%	7.8%	26.0%	44.5%	61.8%	74.1%	90.9%	100.0%
Structure Value	$0	$33,199	$110,137	$184,789	$249,484	$442,655	$513,085	$558,946
Content Value**	$0	$23,976	$91,731	$164,757	$218,655	$300,758	$363,031	$412,079
Total Value	$0	$57,175	$201,868	$349,546	$468,139	$743,413	$876,116	$971,025
Passenger Vehicles								
Number of Vehicles	0	1,263	3,400	5,729	6,543	6,773	7,020	72,220
Distribution	0.0%	1.7%	4.7%	7.9%	9.1%	9.4%	9.7%	100.0%
Vehicle Value	$ 0.00	$9,868	$ 24,259.00	$ 39,691.00	$ 44,843.00	$ 46,652.00	$ 48,102.00	$ 49,321.00
Total Roads								
Roadway Lengths (Miles)	1	22	60	89	122	130	138	150
Distribution	0.7%	14.7%	40.0%	59.3%	81.3%	86.7%	92.0%	100.0%

**content to structure ratio is assumed to be 50 percent for purposes of display.*

Table A5-29:
Single Occurrence Damages by Annual Exceedance Probability (AEP) Event
Without Project (WOP) Hydrology and Hydraulics (H&H)
February 2009 Values in $1,000's

	Annual Exceedance Probability Events							
	50%	20%	10%	4%	2%	1%	0.40%	0.20%
	"2-Year"	"5-Year"	"10-Year"	"25-Year"	"50-Year"	"100-Year"	"250-Year"	"500-Year"
Damage Category								
Residential Property	$1	$10,966	$32,799	$53,606	$71,589	$89,198	$114,141	$126,472
Commercial Property	$0	$1,696	$10,929	$21,570	$30,071	$42,039	$59,571	$69,729
Public Property	$0	$556	$1,776	$3,547	$5,635	$6,544	$8,146	$9,320
Hospital	$0	$0	$0	$55	$822	$5,292	$19,044	$23,464
Total Damages to Structures and Contents	$1	$13,218	$45,504	$78,778	$108,117	$143,073	$200,902	$228,985
Post Disaster Costs	$0	$4,295	$14,274	$26,443	$34,952	$41,026	$49,191	$54,580
Road Damages	$9	$271	$742	$1,146	$1,439	$1,541	$1,638	$1,756
Utility Damages	$0	$106	$349	$645	$853	$1,001	$1,206	$1,345
Vehicle Damages	$0	$410	$2,472	$5,068	$7,795	$10,162	$13,884	$15,980
Total by Event	$10	$18,300	$63,341	$112,081	$153,156	$196,803	$266,821	$302,646
Percent Distribution								
Residential Property	6.32%	59.92%	51.78%	47.83%	46.74%	45.32%	42.78%	41.79%
Commercial Property	0.00%	9.27%	17.25%	19.25%	19.63%	21.36%	22.33%	23.04%
Public Property	0.00%	3.04%	2.80%	3.16%	3.68%	3.33%	3.05%	3.08%
Post Disaster Costs	0.00%	23.47%	22.53%	23.59%	22.82%	20.85%	18.44%	18.03%
Road Damages	93.68%	1.48%	1.17%	1.02%	0.94%	0.78%	0.61%	0.58%
Utility Damages	0.00%	0.58%	0.55%	0.58%	0.56%	0.51%	0.45%	0.44%
Vehicle Damages	0.00%	2.24%	3.90%	4.52%	5.09%	5.16%	5.20%	5.28%
Total by Event	**100.00%**	**100.00%**	**100.00%**	**99.95%**	**99.46%**	**97.31%**	**92.86%**	**92.25%**

Table A5-30:
Distribution of Average Annual Equivalent Damages by Reach
Without Project (WOP) Condition
2009 Values in $1,000's

Reach Name	With No Uncertainty	With Uncertainty	Difference	Percent Difference
D	$0.19	$0.20	$0.01	5.26%
H	$0.03	$0.04	$0.01	33.33%
L	$0.23	$0.25	$0.02	8.70%
M	$12.27	$21.05	$8.78	71.56%
O	$0.14	$0.92	$0.78	557.14%
P	$0.10	$0.21	$0.11	110.00%
R-Left	$36.90	$174.08	$137.18	371.76%
R-Right	$337.64	$680.82	$343.18	101.64%
T-Left	$975.23	$1,513.23	$538.00	55.17%
T-Right	$114.65	$334.28	$219.63	191.57%
U-Left	$90.54	$249.84	$159.30	175.94%
U-Right	$1.53	$11.03	$9.50	620.92%
V	$0.00	$0.30	$0.30	0.00%
X	$148.89	$220.31	$71.42	47.97%
Z	$136.53	$305.42	$168.89	123.70%
AE	$752.31	$1,893.46	$1,141.15	151.69%
AF	$639.37	$1,119.65	$480.28	75.12%
AG	$64.46	$193.13	$128.67	199.61%
AH	$17.56	$49.20	$31.64	180.18%
AI	$535.02	1109.52	$574.50	107.38%
AL	797.92	1284.07	$486.15	60.93%
AP	9521.17	11713.07	$2,191.90	23.02%
AZ	2781.87	4049	$1,267.13	45.55%
Total	**$16,964.55**	**$24,923.08**	**$7,958.53**	**46.91%**
Total Traditional EAD	**$19,142.43**			

Table A5-31:
Distribution of Average Annual Equivalent (AAE) Damages by Reach
Without Project (WOP) Condition
2009 Values in $1,000's with FY2010 Interest Rate – 4.375%

Reach Name	Residential Damages	Commercial Damages	Public Damages	Hospital Damages	Post Disaster Costs	Road Damage	Utility Damages	Vehicle Damages	Total Damages	Percent Distribution
D	$0.00	$0.00	$0.00	$0.00	$0.00	$0.20	$0.00	$0.00	$0.20	0.0%
H	0.04	0.00	0.00	0.00	0.00	0.04	0.00	0.00	$0.08	0.0%
L	0.04	0.16	0.00	0.00	0.00	0.25	0.00	0.00	$0.45	0.0%
M	14.36	0.22	0.01	0.00	5.26	0.44	0.13	0.93	$21.35	0.1%
O	1.17	0.09	0.00	0.00	0.00	0.00	0.00	0.01	$1.27	0.0%
P	0.38	0.04	0.00	0.00	0.00	0.12	0.00	0.00	$0.54	0.0%
R-Left	29.67	136.97	0.00	0.00	7.14	1.02	0.17	0.80	$175.77	0.7%
R-Right	450.56	183.23	0.27	0.00	33.64	3.05	0.82	13.73	$685.30	2.7%
T-Left	1,195.32	2.10	6.91	0.00	257.17	4.31	6.25	51.30	$1,523.36	6.1%
T-Right	280.47	2.78	0.00	0.00	45.06	1.66	1.10	7.28	$338.35	1.3%
U-Left	214.99	0.72	0.00	0.00	30.65	0.00	0.75	4.79	$251.90	1.0%
U-Right	11.11	1.08	0.00	0.00	0.00	0.05	0.00	0.11	$12.35	0.0%
V	0.03	0.38	0.00	0.00	0.00	0.00	0.00	0.00	$0.41	0.0%
X	76.28	121.04	0.00	0.00	19.11	2.88	0.46	3.45	$223.22	0.9%
Z	130.50	170.60	0.92	0.00	0.00	2.26	0.96	2.22	$307.46	1.2%
AE	23.15	1850.40	2.23	0.00	15.32	13.42	0.37	1.36	$1,906.25	7.6%
AF	119.44	910.28	4.74	0.00	70.04	15.52	1.70	5.32	$1,127.04	4.5%
AG	109.33	66.14	0.96	0.00	12.49	3.85	0.30	1.90	$194.97	0.8%
AH	2.52	42.21	0.00	0.00	1.03	3.51	0.03	0.20	$49.50	0.2%
AI	287.59	658.05	29.27	0.00	108.21	14.81	2.63	15.75	$1,116.31	4.4%
AL	424.38	539.07	11.94	0.00	231.15	15.18	5.62	64.77	$1,292.11	5.1%
AP	5,725.12	935.99	586.38	744.66	2973.25	77.69	72.31	671.71	$11,787.11	47.0%
AZ	1,939.44	646.66	105.71	0.00	1117.81	64.27	27.50	176.74	$4,078.13	16.3%
Total	**$11,035.89**	**$6,268.21**	**$749.34**	**$744.66**	**$4,927.33**	**$224.53**	**$121.10**	**$1,022.37**	**$25,093.43**	**100.0%**
Percent Distribution	**44.0%**	**25.0%**	**3.0%**	**3.0%**	**19.6%**	**0.9%**	**0.5%**	**4.1%**	**100.0%**	

12.0 IDENTIFICATION AND REFINEMENT OF THE NATIONAL ECONOMIC DEVELOPMENT (NED) ALTERNATIVE PLAN, 2009 ITERATION

Up to this point, the plan reevaluation process for the Hunting Bayou federal study had identified alternatives located in the upper stream segment of the watershed as the best economic performers. These are components, working in combination, which form the NED Plan alternative. By focusing efforts to reduce flood risk in the upper stream segment, the channel modification and detention basin worked together in a systems manner to reduce damages where they occur.

From previous analysis of measures that maximize net excess benefits, the channel modification and detention combination produced higher net benefits and were chosen to advance as the NED Plan with continued refinement of scale. Other measures and combinations of measures along the entire stream that were evaluated for economic performance were retired from further refinement.

12.1 Adaptation of Channelization Features

The 30-acre in-line detention basin feature of the upper stream segment's channel modification components was not previously analyzed as a stand-alone component to determine its FRM benefits attributable to this component. Therefore, it could not be determined if this feature was economically justified to be included as part of the final plan reevaluation. The extent of the waste layer in the unregistered COH landfill located where this proposed feature was to be constructed was investigated with noninvasive remote sensing (material resistivity signaling) using over six lines of survey and limited subsurface visual confirmation via partial depth trenching. The survey lines and resistivity data are shown in *Exhibit A5-22* and Attachment 2 of Attachment A5-12_2009, 9 Dec 2009, which is available upon request.

The waste volume was previously estimated through a general geospatial extrapolation and interpretation of the resistivity data and aerial interpretation of the horizontal extent of landfill. This estimation assumed that the entire contiguous zone of higher apparent resistivity represented the waste layer, including depths below the local groundwater elevations. Considering the practicalities of groundwater and waste burial management, it is unknown if the resistivity data reflects local geology at the below-groundwater depths or actual waste layers depths. Both the resistivity data and historical aerial imagery indicate the waste layer is buried in two cells in the eastern and western halves of the property bisected by a drainage ditch in the middle. An overview of the in-line detention component and the estimated landfill boundaries are shown in Figure 1 of Attachment A5-12_2009, 9 Dec 2009 and in *Exhibit A5-22*. Previous construction cost estimates of the in-line feature did not incorporate explicit costs of impacting the landfill. When considering a waste volume limited to that above the average groundwater elevation, the calculated AAEV net excess benefits for the landfill portion of the in-line detention component are negative at approximately minus $440K. The calculated AAEV net excess benefits for the landfill portion of the in-line detention component, when considering the entire waste volume indicated by the resistivity data (the "all resistivity" assumption), are also negative at approximately minus $710K.

These ranges also assume that tipping fee price-year reductions are commensurate with the FRM benefits and construction costs. Therefore, the in-line detention basin feature of Component B can be expected to provide no positive AAEV net excess benefits when considering flood damages. These AAEV net excess benefits and BCR estimates assume that the waste material could be disposed at a currently active landfill as municipal solid waste. However, contingency for more costly solid waste was included in the disposal cost estimate. The limited trench testing indicated that the nature of waste material is consistent with municipal waste.

Considering the negative AAEV net excess benefits calculated for the landfill portion of the in-line detention basin, this part of the in-line detention basin feature was not justified for inclusion as part of the upper stream segment plan for this study. More information and direct comparisons of the waste volumes estimated and supporting this conclusion can be found in Attachment A5-12_2009, 9 Dec 2009.

12.2 Reduced Homestead Site Detention Planning Condition

Locating available vacant land that is suitable for construction of detention is a major challenge to planning in the Hunting Bayou watershed. During the initial plan reevaluation phase the Homestead Road site met the location and size requirements for FRM detention. However, in November 2004, during negotiations with Homestead site owner, the Union Pacific Railroad Company (UPRR,), the non-federal sponsor, HCFCD, learned the expansion of the company's intermodal railroad facilities was planned for approximately one-half of the available acreage. This reduced the available vacant land for detention to 75 acres.

With insufficient vacant land available for detention , use of improved land was considered. FY 2001 Gross Appraisal sales data for land with light industrial building improvements ranged from $5.95 per square foot to $12.96 per square foot indicating that an average cost of $7.98 per square foot to purchase other nearby improved industrial lands as a substitution for the Homestead site was not cost effective. Therefore, the planning process for detention storage was constrained to the available acreage on the remaining 75-acre area of the Homestead site.

12.3 Reevaluation of Components A and B in Combination

Realization of the presence of the landfill within the Component B footprint required that the in-line detention basin feature be abandoned and Component B be redesigned without in-line detention. The loss of in-line detention in Component B required more storage in Component A to offset flood flows. However, Component A was constrained by limited land area for detention which required that the cross-sectional area for channel modification be increased for Component B.

The Components A and B were subjected to a reanalysis of combined detention basin size and channel bottom width in an array of 32 optional scales of the alternative in an attempt to identify the most cost effective and economically efficient scale. Channel bottom widths were modeled in a range from 40 feet to 200 feet. Detention sizing offered less variation because of the land constraint and ranged from 25 acres to the maximum 75 acres. The results of the reevaluation are shown in *Table A5-32*.

Table A5-32:
Best Performing NED Plan Scales with Constrained Available Land for Detention

Net Excess Benefit Rank	NED Plan Scale	WOP AAEV* Damages	AAEV Damages (x $1,000)	AAEV Damages Reduced Benefits (x $1,000)	Total Project Cost (x$1,000)	AAEV Project Cost (x$1,000)	AAEV Net Excess Benefit (x$1,000)	BCR
			$24,954.36					
1	B90-A50	90' Channel + 50 Ac	$5,643.70	$19,310.66	$150,966.19	$7,669.67	$11,640.99	2.52
2	B100-A50	100' Channel + 50 Ac	$5,487.27	$19,467.08	$154,159.25	$7,830.21	$11,636.87	2.49
3	B80-A50	80' Channel + 50 Ac	$5,826.31	$19,128.05	$147,632.58	$7,502.16	$11,625.89	2.55
4	B70-A50	70' Channel + 50 Ac	$6,023.19	$18,931.17	$143,950.34	$7,316.01	$11,615.16	2.59
5	B80-A25	80' Channel + 25 Ac	$6,730.65	$18,223.70	$131,064.80	$6,619.17	$11,604.53	2.75
6	B90-A25	90' Channel + 25 Ac	$6,561.39	$18,392.97	$134,462.79	$6,789.90	$11,603.07	2.71
7	B100-A25	100' Channel + 25 Ac	$6,406.68	$18,547.68	$137,721.40	$6,953.70	$11,593.98	2.67
8	B110-A25	110' Channel + 25 Ac	$6,220.10	$18,734.26	$141,648.46	$7,154.16	$11,580.10	2.62
9	B70-A25	70' Channel + 25 Ac	$6,946.85	$18,007.51	$127,290.07	$6,428.42	$11,579.09	2.80
10	B60-A50	60' Channel + 50 Ac	$6,274.23	$18,680.13	$139,701.24	$7,101.74	$11,578.39	2.63
11	B110-A50	110' Channel + 50 Ac	$5,359.65	$19,594.71	$158,062.39	$8,029.48	$11,565.23	2.44
12	B120-A25	120' Channel + 25 Ac	$6,107.36	$18,847.00	$144,906.85	$7,319.10	$11,527.90	2.58
13	B120-A50	120' Channel + 50 Ac	$5,243.94	$19,710.42	$161,301.68	$8,193.47	$11,516.95	2.41
14	B140-A25	140' Channel + 25 Ac	$5,823.87	$19,130.49	$150,784.00	$7,617.52	$11,512.97	2.51
15	B50-A50	50' Channel + 50 Ac	$6,610.93	$18,343.43	$136,226.23	$6,898.47	$11,444.96	2.66
16	B60-A25	60' Channel + 25 Ac	$7,301.98	$17,652.37	$122,947.23	$6,209.48	$11,442.89	2.84
17	B50-A25	50' Channel + 25 Ac	$7,485.88	$17,468.48	$119,406.13	$6,031.25	$11,437.23	2.90
18	B140-A50	140' Channel + 50 Ac	$5,054.28	$19,900.08	$167,249.93	$8,495.42	$11,404.66	2.34
19	B40-A50	40' Channel + 50 Ac	$6,876.43	$18,077.93	$132,723.90	$6,749.58	$11,328.35	2.68
20	B200-A25	200' Channel + 25 Ac	$5,146.60	$19,807.76	$169,587.39	$8,571.13	$11,236.63	2.31
21	B60-A75	60' Channel + 75 Ac	$5,806.12	$19,148.24	$158,295.16	$8,051.43	$11,096.81	2.38
22	B70-A75	70' Channel + 75 Ac	$5,598.37	$19,355.99	$162,643.58	$8,270.62	$11,085.37	2.34
23	B80-A75	80' Channel + 75 Ac	$5,415.41	$19,538.95	$166,420.30	$8,461.45	$11,077.50	2.31
24	B100-A75	100' Channel + 75 Ac	$5,109.54	$19,844.82	$173,083.82	$8,796.29	$11,048.53	2.26
25	B90-A75	90' Channel + 75 Ac	$5,277.47	$19,676.89	$169,822.81	$8,632.38	$11,044.51	2.28
26	B50-A75	50' Channel + 75 Ac	$6,090.92	$18,863.43	$154,750.51	$7,844.70	$11,018.73	2.40
27	B200-A50	200' Channel + 50 Ac	$4,535.31	$20,419.05	$186,195.75	$9,456.10	$10,962.95	2.16
28	B110-A75	110' Channel + 75 Ac	$5,008.81	$19,945.55	$177,071.49	$8,999.75	$10,945.80	2.22
29	B120-A75	120' Channel + 75 Ac	$4,885.07	$20,069.29	$180,473.25	$9,171.82	$10,897.47	2.19
30	B40-A75	40' Channel + 75 Ac	$6,408.48	$18,545.87	$151,147.99	$7,690.85	$10,855.02	2.41
31	B140-A75	140' Channel + 75 Ac	$4,682.40	$20,271.96	$186,659.50	$9,485.62	$10,786.34	2.14
32	B200-A75	200' Channel + 75 Ac	$4,173.55	$20,780.81	$206,341.95	$10,482.97	$10,297.84	1.98

2009 Price Level, Discount Rate = 4.375 percent
**AAEV=average annual equivalent value*

The results of this analysis produced three scales of interest for the NED Plan alternative. B90-A50, the NED Plan scale that maximized net excess benefits; B50-A25, that reasonably maximizes net benefits at least cost; and B60-A75, the non-federal sponsor, HCFCD's preferred NED Plan scale that best addresses all study objectives and reasonably maximizes net excess benefits. The B90-A50 NED Plan scale best satisfied the federal objective of producing the greatest net excess benefits. However, the top 23 NED Plan scales are within 5 percent of the No. 1 ranked scale for net excess benefits. Due to the narrow range of net excess benefit outputs of the NED Plan scale array, the least cost scale that reasonably maximizes net excess benefits (within 5 percent of the maximum) is NED Plan B50-A25 for the 2009 planning iteration.

13.0 ITERATIVE ECONOMIC UPDATE 2013

13.1 Structure Inventory Update to 2013 Conditions

The HEC-FDA structure inventory for Hunting Bayou was originally created in 1998. Over the years of study, estimated values for residential, commercial, and public structures identified in the 1998 structure inventory were adjusted to 2001 and 2004 values based on a statistical sampling technique. In 2009, field surveys and data collections were conducted to update prices to February 2009 levels. During this effort, a reassessment of inventory by reach was accomplished and 128 structures were added to the inventory. Over the years, each price update was accomplished as a factor of change based on an analysis of HCAD data, the result of which was applied across all structures in the inventory.

However, prices reflected in USACE decision documents are required to be current within three years of the approval date of the decision document. In order to comply with the anticipated submission of a FY 2014 decision document, the value of expected benefits or damages reduced required updating to current values. With the 2013 update, a direct comparison method was used and the structure inventory verified and updated with 2Q2013 (FY13) RCNLD values applied. HCAD parcel shape files were accumulated within the physical limits of the economic study area and data were extracted from those parcels for the 2013 update.

13.1.1 Truncation of the Inventory

The structure inventory in the 1998 HEC-FDA model represents structures throughout the entire watershed. Allowing the structure inventory to represent an area beyond the physical limits of probabilistic storm events introduces the opportunity for an exaggerated damage estimate. The HEC-FDA cannot distinguish topographic variability that might erroneously allow a structure to damage based on its flood threshold and not its physical location within a floodplain. Therefore, damages could potentially be calculated for a structure that lies outside the floodplain but has a low flood threshold. In reality the structure would not flood from overbank flooding, the reduction of which is a goal of this study. In order to correct for this type of potential error, the structure inventory was truncated along the 0.2 percent AEP floodplain boundary to which a 1-foot buffer was added for uncertainty sampling. The prior structure inventory was reduced from a watershed-wide count of 22,000 structures to around 10,000 structures within the floodplain boundary with this effort.

13.1.2 City of Houston (COH) Elevation Ordinance Compliance

COH adopted a building ordinance in 1985 for new construction and substantial reconstruction in the floodplain. Substantial reconstruction follows the NFIP definition of reconstruction as 50 percent of the improvement value or greater. The COH ordinance requires first-floor elevations be built 12 inches above the BFE. To verify the Hunting Bayou structure inventory reflects this requirement, an analysis was made of the 2Q2013 HCAD database for the noted year of construction, or substantial reconstruction by parcel. For those structures added to the database that met the criteria of “year built or improved” equals 1985 or later, the damage threshold was assumed to conform to the COH ordinance and the ground elevation and floor correction were adjusted to the 1 percent AEP stage plus 1 foot.

13.1.3 Correction of Uncertainty Parameters in the HEC-FDA

During the Risk and Uncertainty ATR conducted in 2012, it was discovered that an uncertainty parameter had been omitted in the model reviewed. Correction to the model was made for proper inclusion of the structure first-floor elevation uncertainty.

13.2 Price Level Update and Federal Interest Rate

When the study was resumed, prices in the most recent HEC-FDA model represented RCNLD 2009 values for residential and nonresidential structures. In order to comply with the anticipated submission of a FY 2014 decision document, the structure values, upon which expected benefits or damages reduced are based, required updating. Other damageable economic assets within the floodplain are updated based on indexing. They comprise a relatively smaller portion of total damage and benefit estimates.

The most current structure values available to the Hunting Bayou economic study were Harris County Appraisal District (HCAD) property parcel records, certified January, 2013 (2Q2013). The RCNLD values calculated by HCAD for the improvements to property parcels were matched with and assigned to the records in the structure inventory of Hunting Bayou. RCNLD values are reported along with many data variables for property parcels in the HCAD database. These data were entered into a database and methods were applied to create a cross-reference file whereby the structures in the HEC-FDA model could be identified and compared to the HCAD database. The HCAD parcel identification number and the HEC-FDA structure identification variable name comprised the logical key for cross-referencing purposes. Data variables that help characterize the structures such as exterior finish, number of floors, and the 2Q2013 (FY13) RCNLD value were added to the HEC-FDA structure inventory.

A direct comparison to the certified 2Q2013 HCAD parcels was successful for 95 percent of the parcels in the truncated inventory. Additional parcels were added to the structure inventory if they possessed damageable improvements and were characterized by location, type of structure, land use, exterior composition, structure value, ground elevation, and floor correction. The assumption of COH elevation ordinance compliance was applied to the newly added structures that met the criterion of year of improvement.

The FY14 federal discount rate of 3.50 percent was applied to the computations as appropriate.

13.3 Multifamily Depth-Percent Damage Curves Update

Upon closer examination of multifamily structures during the 2013 study update, three general types of multifamily developments were identified. Because of the demographic character of the study area, many multifamily parcels contain multiple small square-footage one-story single-family structures that are clustered in close proximity to one another. Many are detached while others are duplexes or multiplexes. Other multifamily structures take the form of multi-floor motels where the living space is contained on one-level but the units are stacked. And, too, there exist the traditional multi-family developments that are expansive and multi-level. Depth-damage functions were adopted to allow for distinctions to be made that reflect the damage potential of the three general types of multifamily developments observed in the 0.2 percent AEP floodplain of Hunting Bayou.

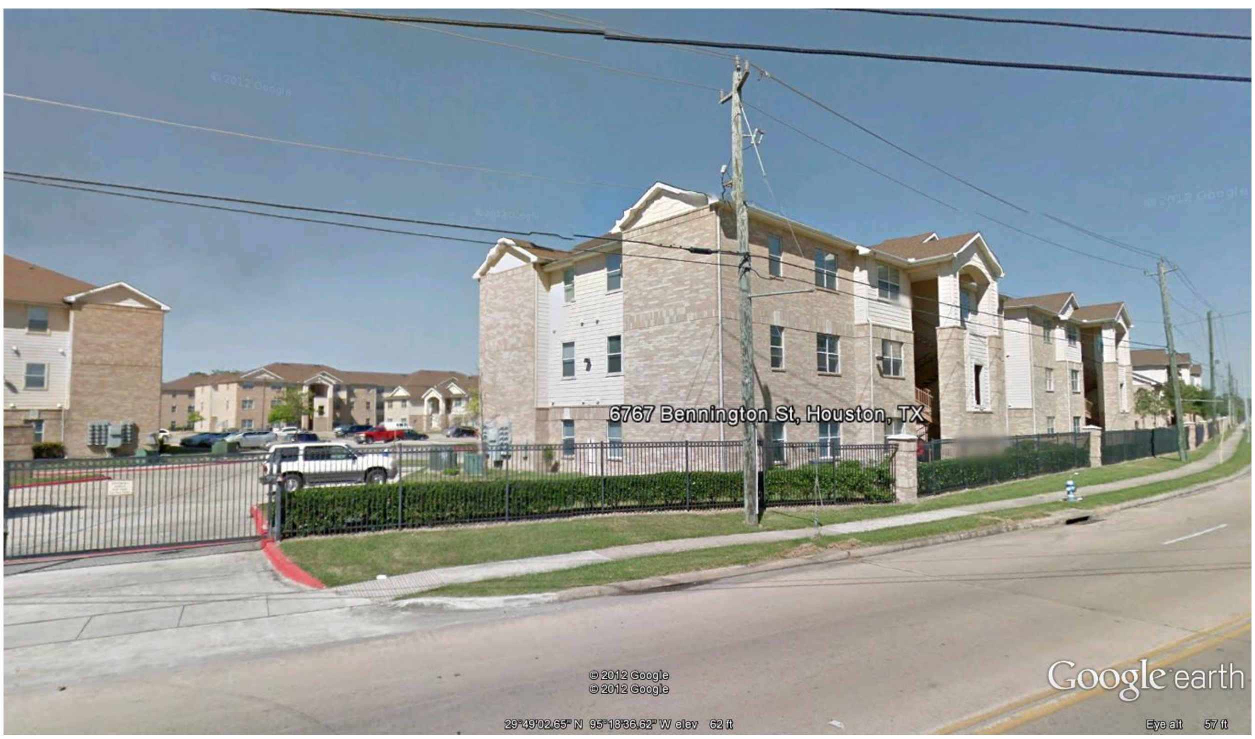
In order to better estimate the damage potential of the one-story and "stacked one-living-level" multifamily structures, depth-damage curves were adopted from the EGM 01-04 that represent single-family one-story structures with no basements. The "stacked" units' total structure value was distributed evenly among the floors with each floor given a separate structure record and floor correction. The upper levels of the "stacked" units were given a 15-foot floor correction to adjust for their flood threshold.

The NOD depth-damage curves for multifamily structures were retained and applied to the traditional multi-family developments with 200 units or more. These traditional multifamily developments were identified by exterior finish and classified as metal frame structures, masonry bearing wall structures, or wood- or steel-frame structures. *Figure A5-1* through *Figure A5-3* display the three typical configurations of multifamily dwellings.

Figure A5-1:
Small Square-Footage Detached Single-Family Dwellings on One Multifamily Parcel

Figure A5-2:
"Stacked" One-Living Level Multifamily Units

Figure A5-3:
Traditional Multifamily Unit Development with 200 Units or More



13.4 Update of Ancillary Damage Values

A comparison of the CPI-U was made to adjust benefit categories other than damages to structures and their contents. The CPI-U adjustment was calculated to be 1.07 from 2009 to 2Q2013. For utilities, the average damage value per structure flooded was updated to a 2Q2013 value of $235. For roads, the average experienced repair cost per mile of inundated asphalt, concrete and dirt roads was updated to a 2Q2013 value of $12,752 per mile. For post disaster costs, the average cost incurred per flooded household was adjusted to a 2Q2013 value of $9,696 using the CPI-U.

13.5 Update of the Hydraulic and Hydrologic Model

The hydrologic model, HEC-HMS, was updated with rainfall data used by the non-federal sponsor, HCFCD, for all local analyses. The USGS determined this rainfall data in their report entitled *Depth-Duration Frequency of Precipitation for Texas* (Water-Resources Investigation Report 98-044). The National Weather Service's TP-40 was used in the original hydrologic analysis. The update to the rainfall data was requested by the USACE-SWG during DQC reviews.

The hydraulic model, HEC-RAS, was updated to change the downstream boundary condition to a known WSEL. Previously, the downstream boundary condition was set to the normal depth option. The change was requested by the USACE-SWG during DQC reviews.

13.6 Calculation of Advance Bridge Replacement Benefits

The Hunting Bayou FRM Project requires 15 bridges be replaced in association with the NED Plan's optimized channel length of the channel modification component in the bayou's upper stream segment. These bridges are listed in *Table A5-33*. The benefits of advance bridge replacement were calculated based on the remaining life of the existing bridges and their replacement costs and apply to all 32 NED Plan scales considered as the potential NED Plan.

The savings in O&M expenditures were not calculated. The O&M costs for bridge repair and rehabilitation were not computed because the O&M differential is anticipated to be too low to produce substantial benefits and also would be problematic to establish for several items. Some routine maintenance items are established on a cyclical schedule independent of the main structure age, while others are condition-based items that are dependent on the condition of the structure at the time of inspection. These types of conditional issues are not predictable.

In consultation with bridge engineers, the primary predictable O&M items for the type of bridges comprising the majority those earmarked for replacement are routine inspection and expansion joint seal replacement. Inspections of these types of bridges are cyclical, being performed every 2 years after the initial inspection in year 5 and are not costly to perform. Since new bridges would undergo the same inspection regime after 5 years, the only cost differential would result from approximately 2 to 3 inspections avoided in the 5 year period that would have been performed by a pair of engineering technicians and would range in the low thousands of dollars.

For joint seal replacement, the bridge engineer indicated a replacement frequency of 10 to 15 years ranging in cost of $20,000 to $50,000, which was corroborated by bridge maintenance literature. If there were a replacement differential between old and new bridges, it would likely be limited to the thousands, and perhaps tens of thousands of dollars over the 50-year period of analysis. However, no replacement differential or predictable replacement pattern with bridge age was available.

Routine maintenance, such as deck washing or bearing lubrication, being independent of main structure age, would be performed at the same frequency for new bridges as for old, yielding no differential. Maintenance based on bridge condition, such as cathodic protection, do not have predictable patterns or replacement differentials between old and new bridges noted in literature. Literature suggests longer term replacement items are required about 10 to 15 or more years. Therefore, this would limit the potential for differences to be established between old and new bridges within a 50-year period of analysis.

Also, establishing the applicable items for each bridge would require site visits or further consultation with the bridge owners. Considering the few predictable O&M items that appear to be discernible, and considering that approximately half of the bridges were built in the late 1980s or later, the aggregate amount of O&M differential appears to be limited. Therefore, O&M cost differentials between existing and new replacement bridges were not pursued.

Following the methodology in the NED Procedures Manual, Urban Flood Damages (1988), benefits were calculated as shown in *Table A5-34*. Average annual equivalent benefits for inclusion in the Hunting Bayou FRM Project were computed to be $981 thousand at 2QFY13 prices and a 3.50 percent federal discount rate. This benefit category would be applicable to any NED Plan scale selected for implementation.

Table A5-33:
Bridges Subject to Replacement with the Hunting Bayou Flood Risk Management (FRM) Project

Station	Bridge	Year	Life Span Left	Cost (main)*	Cost (approaches)*	Aggregated Cost by Life Span*
64892	Kelley Street Westbound - TxDOT (Replace)	1949	0	$1,755,468	$42,525	
56849	S.P. Englewood Yard - RR (Replace due to deepening)	1930	0	$37,450	$6,008	
56699	S.P. Englewood Yard - RR (Replace due to deepening)	1945	0	$38,520	$54,068	
56644	S.P. Englewood Yard - RR (Replace due to deepening)	1930	0	$42,800	$80,798	$2,057,637
59952	Loop 610 2nd Crossing - TxDOT (Replace on main line, replace on frontage roads)	1964	1	$14,718,180	$2,191,860	$16,910,040
73935	Walkway @ Russell - COH (Replace)	1975	12	$149,730	$4,860	
69295	Walkway @ Pickfair - COH (Replace)	1975	12	$223,200	$5,468	
67294	Ped. Brdge @ Hucheson -COH (Replace)	1975	12	$189,720	$4,860	
66153	Ped. Brdge @ Hucheson - COH (Replace)	1975	12	$189,720	$6,683	$774,241
70455	Wipprecht Street - COH (Replace)	1977	14	$1,487,070	$43,740	$1,530,810
56409	Wayside Drive - COH (Replace)	1987	24	$4,491,900	$742,365	$5,234,265
73267	Falls Street - COH (Replace)	1989	26	$1,210,860	$105,705	
72922	Leffingwell Street - COH (Replace)	1989	26	$1,182,030	$88,695	
71669	Wayne Street - COH (Replace)	1989	26	$1,522,968	$161,595	$4,271,853
72466	Hirsch Street - COH (Replace)	1991	28	$2,529,600	$18,360	$2,547,960

**costs are 2QFY13*

Table A5-34:
Advance Bridge Replacement Benefits, Bridge Aggregated by Remaining Useful Life

Aggregations based on Table A5-33	Aggregation 1	Aggregation 2	Aggregation 3	Aggregation 4	Aggregation 5	Aggregation 6	Aggregation 7
cost of new bridge	$2,057,637	$16,910,040	$774,241	$1,530,810	$5,234,265	$4,271,853	$2,547,960
life of new bridge, yrs	50	50	50	50	50	50	50
remaining useful life of existing bridge, yrs	0	1	12	14	24	26	28
extension of bridge life, yrs.	50	49	38	36	26	24	22
annual O&M of existing bridge	$0	$0	$0	$0	$0	$0	$0
annual O&M of new bridge	$0	$0	$0	$0	$0	$0	$0
interest rate	0.035	0.035	0.035	0.035	0.035	0.035	0.035
capital recovery rate (amortization factor), 50 yrs	0.04263	0.04263	0.04263	0.04263	0.04263	0.04263	0.04263
annual cost of new bridge	$87,725	$720,938	$33,009	$65,264	$223,156	$182,125	$108,629
present value of annuity for extended life	23.45562	23.27656	20.84109	20.29049	16.89035	16.05837	15.16712
benefits in beginning year of bridge life extension (future)	$2,057,637	$16,780,954	$687,939	$1,324,241	$3,769,186	$2,924,629	$1,647,589
single payment present worth for period equal to remaining useful life of existing bridge	1.00000	0.96618	0.66178	0.61778	0.43796	0.40884	0.38165
present value in year 1 of bridge extension	$2,057,637	$16,213,482	$455,266	$818,092	$1,650,742	$1,195,699	$628,810
annual O&M savings (over remaining life of existing bridge)	$0	$0	$0	$0	$0	$0	$0
present value of annuity for remaining life of existing bridge	0.00000	0.96618	9.66333	10.92052	16.05837	16.89035	17.66702
present value in year 1 of O&M savings	$0	$0	$0	$0	$0	$0	$0
present value of total credit	$2,057,637	$16,213,482	$455,266	$818,092	$1,650,742	$1,195,699	$628,810
average annual equivalent credit (benefit)	$87,725	$691,241	$19,410	$34,878	$70,377	$50,977	$26,808
Total average annual equivalent benefits							$981,416

13.7 Determination of Existing Capital Investment within the Existing 0.2 Percent Annual Exceedance Probability (AEP) Floodplain

The structure inventory and the capital investment distribution within the eight existing AEP floodplains of Hunting Bayou based on first floor elevations are presented in *Table A5-35*. It is estimated that 90 percent of the total structures in the estimated 0.2 percent AEP floodplain are residential, which accounts for approximately $178 million of structure value. Total structure value in the 0.2 percent floodplain is approximately $500 million.

What was discovered during the 2013 inventory update was that the residential inventory is not increasing at the rate that commercial development is. Growth in residential development averaged 0.7 percent annually while growth in commercial development exceeded 5 percent per annum between 1998 and 2013. Commercial development is taking place near multi-modal opportunities in the middle and lower stream segments closer to the rail yards and the Port of Houston and outside the project impact area. This new development is built to conform to COH first floor elevation standards.

Table A5-35:
Distribution of Capital Investment within Annual Exceedance Probability (AEP) Floodplains
Cumulative Totals based on First-Floor Elevations and Without Project (WOP) Hydrology and Hydraulic Conditions
2Q2013 (FY13) Structure Inventory Update and Values in $1,000's

Property	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"
Residential Property								
Number of Structures	0	203	1091	2265	3564	4614	5759	6616
Single-Family	0	154	933	2018	3226	4233	5345	6163
Multi-Family	0	49	158	247	338	380	412	450
Mobile Homes	0	0	0	0	0	1	2	3
Distribution	0.0%	2.5%	15.1%	32.7%	52.3%	68.7%	86.7%	100.0%
Structure Value	$ 0.00	$ 5,334.41	$ 28,659.54	$ 60,101.18	$ 92,472.23	$ 127,794.13	$ 156,001.36	$ 178,336.62
Content Value**	$ 0.00	$ 2,507.20	$ 13,682.06	$ 28,886.30	$ 44,842.49	$ 61,639.34	$ 75,643.88	$ 86,614.05
Total Value	$ 0.00	$ 7,841.61	$ 42,341.60	$ 88,987.48	$ 137,314.72	$ 189,433.47	$ 231,645.24	$ 264,950.67
Commercial Property								
Number of Structures	0	25	112	251	352	438	542	643
Distribution	0.0%	3.9%	17.4%	39.0%	54.7%	68.1%	84.3%	100.0%
Structure Value	$ 0.00	$ 5,876.43	$ 24,907.56	$ 46,128.99	$ 64,003.99	$ 88,835.05	$ 123,979.63	$ 172,890.13
Content Value**	$ 0.00	$ 9,521.23	$ 39,677.57	$ 73,170.55	$ 101,873.56	$ 131,901.85	$ 183,885.02	$ 244,613.38
Total Value	$ 0.00	$ 15,397.66	$ 64,585.13	$ 119,299.54	$ 165,877.55	$ 220,736.90	$ 307,864.65	$ 417,503.51
Public Property								
Number of Structures	0	2	13	33	52	57	66	69
Distribution	0.0%	2.9%	18.8%	47.8%	75.4%	82.6%	95.7%	100.0%
Structure Value	$ 0.00	$ 37.46	$ 3,537.56	$ 6,295.78	$ 9,748.17	$ 11,187.13	$ 12,776.02	$ 13,412.68
Content Value**	$ 0.00	$ 42.70	$ 4,032.82	$ 7,177.19	$ 11,112.91	$ 12,753.33	$ 14,564.66	$ 15,290.46
Total Value	$ 0.00	$ 80.16	$ 7,570.38	$ 13,472.97	$ 20,861.08	$ 23,940.46	$ 27,340.68	$ 28,703.14

Property	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"
Hospital Property								
Number of Structures	0	0	0	0	0	1	1	1
Distribution	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%	100.0%
Structure Value	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 137,000.00	$ 137,000.00	$ 137,000.00
Content Value**	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 36,990.00	$ 36,990.00	$ 36,990.00
Total Value	0	0	0	0	0	173990	173990	173990
Total Property								
Number of Structures	0	230	1216	2549	3968	5110	6368	7329
Distribution	0.0%	3.1%	16.6%	34.8%	54.1%	69.7%	86.9%	100.0%
Structure Value	$ 0.00	$ 11,248.30	$ 57,104.66	$ 112,525.95	$ 166,224.39	$ 364,816.31	$ 429,757.01	$ 501,639.43
Content Value**	$ 0.00	$ 12,071.13	$ 57,392.45	$ 109,234.04	$ 157,828.96	$ 243,284.52	$ 311,083.56	$ 383,507.89
Total Value	$ 0.00	$ 23,319.43	$ 114,497.11	$ 221,759.99	$ 324,053.35	$ 608,100.83	$ 740,840.57	$ 885,147.32
Passenger Vehicles								
Number of Vehicles	0	194	1050	2186	3477	4512	5674	6583
Distribution	0.0%	2.9%	16.0%	33.2%	52.8%	68.5%	86.2%	100.0%
Vehicle Value	$ 0.00	$ 1,495.85	$ 8,750.98	$ 18,612.32	$ 27,037.30	$ 33,345.51	$ 40,233.86	$ 45,849.47
Total Roads								
Roadway Lengths (Miles)	1	22	60	89	122	130	138	150
Distribution	0.7%	14.7%	40.0%	59.3%	81.3%	86.7%	92.0%	100.0%

**Residential Single Family Content Values displayed are based on a 50 percent content-to-structure value ratio (CSVR)*

13.8 Determination of Flood Damages for Without Project (WOP) Condition

Flood damages were estimated for all properties within the 0.2 percent AEP floodplain of Hunting Bayou for the WOP condition. Damages from inundation are based on data obtained from the previously described update of existing development. Damage estimates were computed for structures and contents for the various types of physical properties classified as residential, commercial, and public. Damages were also estimated for vehicles, utilities, roads, and post-disaster recovery costs.

13.8.1 Single Occurrence Damages

Damages expected to accrue from the various AEP events for the WOP condition are displayed in *Table A5-36*. These values represent damages expected for individual events under the WOP hydrologic and hydraulic conditions and include structure and content values. Values are based on 2Q2013 (FY13) price levels. As an example, total flood damages expected from a 1 percent AEP event approximate $160 million. The flood damages expected from a 0.2 percent exceedance probability event approximate $271 million.

13.8.2 Average Annual Equivalent Damages with and without Uncertainty

AAEV damages were calculated for WOP conditions. The AAEV was then recomputed within the HEC-FDA program without consideration of uncertainty. This produced a value of approximately $11.4 million as shown in *Table A5-37*. EAD computations in the HEC-FDA model with consideration of uncertainty resulted in EAD values of $19.8 million.

13.8.3 Average Annual Equivalent Value (AAEV) Damages

AAEV damages by reach over the 50-year project life are shown in *Table A5-38*. These damages correspond to damages accruing from all damage categories earlier described and, because there is no expected change in the WSEL and the structure inventory over time, the AAEV damages are equivalent to the expected annual damages of $19.8 million.

Table A5-36:
Single Occurrence Damages by Annual Exceedance Probability (AEP) Event
Without Project (WOP) Hydrology and Hydraulic Condition
2Q2013 (FY13) Structure Inventory Update and Values in $1,000's

	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 Damage								
Residential Property	$0.00	$2,157.13	$8,547.84	$17,646.96	$27,465.85	$36,398.65	$47,716.98	$54,611.13
Commercial Property	$0.00	$422.47	$1,717.77	$3,784.31	$5,633.65	$8,052.69	$11,431.01	$14,557.29
Public Property	$0.00	$4.56	$293.51	$701.87	$1,291.51	$1,573.91	$2,086.22	$2,385.04
Hospital	$0.00	$0.00	$0.00	$0.00	$808.30	$3,797.64	$14,943.96	$19,404.68
Content Damage								
Residential Property	$0.00	$1,396.06	$5,168.67	$10,414.87	$15,925.20	$20,607.34	$26,886.48	$30,557.91
Commercial Property	$0.00	$1,175.27	$6,146.72	$13,862.11	$21,486.17	$32,026.26	$48,662.71	$61,319.64
Public Property	$0.00	$0.66	$191.21	$715.55	$1,761.19	$2,172.83	$3,138.00	$3,945.56
Hospital	$0.00	$0.00	$0.00	$0.00	$0.00	$914.39	$4,573.44	$5,737.89
Totals								
Residential Property	$0.00	$3,553.19	$13,716.51	$28,061.82	$43,391.05	$57,005.99	$74,603.46	$85,169.04
Commercial Property	$0.00	$1,597.74	$7,864.49	$17,646.41	$27,119.82	$40,078.96	$60,093.72	$75,876.93
Public Property	$0.00	$5.22	$484.72	$1,417.42	$3,052.70	$3,746.75	$5,224.22	$6,330.60
Hospital	$0.00	$0.00	$0.00	$0.00	$808.30	$4,712.03	$19,517.40	$25,142.57
Total Property Damages	**$0.00**	**$5,156.15**	**$22,065.73**	**$47,125.66**	**$74,371.87**	**$105,543.72**	**$159,438.81**	**$192,519.14**
Post Disaster Costs	$0.00	$3,481.49	$10,814.48	$22,615.29	$34,638.10	$41,346.56	$50,713.42	$56,486.79
Road Damages	$10.50	$219.80	$555.61	$1,000.47	$1,410.66	$1,561.97	$1,664.88	$1,783.38
Utility Damages	$0.00	$85.13	$264.44	$549.97	$842.35	$1,005.51	$1,233.30	$1,373.70
Vehicle Damages	$0.00	$132.98	$1,591.67	$4,476.63	$8,286.04	$11,034.84	$15,489.79	$18,688.12
Total by Event	**$10.50**	**$9,075.55**	**$35,291.93**	**$75,768.02**	**$119,549.03**	**$160,492.60**	**$228,540.19**	**$270,851.12**
Percent Distribution								
Residential Property	0.00%	39.15%	38.87%	37.04%	36.30%	35.52%	32.64%	31.44%
Commercial Property	0.00%	17.60%	22.28%	23.29%	22.69%	24.97%	26.29%	28.01%
Public Property	0.00%	0.06%	1.37%	1.87%	2.55%	2.33%	2.29%	2.34%
Hospital	0.00%	0.00%	0.00%	0.00%	0.68%	2.94%	8.54%	9.28%
Post Disaster Costs	0.00%	38.36%	30.64%	29.85%	28.97%	25.76%	22.19%	20.86%
Road Damages	100.00%	2.42%	1.57%	1.32%	1.18%	0.97%	0.73%	0.66%
Utility Damages	0.00%	0.94%	0.75%	0.73%	0.70%	0.63%	0.54%	0.51%
Vehicle Damages	0.00%	1.47%	4.51%	5.91%	6.93%	6.88%	6.78%	6.90%
Total by Event	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Table A5-37:
Distribution of AAEV Damages by Reach With and Without Uncertainty
Without Project (WOP) Condition
2Q2013 (FY13) Structure Inventory Update and Values in $1,000's

Reach Name	With No Uncertainty	With Uncertainty	Difference	Percent Difference
D	$0.86	$0.85	-$0.01	-1.16%
H	$0.06	$0.06	$0.00	0.00%
L	$1.07	$3.53	$2.46	229.91%
M	$31.35	$67.48	$36.13	115.25%
O	$1.31	$5.00	$3.69	281.68%
P	$1.04	$5.35	$4.31	414.42%
R-Left	$81.27	$334.35	$253.08	311.41%
R-Right	$130.71	$445.15	$314.44	240.56%
T-Left	$83.87	$254.94	$171.07	203.97%
T-Right	$590.13	$989.47	$399.34	67.67%
U-Left	$1.14	$11.99	$10.85	951.75%
U-Right	$60.35	$182.83	$122.48	202.95%
V	$0.01	$10.29	$10.28	102,800.00%
X	$96.69	$198.12	$101.43	104.90%
Z	$89.99	$309.03	$219.04	243.40%
AE	$984.00	$2,356.58	$1,372.58	139.49%
AF	$461.05	$1,031.96	$570.91	123.83%
AG	$41.27	$183.35	$142.08	344.27%
AH	$7.13	$51.65	$44.52	624.40%
AI	$327.37	$876.48	$549.11	167.73%
AL	$526.54	$1,029.67	$503.13	95.55%
AP	$6,125.31	$8,359.95	$2,234.64	36.48%
AZ	$1,768.02	$3,084.02	$1,316.00	74.43%
Total	$11,410.54	$19,792.10	$8,381.56	73.45%
Manual Integration EAD	$11,935.52			

3.50 percent discount rate

Table A5-38:
Distribution of Average Annual Equivalent Value (AAEV) Damages by Reach
Without Project (WOP) Condition
2Q2013 (FY13) Structure Inventory Update and Values in $1,000's
FY2014 Interest Rate – 3.50 Percent

Reach Name	Residential	Commercial	Public	Hospital	Post-Disaster	Road	Utility	Vehicle	Total	Percent Distribution
D	$0.00	$0.00	$0.00	$0.00	$0.00	$0.85	$0.00	$0.00	$0.85	0.0%
H	$0.00	$0.00	$0.00	$0.00	$0.00	$0.06	$0.00	$0.00	$0.06	0.0%
L	$3.06	$0.00	$0.00	$0.00	$0.00	$0.32	$0.00	$0.15	$3.53	0.0%
M	$42.50	$7.49	$0.48	$0.00	$8.80	$0.58	$0.21	$7.42	$67.48	0.3%
O	$4.25	$0.00	$0.27	$0.00	$0.00	$0.00	$0.00	$0.48	$5.00	0.0%
P	$2.17	$2.87	$0.00	$0.00	$0.00	$0.15	$0.00	$0.16	$5.35	0.0%
R-Left	$25.10	$299.14	$0.00	$0.00	$8.12	$1.11	$0.20	$0.68	$334.35	1.7%
R-Right	$157.49	$234.56	$0.69	$0.00	$34.00	$3.18	$0.83	$14.40	$445.15	2.2%
T-Left	$196.96	$1.39	$0.00	$0.00	$45.65	$1.68	$1.11	$8.15	$254.94	1.3%
T-Right	$668.76	$3.50	$5.00	$0.00	$250.23	$4.15	$6.08	$51.75	$989.47	5.0%
U-Left	$7.90	$3.83	$0.00	$0.00	$0.00	$0.06	$0.00	$0.20	$11.99	0.1%
U-Right	$146.44	$0.00	$0.00	$0.00	$30.41	$0.00	$0.74	$5.24	$182.83	0.9%
V	$0.00	$10.29	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$10.29	0.1%
X	$46.25	$127.35	$0.00	$0.00	$18.26	$2.81	$0.44	$3.01	$198.12	1.0%
Z	$103.47	$159.37	$2.57	$0.00	$38.35	$2.11	$0.93	$2.23	$309.03	1.6%
AE	$6.35	$2,321.43	$0.01	$0.00	$14.83	$12.38	$0.36	$1.22	$2,356.58	11.9%
AF	$83.14	$856.01	$3.15	$0.00	$68.16	$15.09	$1.66	$4.75	$1,031.96	5.2%
AG	$98.72	$67.91	$0.64	$0.00	$10.85	$3.45	$0.26	$1.52	$183.35	0.9%
AH	$2.73	$44.12	$0.00	$0.00	$1.07	$3.48	$0.03	$0.22	$51.65	0.3%
AI	$183.14	$551.04	$25.75	$0.00	$88.66	$12.82	$2.16	$12.91	$876.48	4.4%
AL	$269.46	$503.40	$8.64	$0.00	$179.24	$12.66	$4.36	$51.91	$1,029.67	5.2%
AP	$3,210.49	$748.60	$254.48	$750.20	$2,682.90	$71.15	$65.25	$576.88	$8,359.95	42.2%
AZ	$1,268.36	$521.99	$91.65	$0.00	$974.38	$57.87	$24.01	$145.76	$3,084.02	15.6%
Total	**$6,526.74**	**$6,464.29**	**$393.33**	**$750.20**	**$4,453.91**	**$205.96**	**$108.63**	**$889.04**	**$19,792.10**	**100.0%**
Percent Distribution	**33.0%**	**32.7%**	**2.0%**	**3.8%**	**22.5%**	**1.0%**	**0.5%**	**4.5%**	**100.0%**	

Colors designate lower, middle and upper stream segments.

14.0 DETERMINING THE NATIONAL ECONOMIC DEVELOPMENT (NED) PLAN, 2013

In 2009, the NED Plan of channel modification, bridge replacement, and offline detention components were refined into an array of 32 possible combinations in an attempt to identify the scale that maximized net excess benefits. Based on the update of the WOP condition, the 32 NED Plan scales were updated with current planning level costs and were reanalyzed and compared for net excess benefit production. *Table A5-39* presents the 32-scale array's performance under current conditions.

With the update to current conditions, the NED Plan scale that maximizes net excess benefits changed from B90-A50 in 2009 to B60-A50 in 2013. The NED Plan scale that maximized net excess benefits at least cost remained B50-A25.

When evaluated against the current 2013 condition within the watershed, nineteen combinations of channel bottom-width and detention basin size produced net excess benefits within five percent of B60-A50. Of these 19, the NED Plan scale of B50-A25 "reasonably" maximizes net excess benefits at the least cost. However, B50-A25 ranks last among the 32-scale array for inundation damages reduced.

Table A5-39:
Economic Performance of 32 NED Plan Scales
2Q2013 (FY13) Structure Inventory Update and Values in $1,000's

2013 Net Excess Benefit Rank	NED Plan Scale	Equivalent Annual Damage (x $1,000)	Equivalent Annual Inundation Damage Reduction Benefit (x $1,000)	Advance Bridge Replacement Benefit	Total Annual Equivalent NED Benefits	2013 Total Project Cost (x $1,000)^1	Annual Equivalent Project Cost (x $1,000)^1	Annual Equivalent Net Excess Benefits (x $1,000)	BCR	Difference in Net Excess Benefits vs Top Performer (%)	Rank Order Least Cost	Rank Order Inundation Damages Reduced
	WOP	**$19,792.10**										
1	B60-A50	$5,562.01	$14,230.09	$981.42	$15,211.51	$151,345.80	$6,596.02	$8,615.48	2.31	0.00%	9	20
2	B90-A25	$5,945.02	$13,847.08	$981.42	$14,828.50	$147,070.47	$6,362.52	$8,465.98	2.33	1.74%	6	26
3	B90-A50	$5,149.44	$14,642.66	$981.42	$15,624.08	$164,509.92	$7,163.91	$8,460.17	2.18	1.80%	16	14
4	B140-A25	$5,197.64	$14,594.46	$981.42	$15,575.88	$165,212.99	$7,150.61	$8,425.27	2.18	2.21%	15	15
5	B80-A25	$6,136.00	$13,656.10	$981.42	$14,637.52	$143,594.25	$6,212.79	$8,424.72	2.36	2.21%	4	28
6	B100-A25	$5,843.27	$13,948.83	$981.42	$14,930.25	$150,772.97	$6,521.84	$8,408.41	2.29	2.40%	8	24
7	B70-A25	$6,333.76	$13,458.34	$981.42	$14,439.76	$139,459.70	$6,033.79	$8,405.97	2.39	2.43%	3	29
8	B60-A25	$6,598.01	$13,194.09	$981.42	$14,175.51	$133,710.30	$5,786.26	$8,389.25	2.45	2.63%	2	31
9	B110-A25	$5,682.11	$14,109.99	$981.42	$15,091.41	$154,955.70	$6,705.04	$8,386.37	2.25	2.66%	10	23
10	B80-A50	$5,382.33	$14,409.77	$981.42	$15,391.19	$161,084.70	$7,016.36	$8,374.82	2.19	2.79%	13	17
11	B120-A25	$5,548.09	$14,244.01	$981.42	$15,225.43	$158,566.03	$6,861.59	$8,363.84	2.22	2.92%	12	19
12	B70-A50	$5,591.42	$14,200.68	$981.42	$15,182.10	$157,022.56	$6,840.45	$8,341.65	2.22	3.18%	11	21
13	B50-A25	$6,820.55	$12,971.55	$981.42	$13,952.97	$129,858.40	$5,620.19	$8,332.78	2.48	3.28%	1	32
14	B100-A50	$5,122.05	$14,670.05	$981.42	$15,651.47	$168,162.65	$7,321.10	$8,330.37	2.14	3.31%	18	13
15	B110-A50	$4,944.79	$14,847.31	$981.42	$15,828.73	$172,318.55	$7,503.16	$8,325.57	2.11	3.37%	20	11
16	B120-A50	$4,848.24	$14,943.86	$981.42	$15,925.28	$175,906.01	$7,658.74	$8,266.54	2.08	4.05%	21	9
17	B50-A50	$6,080.03	$13,712.07	$981.42	$14,693.49	$147,546.13	$6,432.18	$8,261.30	2.28	4.11%	7	27
18	B140-A50	$4,654.30	$15,137.80	$981.42	$16,119.22	$182,637.84	$7,951.36	$8,167.86	2.03	5.20%	24	6
19	B40-A50	$6,352.70	$13,439.40	$981.42	$14,420.82	$143,631.82	$6,262.54	$8,158.27	2.30	5.31%	5	30
20	B200-A25	$4,670.27	$15,121.83	$981.42	$16,103.25	$185,768.74	$8,044.00	$8,059.24	2.00	6.46%	26	7
21	B60-A75	$5,409.89	$14,382.21	$981.42	$15,363.63	$171,135.52	$7,463.38	$7,900.25	2.06	8.30%	19	18
22	B80-A75	$5,047.02	$14,745.08	$981.42	$15,726.50	$181,082.50	$7,892.54	$7,833.95	1.99	9.07%	23	12

2013 Net Excess Benefit Rank	NED Plan Scale	Equivalent Annual Damage (x $1,000)	Equivalent Annual Inundation Damage Reduction Benefit (x $1,000)	Advance Bridge Replacement Benefit	Total Annual Equivalent NED Benefits	2013 Total Project Cost (x $1,000)^1	Annual Equivalent Project Cost (x $1,000)^1	Annual Equivalent Net Excess Benefits (x $1,000)	BCR	Difference in Net Excess Benefits vs Top Performer (%)	Rank Order Least Cost	Rank Order Inundation Damages Reduced
23	B90-A75	$4,899.96	$14,892.14	$981.42	$15,873.56	$184,583.20	$8,043.29	$7,830.27	1.97	9.11%	25	10
24	B70-A75	$5,235.57	$14,556.53	$981.42	$15,537.95	$176,910.38	$7,711.96	$7,825.98	2.01	9.16%	22	16
25	B200-A50	$4,102.56	$15,689.54	$981.42	$16,670.96	$203,348.54	$8,851.33	$7,819.63	1.88	9.24%	30	2
26	B50-A75	$5,666.26	$14,125.84	$981.42	$15,107.26	$167,247.81	$7,295.80	$7,811.45	2.07	9.33%	17	22
27	B100-A75	$4,780.54	$15,011.56	$981.42	$15,992.98	$188,310.64	$8,203.65	$7,789.32	1.95	9.59%	27	8
28	B40-A75	$5,887.32	$13,904.78	$981.42	$14,886.20	$163,221.76	$7,121.42	$7,764.77	2.09	9.87%	14	25
29	B110-A75	$4,636.54	$15,155.56	$981.42	$16,136.98	$192,561.14	$8,389.72	$7,747.25	1.92	10.08%	28	5
30	B120-A75	$4,520.57	$15,271.53	$981.42	$16,252.95	$196,315.42	$8,552.40	$7,700.54	1.90	10.62%	29	4
31	B140-A75	$4,298.28	$15,493.82	$981.42	$16,475.24	$203,272.90	$8,854.65	$7,620.59	1.86	11.55%	31	3
32	B200-A75	$3,790.26	$16,001.84	$981.42	$16,983.26	$224,687.26	$9,784.63	$7,198.63	1.74	16.45%	32	1

14.1 Induced Damages

During the plan refinement process, it was determined that most of the NED Plan scales eligible to be named the NED Plan raise the WSELs of probabilistic storm events with their implementation above levels expected without the project in place. Inducing higher WSELs above the WOP condition can consequently induce damages to vulnerable property and habitable structures. Induced damages are captured in the overall damage estimate for each plan scale but are not readily apparent because HED-FDA outputs are aggregated with damages reduced overshadowing damages induced.

An analysis of induced damages revealed that all of the NED Plan scales that perform within ten percent of the top net excess benefit producer, B60-A50, induce damages primarily downstream in the middle stream segment between cross-sections 285+13 and 565+44. Generally, those scale combinations that include a 25-acre basin induce damages beginning at the 4 percent event. Those scale combinations that include a 50-acre basin induce damages beginning at the 2 percent event. The scale combination that produces the highest net excess benefits among those scales with 75-acre detention basins is B60-A75. B60-A75 induces damages above the 1 percent event.

Based on their rank order for next excess damages produced, the number of NED Plan scales was truncated from 32 to 21 since B60-A75 was the highest-ranking NED Plan scale to have a 75- acre basin and produce no damages at the 1 percent or more frequent event. Any lower ranking NED Plan scale would have to induce no damage downstream to overcome its lack of net excess benefit production to improve its rank order. This distinction was important for subsequent evaluation of FEMA mitigation costs associated with identification of an NED Plan.

Table A5-40 displays damages induced by the top 21 NED Plan scales and their rank order. The least cost NED Plan scale B50-A25 ranks highest overall in induced damages. NED Plan scale B60-A75 induces the least damages.

Table A5-40:
Induced Damages of Top 21 NED Plan Scales
2Q2013 (FY13) Structure Inventory Update

2013 Net Excess Benefit Rank	NED Plan Scale	Expected Annual Induced Damages	Present Worth Equivalent Induced Damages (x $1,000)	Rank Order Induced Damages
1	B60-A50	$81.89	$1,920.88	13
2	B90-A25	$131.94	$3,094.84	6
3	B90-A50	$65.15	$1,528.05	19
4	B140-A25	$106.40	$2,495.58	9
5	B80-A25	$168.52	$3,952.79	4
6	B100-A25	$143.16	$3,357.99	5
7	B70-A25	$177.07	$4,153.28	3
8	B60-A25	$183.36	$4,300.77	2
9	B110-A25	$129.55	$3,038.57	7
10	B80-A50	$70.88	$1,662.64	16
11	B120-A25	$126.52	$2,967.70	8
12	B70-A50	$84.41	$1,980.00	12
13	B50-A25	$200.75	$4,708.70	1
14	B100-A50	$71.19	$1,669.80	15
15	B110-A50	$64.35	$1,509.38	20
16	B120-A50	$68.94	$1,616.99	17
17	B50-A50	$89.37	$2,096.22	11
18	B140-A50	$66.11	$1,550.76	18
19	B40-A50	$93.09	$2,183.43	10
20	B200-A25	$76.55	$1,795.61	14
21	B60-A75	$26.37	$618.59	21

3.50 percent interest rate

14.2 Reassessment of the Least Cost National Economic Development (NED) Plan Scale

The uncompensated cost of induced damages was added to the NED Plan project cost estimate as an negative externality. *Table A5-41* demonstrates the outcome of the rank order of the NED Plan scales that reasonably maximize net excess benefits. B60-A50 remains the NED Plan scale that maximizes net excess benefits. B50-A25 maximizes net excess benefits within 5 percent of the top net excess benefit performer and remains the least cost NED Plan scale.

Table A5-41:
Net Excess Benefits of NED Plan Scales with Inclusion of Uncompensated Induced Damages*

NED Plan Scale	Expected Annual Induced Damages (x $1,000)	Project Cost with Induced Damages Included (x $1,000)	Net Excess Benefits with Induced Damages included in Cost (x $1,000)	Revised Rank Order Net Excess Benefits	Rank Order Least Cost	Difference in Net Excess Benefits vs Top Performer (x $1,000)
B60-A50	$81.89	$6,677.92	$7,552.17	1	9	0.0%
B90-A25	$131.94	$6,494.46	$7,352.62	3	6	2.6%
B90-A50	$65.15	$7,229.05	$7,413.61	2	14	1.8%
B140-A25	$106.40	$7,257.01	$7,337.45	4	15	2.8%
B80-A25	$168.52	$6,381.32	$7,274.78	11	5	3.7%
B100-A25	$143.16	$6,665.00	$7,283.83	6	8	3.6%
B70-A25	$177.07	$6,210.86	$7,247.48	13	3	4.0%
B60-A25	$183.36	$5,969.62	$7,224.47	14	2	4.3%
B110-A25	$129.55	$6,834.58	$7,275.41	10	10	3.7%
B80-A50	$70.88	$7,087.25	$7,322.52	5	13	3.0%
B120-A25	$126.52	$6,988.11	$7,255.90	12	12	3.9%
B70-A50	$84.41	$6,924.86	$7,275.82	9	11	3.7%
B50-A25	$200.75	$5,820.93	$7,150.62	17	1	5.3%
B100-A50	$71.19	$7,392.29	$7,277.76	8	16	3.6%
B110-A50	$64.35	$7,567.51	$7,279.80	7	18	3.6%
B120-A50	$68.94	$7,727.68	$7,216.18	15	19	4.4%
B50-A50	$89.37	$6,521.55	$7,190.52	16	7	4.8%
B140-A50	$66.11	$8,017.48	$7,120.32	18	20	5.7%
B40-A50	$93.09	$6,355.63	$7,083.77	19	4	6.2%
B200-A25	$76.55	$8,120.56	$7,001.27	20	21	7.3%
B60-A75	$26.37	$7,489.75	$6,892.46	21	17	8.7%

**3.5 percent interest rate, 2Q13 price level*

14.3 Mitigation of Induced Damages

ER 1105-2-100 states in Section 3-3.b.(5) Induced Flooding:

> "When a project results in induced damages, mitigation should be investigated and recommended if appropriate. Mitigation is appropriate when economically justified or there are overriding reasons of safety, economic or social concerns, or a determination of a real estate taking (flowage easement, etc.) has been made. Remaining induced damages are to be accounted for in the economic analysis and the impacts should be displayed and discussed in the report."

Plan B50-A25 "reasonably" maximizes net excess benefits at least cost and could be considered the NED Plan. However, inspection of its performance indicates that B50-A25 produces the highest induced damages downstream from the project area of the top 21 NED Plan scales evaluated. The AAEV of the induced damages is $200 thousand or $4.7 million in present value equivalents at 3.5 percent interest. In order to economically justify full mitigation of these induced damages, the cost for mitigation would necessarily be $4.7 million or less to reach parity with the benefits realized.

14.3.1 Economic Justification of Mitigation

Opportunities for mitigating induced damages in a cost effective manner are limited. Levee construction along the middle stream segment would be cost-prohibitive and would serve to further exacerbate the transfer of risk and damages further downstream. Increasing the detention basin sizing is an option since there may be opportunities for economies of scale, and storage volume upstream is a strong indicator of downstream impacts. By comparing the estimated costs of
B50-A25 and B50-A50 from *Table A5-39*, the difference in costs is approximately $17.5 million. It is apparent a larger detention increment is not economically justifiable as a mitigation strategy, since the cost for the next larger storage increment is greater than the $4.7 million in present worth equivalent induced damages and would not mitigate fully the downstream impacts from B50-A25 shown in *Table A5-41*.

With induced damages impacting structures at infrequent events, there exists little expectation for economic justification for mitigating induced damages by nonstructural means because the low probability of damages occurring diminishes their expected AAEV and consequently limits any economical remedy.

14.3.2 Mitigation based on Safety, Economic or Social Concerns

Mitigation of induced damages could be appropriate based on safety, economic or social concerns. The transfer of risk and damages to an area downstream from the project area on Hunting Bayou is considered to be socially unacceptable by the non-federal sponsor, HCFCD, and violates local policies of the non-federal sponsor, HCFCD, to induce damages at or below the 1 percent AEP event. Inducing additional damages on a local population which has limited ability to respond to and recover from catastrophic events is neither acceptable nor implementable.

However minimizing disruption of neighborhoods is a study objective and displacing the population to mitigate induced damages using buyout as a mitigating measure violates that objective. A measure which would adhere to study objectives and potentially be less costly with regard to mitigation of induced damages is implementing B60-A75.

14.3.3 Mitigation based on a Determination of a Real Estate Taking

Inducing damages might constitute a real estate taking according to the Fifth Amendment Takings Clause of the Constitution of the United States. If a legal real estate taking determination is made, payment of just compensation to the property owner is required. The value of that compensation would be included in the total project cost which would influence not only its total cost but also the net excess benefits attributable to that project. A real estate taking was determined not to exist based on the character of induced damages with regard to frequency, extent, flooding depth and damages incurred as shown in *Table A5-41*. Should B50-A25 be recommended for implementation, a takings determination will be conducted.

14.4 Identification of the NED Plan

Even though B50-A25 induces the greatest damages downstream and violates other study objectives, it best addresses the federal objective by reasonably maximizing net excess NED benefits at least cost. Therefore, B50-A25 is identified as the NED Plan.

14.4.1 Economic Performance of B50-A25

As the NED Plan scale that “reasonably” maximizes NED net excess benefits at least cost, B50-A25 is, by definition, the NED Plan. B50-A25 is described by its economic and performance characteristics.

14.4.1.1 Economic Assets in the B50-A25 Residual Floodplain

The distribution of economic assets remaining at risk in the residual floodplain of B90-A50 is shown in *Table A5-43.* Total structures at risk from a 0.2 percent AEP event along Hunting Bayou decrease 45 percent from a count of 7,329 to a count of 3,998 with implementation of B50-A25. Residential structures at risk from the 0.2 percent AEP event are reduced from a count 6,616 to 3,506 by implementing B50-A25.

An estimated 79 percent of the structures in the WOP condition 1 percent AEP floodplain would experience reduced risk from a 1 percent AEP event by implementing B50-A25. An estimated 5,015 structures are currently exposed to the risk of a 1 percent AEP event. By implementing B50-A25, structures at risk in the residual 1 percent AEP floodplain would drop to 1,089 of which 942 are residential.

14.4.1.2 Single Occurrence Damages in the B50-A25 Residual Floodplain

Table A5-44 displays the single occurrence damages expected to occur in the residual floodplain of B50-A25. Damages to economic assets are expected from a 0.2 percent AEP event would drop an estimated 38 percent to $168 million by implementing B50-A25. Damages to assets from a 1 percent event are expected to decline by 67 percent to $53.1 million by implementing B50-A25.

14.4.1.3 Average Annual Equivalent Damages Reduced with the Implementation of B50-A25

Table A5-45 displays the AAEV damages reduced by B50-A25. Table A5-46 shows the AAEV damages remaining in the residual 0.2 percent AEP floodplain of B50-A25. AAEV damages are reduced by 65 percent by implementing B50-A25 over the WOP condition. *Table A5-47* presents AAEV values with and without uncertainty in estimation.

Table A5-42:
Economic Assets by Annual Exceedance Probability (AEP) Event
B50-A25 With Project Condition
2Q2013 (FY13) Structure Inventory Update and Values in $1,000's

	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"
Residential Property								
Number of Structures	0	5	30	162	417	942	2,033	3,506
Single-Family	0	5	30	161	368	815	1,841	3,212
Multi-Family	0	0	0	1	49	127	192	294
Mobile Homes	0	0	0	0	0	0	0	0
Distribution	0.0%	0.1%	0.9%	4.6%	11.9%	26.9%	58.0%	100.0%
Structure Value	$0.00	$366.20	$1,723.84	$7,497.81	$16,597.59	$40,017.92	$72,210.41	$114,206.15
Content Value*	$0.00	$183.10	$861.92	$3,729.05	$8,136.44	$18,948.39	$34,700.08	$55,219.81
Total Value	$0.00	$549.30	$2,585.76	$11,226.86	$24,734.03	$58,966.31	$106,910.49	$169,425.96
Commercial Property								
Number of Structures	0	1	15	57	84	139	259	447
Distribution	0.0%	0.2%	3.4%	12.8%	18.8%	31.1%	57.9%	100.0%
Structure Value	$0.00	$116.40	$12,700.48	$32,241.29	$42,182.69	$61,151.13	$101,397.80	$149,746.20
Content Value*	$0.00	$195.55	$21,170.13	$53,570.66	$64,528.71	$89,724.03	$149,189.58	$207,031.66
Total Value	$0.00	$311.95	$33,870.61	$85,811.95	$106,711.40	$150,875.16	$250,587.38	$356,777.86
Public Property								
Number of Structures	0	0	0	4	4	8	21	45
Distribution	0.0%	0.0%	0.0%	8.9%	8.9%	17.8%	46.7%	100.0%
Structure Value	$0.00	$0.00	$0.00	$184.02	$184.02	$2,571.52	$3,967.29	$9,381.17
Content Value*	$0.00	$0.00	$0.00	$209.78	$209.78	$2,931.53	$4,522.71	$10,694.53
Total Value	$0.00	$0.00	$0.00	$393.80	$393.80	$5,503.05	$8,490.00	$20,075.70

	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"
Hospital Property								
Number of Structures	0	0	0	0	0	0	0	0
Distribution	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Structure Value	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Content Value*	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Total Value	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Total Property								
Number of Structures	0	6	45	223	505	1,089	2,313	3,998
Distribution	0.0%	0.2%	1.1%	5.6%	12.6%	27.2%	57.9%	100.0%
Structure Value	$0.00	$482.60	$14,424.32	$39,923.12	$58,964.30	$103,740.57	$177,575.50	$273,333.52
Content Value*	$0.00	$378.65	$22,032.05	$57,509.49	$72,874.93	$111,603.95	$188,412.37	$272,946.01
Total Value	$0.00	$861.25	$36,456.37	$97,432.61	$131,839.23	$215,344.52	$365,987.87	$546,279.53
Passenger Vehicles								
Number of Vehicles	0	6	40	170	401	874	1,973	3,445
Distribution	0.0%	0.2%	1.2%	4.9%	11.6%	25.4%	57.3%	100.0%
Vehicle Value	$0.00	$33.44	$264.23	$1,072.84	$2,736.67	$6,662.10	$14,457.42	$26,641.10
Total Roads								
Roadway Lengths (Miles)	1	2	7	9	12	19	37	50
Distribution	2.0%	4.0%	14.0%	18.0%	24.0%	38.0%	74.0%	100.0%

Table A5-43:
Single Occurrence Damages by Annual Exceedance Probability (AEP) Event
B50-A25 Project Condition
2Q2013 (FY13) Structure Inventory Update and Values in $1,000's

	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 Damage								
Residential Property	$0.00	$118.61	$837.31	$2,618.07	$5,512.77	$11,635.14	$20,824.07	$33,218.08
Commercial Property	$0.00	$8.10	$568.49	$2,250.53	$3,096.98	$4,505.58	$8,239.13	$12,745.13
Public Property	$0.00	$0.00	$1.95	$28.11	$36.91	$102.23	$397.29	$1,058.62
Hospital	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$131.52
Content Damage								
Residential Property	$0.00	$78.91	$515.23	$1,661.81	$3,387.94	$6,722.11	$12,240.25	$19,076.47
Commercial Property	$0.00	$29.36	$2,404.29	$9,833.05	$13,692.56	$19,616.86	$36,177.38	$57,939.00
Public Property	$0.00	$0.00	$0.00	$9.34	$22.84	$67.12	$299.95	$1,057.76
Hospital	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Totals								
Residential Property	$0.00	$197.52	$1,352.54	$4,279.87	$8,900.71	$18,357.25	$33,064.32	$52,294.54
Commercial Property	$0.00	$37.46	$2,972.79	$12,083.58	$16,789.53	$24,122.44	$44,416.51	$70,684.13
Public Property	$0.00	$0.00	$1.95	$37.45	$59.75	$169.35	$697.24	$2,116.39
Hospital	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$131.52
Total Property Damages	**$0.00**	**$234.98**	**$4,327.27**	**$16,400.90**	**$25,750.00**	**$42,649.04**	**$78,178.08**	**$125,226.58**
Post Disaster Costs	$0.00	$222.37	$993.95	$3,348.91	$5,766.85	$8,157.60	$18,461.17	$33,206.67
Road Damages	$9.87	$35.34	$90.55	$331.71	$491.44	$622.96	$1,047.93	$1,424.31
Utility Damages	$0.00	$5.40	$24.16	$81.59	$140.60	$198.93	$448.95	$807.54
Vehicle Damages	$0.00	$2.62	$43.85	$273.73	$542.80	$1,440.90	$3,449.63	$7,585.73
Total by Event	**$9.87**	**$500.71**	**$5,479.78**	**$20,436.85**	**$32,691.69**	**$53,069.43**	**$101,585.75**	**$168,250.83**
Percent Distribution								
Residential Property	0.00%	39.45%	24.68%	20.94%	27.23%	34.59%	32.55%	31.08%
Commercial Property	0.00%	7.48%	54.25%	59.13%	51.36%	45.45%	43.72%	42.01%
Public Property	0.00%	0.00%	0.04%	0.18%	0.18%	0.32%	0.69%	1.26%
Hospital	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.08%
Post Disaster Costs	0.00%	44.41%	18.14%	16.39%	17.64%	15.37%	18.17%	19.74%
Road Damages	100.00%	7.06%	1.65%	1.62%	1.50%	1.17%	1.03%	0.85%
Utility Damages	0.00%	1.08%	0.44%	0.40%	0.43%	0.37%	0.44%	0.48%
Vehicle Damages	0.00%	0.52%	0.80%	1.34%	1.66%	2.72%	3.40%	4.51%
Total by Event	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Table A5-44:
Distribution of Average Annual Equivalent Value (AAEV) Damages Reduced by Reach
B50-A25 Project Condition
2Q2013 (FY13) Structure Inventory Update and Values in $1,000's
FY2014 Interest Rate – 3.50 Percent

Reaches	Residential	Commercial	Public	Hospital	Post-Disaster	Road	Utility	Vehicle	Total	Percent Distribution
D	$0.00	$0.00	$0.00	$0.00	$0.00	-$0.01	$0.00	$0.00	-$0.01	0.0%
H	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	0.0%
L	$0.17	$0.00	$0.00	$0.00	$0.00	$0.02	$0.00	$0.01	$0.20	0.0%
M	$3.21	$0.42	$0.03	$0.00	$0.83	$0.03	$0.02	$0.46	$5.00	0.0%
O	$0.63	$0.00	$0.05	$0.00	$0.00	$0.00	$0.00	$0.08	$0.76	0.0%
P	$0.35	$0.47	$0.00	$0.00	$0.00	$0.00	$0.00	$0.03	$0.85	0.0%
R-Left	$5.09	$59.89	$0.00	$0.00	$1.71	$0.13	$0.04	$0.12	$66.98	0.5%
R-Right	$31.19	$48.22	$0.14	$0.00	$6.37	$0.50	$0.16	$2.85	$89.43	0.7%
T-Left	$46.08	$0.33	$0.00	$0.00	$10.99	$0.39	$0.27	$1.97	$60.03	0.5%
T-Right	$142.90	$0.82	$1.07	$0.00	$51.61	$0.83	$1.25	$11.86	$210.34	1.6%
U-Left	$1.87	$0.92	$0.00	$0.00	$0.00	$0.01	$0.00	$0.05	$2.85	0.0%
U-Right	$33.80	$0.00	$0.00	$0.00	$7.43	$0.00	$0.18	$1.28	$42.69	0.3%
V	$0.00	$2.21	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$2.21	0.0%
X	$9.17	$22.79	$0.00	$0.00	$3.85	$0.37	$0.09	$0.59	$36.86	0.3%
Z	$21.58	$34.52	$0.41	$0.00	$9.34	$0.48	$0.22	$0.16	$66.71	0.5%
AE	$1.26	$363.75	$0.00	$0.00	$3.34	$2.33	$0.08	$0.21	$370.97	2.9%
AF	$16.04	$142.68	$0.20	$0.00	$15.54	$3.20	$0.38	$0.66	$178.70	1.4%
AG	$18.13	$6.06	$0.02	$0.00	$1.73	$0.66	$0.04	-$0.62	$26.02	0.2%
AH	$1.87	$30.47	$0.00	$0.00	$0.76	$1.95	$0.02	$0.15	$35.22	0.3%
AI	$147.87	$459.68	$21.57	$0.00	$73.05	$9.20	$1.78	$11.29	$724.44	5.6%
AL	$232.78	$436.80	$7.78	$0.00	$154.89	$9.48	$3.77	$47.33	$892.83	6.9%
AP	$2,765.68	$667.32	$227.21	$702.09	$2,317.76	$60.04	$56.37	$520.60	$7,317.07	56.4%
AZ	$1,179.26	$484.85	$84.37	$0.00	$881.37	$49.61	$21.70	$140.22	$2,841.38	21.9%
Total	**$4,658.93**	**$2,762.20**	**$342.85**	**$702.09**	**$3,540.57**	**$139.22**	**$86.37**	**$739.30**	**$12,971.53**	**100.0%**
Percent Distribution	**35.9%**	**21.3%**	**2.6%**	**5.4%**	**27.3%**	**1.1%**	**0.7%**	**5.7%**	**100.0%**	

Colors designate lower, middle, and upper stream segments

Table A5-45:
Distribution of Average Annual Equivalent Value (AAEV) Residual Damages by Reach
B50-A25 Project Condition
2Q2013 (FY13) Structure Inventory Update and Values in $1,000's
FY2014 Interest Rate – 3.50 Percent

Reaches	Residential	Commercial	Public	Hospital	Post-Disaster	Road	Utility	Vehicle	Total	Percent Distribution
D	$0.00	$0.00	$0.00	$0.00	$0.00	$0.86	$0.00	$0.00	$0.86	0.0%
H	$0.00	$0.00	$0.00	$0.00	$0.00	$0.06	$0.00	$0.00	$0.06	0.0%
L	$2.89	$0.00	$0.00	$0.00	$0.00	$0.30	$0.00	$0.14	$3.33	0.0%
M	$39.29	$7.07	$0.45	$0.00	$7.97	$0.55	$0.19	$6.96	$62.48	0.9%
O	$3.62	$0.00	$0.22	$0.00	$0.00	$0.00	$0.00	$0.40	$4.24	0.1%
P	$1.82	$2.40	$0.00	$0.00	$0.00	$0.15	$0.00	$0.13	$4.50	0.1%
R-Left	$20.01	$239.25	$0.00	$0.00	$6.41	$0.98	$0.16	$0.56	$267.37	3.9%
R-Right	$126.30	$186.34	$0.55	$0.00	$27.63	$2.68	$0.67	$11.55	$355.72	5.2%
T-Left	$150.88	$1.06	$0.00	$0.00	$34.66	$1.29	$0.84	$6.18	$194.91	2.9%
T-Right	$525.86	$2.68	$3.93	$0.00	$198.62	$3.32	$4.83	$39.89	$779.13	11.4%
U-Left	$6.03	$2.91	$0.00	$0.00	$0.00	$0.05	$0.00	$0.15	$9.14	0.1%
U-Right	$112.64	$0.00	$0.00	$0.00	$22.98	$0.00	$0.56	$3.96	$140.14	2.1%
V	$0.00	$8.08	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$8.08	0.1%
X	$37.08	$104.56	$0.00	$0.00	$14.41	$2.44	$0.35	$2.42	$161.26	2.4%
Z	$81.89	$124.85	$2.16	$0.00	$29.01	$1.63	$0.71	$2.07	$242.32	3.6%
AE	$5.09	$1,957.68	$0.01	$0.00	$11.49	$10.05	$0.28	$1.01	$1,985.61	29.1%
AF	$67.10	$713.33	$2.95	$0.00	$52.62	$11.89	$1.28	$4.09	$853.26	12.5%
AG	$80.59	$61.85	$0.62	$0.00	$9.12	$2.79	$0.22	$2.14	$157.33	2.3%
AH	$0.86	$13.65	$0.00	$0.00	$0.31	$1.53	$0.01	$0.07	$16.43	0.2%
AI	$35.27	$91.36	$4.18	$0.00	$15.61	$3.62	$0.38	$1.62	$152.04	2.2%
AL	$36.68	$66.60	$0.86	$0.00	$24.35	$3.18	$0.59	$4.58	$136.84	2.0%
AP	$444.81	$81.28	$27.27	$48.11	$365.14	$11.11	$8.88	$56.28	$1,042.88	15.3%
AZ	$89.10	$37.14	$7.28	$0.00	$93.01	$8.26	$2.31	$5.54	$242.64	3.6%
Total	**$1,867.81**	**$3,702.09**	**$50.48**	**$48.11**	**$913.34**	**$66.74**	**$22.26**	**$149.74**	**$6,820.57**	**100.0%**
Percent Distribution	**27.4%**	**54.3%**	**0.7%**	**0.7%**	**13.4%**	**1.0%**	**0.3%**	**2.2%**	**100.0%**	

Colors designate lower, middle, and upper stream segments

Table A5-46:
Distribution of AAEV Damages by Reach With and Without Uncertainty
B50-A25 Condition
2Q2013 (FY13) Structure Inventory Update and Values in $1,000s

Reach Name	With No Uncertainty	With Uncertainty	Difference	Percent Difference
D	$ 0.88	$ 0.86	-$ 0.02	-2.27%
H	$ 0.06	$ 0.06	$ 0.00	0.00%
L	$ 1.04	$ 3.33	$ 2.29	220.19%
M	$ 29.67	$ 62.48	$ 32.81	110.58%
O	$ 1.27	$ 4.24	$ 2.97	233.86%
P	$ 1.02	$ 4.50	$ 3.48	341.18%
R-Left	$ 73.61	$ 267.37	$ 193.76	263.23%
R-Right	$ 114.50	$ 355.72	$ 241.22	210.67%
T-Left	$ 71.92	$ 194.91	$ 122.99	171.01%
T-Right	$ 477.71	$ 779.13	$ 301.42	63.10%
U-Left	$ 1.05	$ 9.14	$ 8.09	770.48%
U-Right	$ 51.19	$ 140.14	$ 88.95	173.76%
V	$ 0.01	$ 8.08	$ 8.07	80,700.00%
X	$ 79.09	$ 161.26	$ 82.17	103.89%
Z	$ 86.75	$ 242.32	$ 155.57	179.33%
AE	$ 927.75	$ 1,985.61	$ 1,057.86	114.02%
AF	$ 421.79	$ 853.26	$ 431.47	102.29%
AG	$ 51.10	$ 157.33	$ 106.23	207.89%
AH	$ 3.74	$ 16.43	$ 12.69	339.30%
AI	$ 33.27	$ 152.04	$ 118.77	356.99%
AL	$ 39.94	$ 136.84	$ 96.90	242.61%
AP	$ 444.32	$ 1,042.88	$ 598.56	134.71%
AZ	$ 80.20	$ 242.64	$ 162.44	202.54%
Total	$ 2,991.88	$ 6,820.57	$ 3,828.69	127.97%
Manual Integration EAD	$2,116.52			

15.0 DETERMINING THE TENTATIVELY SELECTED PLAN (TSP), 2013

15.1 Compliance with FEMA Requirements

The Memorandum, "Federal Emergency Management Agency (FEMA)/U.S. Army Corps of Engineers (USACE) Joint Actions on Planning for FRM Projects," signed on June 2012, addresses the requirement to perform mitigation when proposed USACE flood-risk reduction projects increase the Base (1 percent annual chance) Flood Elevation (BFE). NFIP regulations, found in 44 CFR 65.12, require revisions to flood insurance rate maps to reflect BFE and/or floodway changes caused by encroachments permitted by an NFIP participating community. Once the area subject to map revision has been defined, the community must certify to the Federal Flood Insurance Administrator that no structures are impacted by the increase to the BFE in order to maintain the community's participation in the NFIP. Mitigation for all structures impacted is a necessary cost for the local community in association with project implementation; this action could be considered a NED associated cost.

If B50-A25, or any other the NED Plan scale that induced damages by raising the BFE in the 1 percent or more frequent AEP events, were to be implemented, the non-federal sponsor, HCFCD, would be required by NFIP regulation to mitigate the induced damages within the 1 percent AEP flood hazard area. This is an absolute requirement and not subject to economic justification.

Options for structural mitigation are limited by the same factors that limit mitigation for induced damages as described in Section 16.3. One structural measure by which all induced damages would be fully mitigated at the 1 percent AEP event is the construction of B60-A75 since NED Plan scale B60-A75 does not induce damages at the 1 percent AEP or more frequent events.

A comparison of nonstructural buyout of impacted structures versus the construction of B60-A75 as a mitigating NED Plan scale was made and is displayed in Table A5-48. For all but two NED Plan scales, B60-A25 and B50-A25, implementation of B60-A75 is the least cost mitigation option. Buyout is less costly for B60-A25 and B50-A25. Buyout for either B60-A25 or B50-A25 would involve acquiring 171 residential and commercial properties.

Table A5-47:
NED Plan Scale Economic Performance with Uncompensated Induced Damages and FEMA/NFIP Least Cost Mitigation Included

NED Plan Scale	Equivalent Annual Damage (x $1,000)	Equivalent Annual Inundation Damage Reduction Benefit (x $1,000)	Advance Bridge Replacement Benefit (x $1,000)	Total Equivalent Annual NED Benefits (x $1,000)	2013 Total Project Cost (x 1,000)^1	Equivalent Annual Project Cost (x 1,000)^1	Equivalent Annual Induced Damages (x $1,000)	Equivalent Annual Project Cost with Uncompensated Induced Damages Included (x $1,000)	Present Worth Equivalent of Project Cost with Induced Damages Included (x $1,000)	Net Excess Benefits with Uncompensated Induced Damages included in Cost (x $1,000)	Revised Rank Order Net Excess Benefits	Rank Order Least Cost	Difference in Net Excess Benefits vs Top Performer (x $1,000)	No. Structures Impacted by Rise in BFE at 1 Percent Event	Cost for Buyout as Mitigation for Rise in BFE (x $1,000)	Incremental Cost of B60-A75 as Mitigation for Rise in BFE (x $1,000)	Least Cost Option to Mitigate for Rise in BFE--Buyouts or B60-A75	Revised Cost for Project Implementation and Least Cost FEMA/NFIP Mitigation
WOP	**$19,792.10**																	
B60-A50	$5,562.01	$14,230.09	$981.42	$15,211.51	$151,345.80	$6,596.02	$81.89	$6,677.92	$156,634.72	$7,552.17	1	9	0.0%	167	$35,481.10	$19,042.06	B60-A75	$175,676.77
B90-A25	$5,945.02	$13,847.08	$981.42	$14,828.50	$147,070.47	$6,362.52	$131.94	$6,494.46	$152,331.64	$7,352.62	3	6	2.6%	152	$31,069.61	$23,345.13	B60-A75	$175,676.77
B90-A50	$5,149.44	$14,642.66	$981.42	$15,624.08	$164,509.92	$7,163.91	$65.15	$7,229.05	$169,561.89	$7,413.61	2	14	1.8%	142	$28,721.60	$6,114.88	B60-A75	$175,676.77
B140-A25	$5,197.64	$14,594.46	$981.42	$15,575.88	$165,212.99	$7,150.61	$106.40	$7,257.01	$170,217.54	$7,337.45	4	15	2.8%	163	$35,044.08	$5,459.23	B60-A75	$175,676.77
B80-A25	$6,136.00	$13,656.10	$981.42	$14,637.52	$143,594.25	$6,212.79	$168.52	$6,381.32	$149,677.72	$7,274.78	11	5	3.7%	184	$37,722.95	$25,999.05	B60-A75	$175,676.77
B100-A25	$5,843.27	$13,948.83	$981.42	$14,930.25	$150,772.97	$6,521.84	$143.16	$6,665.00	$156,331.74	$7,283.83	6	8	3.6%	184	$37,722.95	$19,345.03	B60-A75	$175,676.77
B70-A25	$6,333.76	$13,458.34	$981.42	$14,439.76	$139,459.70	$6,033.79	$177.07	$6,210.86	$145,679.45	$7,247.48	13	3	4.0%	184	$37,722.95	$29,997.32	B60-A75	$175,676.77
B60-A25	$6,598.01	$13,194.09	$981.42	$14,175.51	$133,710.30	$5,786.26	$183.36	$5,969.62	$140,021.01	$7,224.47	14	2	4.3%	171	$34,589.54	$35,655.76	BUYOUT	$174,610.55
B110-A25	$5,682.11	$14,109.99	$981.42	$15,091.41	$154,955.70	$6,705.04	$129.55	$6,834.58	$160,309.33	$7,275.41	10	10	3.7%	167	$35,481.10	$15,367.44	B60-A75	$175,676.77
B80-A50	$5,382.33	$14,409.77	$981.42	$15,391.19	$161,084.70	$7,016.36	$70.88	$7,087.25	$166,235.74	$7,322.52	5	13	3.0%	144	$29,495.00	$9,441.03	B60-A75	$175,676.77
B120-A25	$5,548.09	$14,244.01	$981.42	$15,225.43	$158,566.03	$6,861.59	$126.52	$6,988.11	$163,910.47	$7,255.90	12	12	3.9%	184	$37,722.95	$11,766.30	B60-A75	$175,676.77
B70-A50	$5,591.42	$14,200.68	$981.42	$15,182.10	$157,022.56	$6,840.45	$84.41	$6,924.86	$162,426.94	$7,275.82	9	11	3.7%	167	$35,481.10	$13,249.83	B60-A75	$175,676.77
B50-A25	$6,820.55	$12,971.55	$981.42	$13,952.97	$129,858.40	$5,620.19	$200.75	$5,820.93	$136,533.61	$7,150.62	17	1	5.3%	171	$34,589.54	$39,143.16	BUYOUT	$171,123.15
B100-A50	$5,122.05	$14,670.05	$981.42	$15,651.47	$168,162.65	$7,321.10	$71.19	$7,392.29	$173,390.69	$7,277.76	8	16	3.6%	153	$32,702.18	$2,286.09	B60-A75	$175,676.77
B110-A50	$4,944.79	$14,847.31	$981.42	$15,828.73	$172,318.55	$7,503.16	$64.35	$7,567.51	$177,500.58	$7,279.80	7	18	3.6%	141	$28,129.06	-$1,823.81	B60-A75	$175,676.77
B120-A50	$4,848.24	$14,943.86	$981.42	$15,925.28	$175,906.01	$7,658.74	$68.94	$7,727.68	$181,257.44	$7,216.18	15	19	4.4%	153	$32,702.18	-$5,580.67	B60-A75	$175,676.77
B50-A50	$6,080.03	$13,712.07	$981.42	$14,693.49	$147,546.13	$6,432.18	$89.37	$6,521.55	$152,967.09	$7,190.52	16	7	4.8%	166	$35,458.60	$22,709.68	B60-A75	$175,676.77
B140-A50	$4,654.30	$15,137.80	$981.42	$16,119.22	$182,637.84	$7,951.36	$66.11	$8,017.48	$188,054.84	$7,120.32	18	20	5.7%	153	$32,702.18	-$12,378.07	B60-A75	$175,676.77
B40-A50	$6,352.70	$13,439.40	$981.42	$14,420.82	$143,631.82	$6,262.54	$93.09	$6,355.63	$149,075.27	$7,083.77	19	4	6.2%	184	$37,722.95	$26,601.50	B60-A75	$175,676.77
B200-A25	$4,670.27	$15,121.83	$981.42	$16,103.25	$185,768.74	$8,044.00	$76.55	$8,120.56	$190,472.68	$7,001.27	20	21	7.3%	162	$34,956.21	-$14,795.91	B60-A75	$175,676.77
B60-A75	$5,409.89	$14,382.21	$981.42	$15,363.63	$171,135.52	$7,463.38	$26.37	$7,489.75	$175,676.77	$6,892.46	21	17	8.7%	0	$0.00	$0.00		$175,676.77

15.2 Meeting Study Objectives

The study objectives for the Hunting Bayou Federal FRM Study are as follows:

- Reduce residential and business flood risk due to riverine flooding to a socially vulnerable population along Hunting Bayou from its mouth to US 59.
  - The study area has been established as an area of social vulnerability having a high minority population with limited economic resources and having a demographic profile comprised of more younger and older residents than in Harris County as a whole.
- Minimize adverse effects from implementing flood risk reduction measures on existing neighborhoods and wildlife habitat.
  - Minimizing adverse effects from implementing flood risk reduction measures on existing neighborhoods is an important study objective. Community concern over residential and other displacements of the population was expressed repeatedly in public outreach sessions. Social anxiety over the ability to relocate in the same neighborhood, the extreme difficulty, if not impossibility, of relocating elderly or ill members of the community, and other constraints on relocation, including cost, warranted a close review when evaluating required displacements.
- Provide FRM to structures and infrastructure in the Hunting Bayou watershed without increasing the potential for flooding in other areas.
  - 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. This requirement is in line with FEMA/NFIP requirements for full mitigation from an NFIP-participating community's permit of a rise in the BFE such that the local community must certify that no structures are impacted by the proposed increase in the BFE.
- Maintain and protect community cohesiveness for the residents living within Hunting Bayou watershed.
  - This study objective is similar to minimizing adverse effects from implementing flood risk reduction measures on existing neighborhoods with the intention of minimizing displacements that tear at the social fabric of the community.

15.3 Comparison of the National Economic Development (NED) Plan Scales, B50-A25 and B60-A75, and the 1990 Authorized Plan

"Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G)," 1983, define four evaluation criteria for the formulation of alternatives: completeness, effectiveness, efficiency, and acceptability. These criteria were applied for a comparison of the designated NED Plan, B50-A25, and to the Local Sponsor's preferred alternative to the NED Plan, B60-A75 and to the 1990 Authorized Plan.

15.3.1 Completeness

Completeness is the extent to which a given plan provided and accounts for all necessary investments or other actions to ensure the realization of planned effects. The expected project effects that are attributed to the TSP, the NED Plan, or the Authorized Plan are realized with implementation of their respective project features. The structural measures of channel modification, bridge replacement, and offline detention for the TSP and the NED Plan are sufficient to realize the NED benefits claimed. No other actions, programs, or features are required in order to realize the economic and life, health, and safety effects attributed to the NED Plan or the TSP. The project features of the Authorized Design as authorized and described in Section 1.5 are sufficient to produce the effects claimed. Therefore, there is no difference in completeness with regard to implementation of the TSP, the NED Plan, or the Authorized Plan.

However, while B50-A25 reasonably maximizes net excess benefits at least cost, B50-A25 also produces the least amount of AAEV inundation reduction benefits, $12.9 million, (65 percent over WOP) ranking last within the 32 NED Plan scale array. B60-A75 reduces AAEV inundation damages by $14.4 million, or 73 percent over the WOP condition. This is an important consideration for the study objective of providing FRM to a socially vulnerable population in that greater residual damages are associated with B50-A25 than for B60-A75. These residual damages will be experienced by a resident population with limited resources for response and recovery.

The Authorized Design reduces WOP condition AAEV inundation damages by 99 percent. When assessing the sole objective of flood damage reduction, without regard for environmental or social impacts, the 1990 Authorized Plan is nearly perfect in its FRM performance.

15.3.2 Acceptability

Acceptability is the workability and viability of the alternative plan with respect to acceptance by State and local entities and the public and compatibility with existing laws, regulations, and public policies. Study objectives were to minimize adverse effects from implementing flood risk reduction measures on existing neighborhoods and to maintain community cohesiveness. The operational metric for that objective was the number of displacements that would be necessary to implement a plan. Displacement actions are property acquisitions that remove the resident or owner from the property through monetary compensation and relocation assistance. The distinction is made between property acquisitions which are transacted on a parcel-by-parcel basis and involve a change in property ownership as opposed to displacements which entail the human element of the transaction in which families and homes are disrupted and whose residents are required to vacate their homes and businesses. In the situation of multifamily displacements, one property transaction can impact multiple families. Therefore, the term “displacements” is the more appropriate expression of the action of impacting the social fabric of the community.

Table A5-48 shows displacements required from implementing the NED Plan, B60-A75 or the 1990 Authorized Plan under current conditions. The 1990 Authorized Plan would require displacing 125 residential units and 15 commercial businesses directly impacting an estimated 316 residents based on ROW acquisition needs.

B60-A75 would require 70 displacements impacting an estimated 167 persons. Of the 70 displacements, 66 are residential and 4 are nonresidential.

Implementing the NED Plan B50-A25 would require 240 displacements, of which 171 would occur in the middle stream reach to comply with FEMA/NFIP regulations. Of these FEMA/NFIP compliance displacements, 86 are residential structures housing an estimated 218 residents. In total, buyout and relocation due to implementing the NED Plan B50-A25 would directly impact approximately 380 residents along Hunting Bayou.

Table A5-48:
Displacements* by Plan for Project Construction (Not structure acquisitions)

Plan	Displacement Reason	Single Family Residential	Multifamily Residential (4 units/ea)	Commercial	Religious	Industrial	Total	Residents
B50-A25	ROW	57	8	2	1	1	69	164
	Rise in BFE^1	86		85			171	218
B60-A75	ROW	58	8	2	1	1	70	167
Authorized Design	ROW	115	10	15	0	0	140	316

**displacements are relocations of persons or families from structures as differentiated from property acquisitions and which may impact multiple families with one transaction.*

^1 FEMA requires certification that no structures are impacted by rise in BFE due to project implementation. Buyout is lease cost option for FEMA mitigation.

The NED Plan scale B50-A25 induces the greatest damages downstream from the project area among the top NED Plan scales and violates local policy of "no adverse impact" at the 1 percent AEP or more frequent events. NED Plan scale B50-A25, in effect, transfers some flood risk from the upper stream segment to the middle stream segment with its implementation. As shown in *Table A5-41*, to mitigate for the rise in the BFE from implementing B50-A25, the non-federal sponsor, HCFCD, and local communities will be required to fully mitigate for structures impacted and to certify to the National Floodplain Administrator that no structures are impacted by the change to the BFE. To mitigate for these impacts, 171 residential and commercial structures will be subjected to buyout and relocation as a least cost mitigating measure for implementing B50-A25, the designated NED Plan.

B60-A75 does not induce damages downstream at the 1 percent AEP or more frequent event. Therefore, no mitigation of downstream effects is required for FEMA/NFIP compliance. The 1990 Authorized Plan does not induce damages downstream by design.

The requirement for FEMA mitigation by relocation of the population is unacceptable to the local community regarding disruption of community cohesiveness by displacing the resident population. B50-A25 is not implementable by the non-federal sponsor, HCFCD, based on its downstream impacts to WSELs and the displacements required to mitigate for those impacts.

15.3.3 Effectiveness

Effectiveness is the extent to which a plan alleviates the specified problems and achieves the specified opportunities. The operational metric for effectiveness was the extent to which flood risk was reduced while minimizing associated consequences or impacts.

Overall the NED Plan scale B60-A75 better addresses study objectives than the designated NED Plan B50-A25. B60-A75 reduces flood damages to a greater extent than B50-A25 without transferring risk downstream to the extent that B50-A25 does. In addition, NED Plan scale B60-A75 produces the least induced damages among those NED Plan scales that “reasonably” maximize net excess benefits. No mitigation of downstream impact would be required since implementation of B60-A75 does not cause the BFE to rise in the 1 percent or more frequent AEP event and would therefore be less disruptive to the local neighborhoods and surrounding community. NED Plan scale B60-A75 would require 70 displacements in total as compared with the 240 required for B50-A25 implementation from project construction and mitigation of downstream impacts.

The 1990 Authorized Plan is highly effective when assessing its flood risk reduction performance. The 1990 Authorized Plan reduces 99 percent of the WOP condition flood damages. However, the extent of the environmental and local community impacts associated with its implementation has made the 1990 Authorized Plan implementable by the non-federal sponsor, HCFCD.

15.3.4 Efficiency

Effectiveness is the extent to which a plan alleviates the specified problems and achieves the specified opportunities. The operational metric for effectiveness was the extent to which flood risk was reduced while minimizing associated consequences or impacts.

Overall the NED Plan scale B60-A75 better addresses study objectives than the designated NED Plan B50-A25. B60-A75 reduces flood damages to a greater extent than B50-A25 without transferring risk downstream to the extent that B50-A25 does. In addition, NED Plan scale B60-A75 produces the least induced damages among those NED Plan scales that “reasonably” maximize net excess benefits. No mitigation of downstream impact would be required since implementation of B60-A75 does not cause the BFE to rise in the 1 percent or more frequent AEP event and would therefore be less disruptive to the local neighborhoods and surrounding community. NED Plan scale B60-A75 would require 70 displacements in total as compared with the 240 required for B50-A25 implementation from project construction and mitigation of downstream impacts.

The 1990 Authorized Plan is highly effective when assessing its flood risk reduction performance. The 1990 Authorized Plan reduces 99 percent of the WOP condition flood damages. However, the extent of the environmental and local community impacts associated with its implementation has made the 1990 Authorized Plan implementable by the non-federal sponsor, HCFCD.

15.4 Identifying the Tentatively Selected Plan (TSP)

NED Plan scale B60-A75 maximizes available off-line detention storage and is the non-federal sponsor, HCFCD’s Locally Preferred Plan in that it adheres to the local policy of “no adverse impact” at the 1 percent AEP or more frequent events, maximizes use of 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.

Because the overall economic cost difference to the non-federal sponsor, HCFCD, is estimated to be within $5 million between B50-A25 and B60-A75 and because the NED Plan scale B60-A75 better meets the study objectives by providing greater flood risk reduction without displacing the resident population associated with mitigation for downstream increases of the BFE, the NED Plan scale B60-A75 is named the TSP.

15.5 Economic Performance of B60-A75, the Tentatively Selected Plan (TSP)

The non-federal sponsor, HCFCD, prefers to implement another NED Plan scale, B60-A75. Economic and performance characteristics of B60-A75 are presented in the following discussion.

15.5.1 Economic Assets in the Residual Floodplain of B60-A75

The distribution of economic assets remaining in the residual floodplain of B60-A75 is shown in *Table A5-49.*. Total structures in the 0.2 percent AEP floodplain of Hunting Bayou are reduced 58 percent from a count of 7,329 to a count of 3,042 by implementing B60-A75. Residential structures in the 0.2 percent AEP floodplain are reduced 60 percent from 6,616 to 2,645 in the TSP With Project condition.

An estimated 87 percent of the structures in the WOP condition 1 percent AEP floodplain would have reduced risk from the residual 1 percent AEP floodplain. An estimated 5,110 structures are currently in the 1 percent AEP floodplain. By implementing B60-A75, the structure count in the residual 1 percent AEP floodplain would drop to 645.

15.5.2 Single Occurrence Damages in the Residual Floodplain of B60-A75

Table A5-50 displays the single occurrence damages expected to occur in the residual floodplain of B60-A75. Damages to economic assets are expected from a 0.2 percent AEP event would drop an estimated 51 percent to $132.8 million by implementing B60-A75. Damages to assets from a 1 percent event are expected to decline by 73 percent to $43.8 million by implementing the TSP.

15.5.3 Average Annual Equivalent Value Damages Reduced with the Implementation of B60-A75

Table A5-51 shows the AAEV damages remaining in the B60-A75 residual 0.2 percent floodplain. *Figure A5-4* graphically represents the damages in the WOP and with TSP conditions. *Table A5-52* shows the distribution of AAEV damages by reach with and without uncertainty in the TSP condition. *Table A5-53* shows the AAEV damages reduced by implementing B60-A75. AAEV damages are reduced by 73 percent by implementing the TSP over the WOP condition.

Table A5-49:
Economic Assets by Annual Exceedance Probability (AEP) Event
B60-A75 Project Condition
2Q2013 (FY13) Structure Inventory Update and Values in $1,000's

Property	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"
Residential Property								
Number of Structures	0	3	25	151	248	553	1272	2645
Single-Family	0	3	25	150	247	506	1141	2434
Multi-Family	0	0	0	1	1	47	131	211
Mobile Homes	0	0	0	0	0	0	0	0
Distribution	0.0%	0.1%	0.9%	5.7%	9.4%	20.9%	48.1%	100.0%
Structure Value	$0.00	$204.88	$1,512.08	$7,241.75	$12,423.73	$29,501.63	$52,369.14	$93,207.52
Content Value*	$0.00	$102.44	$756.04	$3,601.02	$6,192.01	$14,038.43	$25,108.60	$45,013.56
Total Value	**$0.00**	**$307.32**	**$2,268.12**	**$10,842.77**	**$18,615.74**	**$43,540.06**	**$77,477.74**	**$138,221.08**
Commercial Property								
Number of Structures	0	1	10	29	57	87	187	370
Distribution	0.0%	0.3%	2.7%	7.8%	15.4%	23.5%	50.5%	100.0%
Structure Value	$0.00	$116.40	$5,516.11	$21,187.26	$32,241.29	$50,194.21	$89,294.81	$133,282.92
Content Value*	$0.00	$195.55	$9,267.06	$35,009.40	$53,570.66	$71,996.02	$131,183.79	$180,297.96
Total Value	**$0.00**	**$311.95**	**$14,783.17**	**$56,196.66**	**$85,811.95**	**$122,190.23**	**$220,478.60**	**$313,580.88**
Public Property								
Number of Structures	0	0	0	3	4	5	12	27
Distribution	0.0%	0.0%	0.0%	11.1%	14.8%	18.5%	44.4%	100.0%
Structure Value	$0.00	$0.00	$0.00	$132.50	$184.02	$210.76	$3,397.44	$5,308.66
Content Value*	$0.00	$0.00	$0.00	$151.05	$209.78	$240.27	$3,873.08	$6,051.87
Total Value	**$0.00**	**$0.00**	**$0.00**	**$283.55**	**$393.80**	**$451.03**	**$7,270.52**	**$11,360.53**

Property	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"
Hospital Property								
Number of Structures	0	0	0	0	0	0	0	0
Distribution	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Structure Value	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Content Value*	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Total Value	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Total Property								
Number of Structures	0	4	35	183	309	645	1471	3042
Distribution	0.0%	0.1%	1.2%	6.0%	10.2%	21.2%	48.4%	100.0%
Structure Value	$0.00	$321.28	$7,028.19	$28,561.51	$44,849.04	$79,906.60	$145,061.39	$231,799.10
Content Value*	$0.00	$297.99	$10,023.10	$38,761.47	$59,972.45	$86,274.73	$160,165.47	$231,363.39
Total Value	**$0.00**	**$619.27**	**$17,051.29**	**$67,322.98**	**$104,821.49**	**$166,181.33**	**$305,226.86**	**$463,162.49**
Passenger Vehicles								
Number of Vehicles	0	4	31	158	255	525	1218	2626
Distribution	0.0%	0.2%	1.2%	6.0%	9.7%	20.0%	46.4%	100.0%
Vehicle Value	$0.00	$22.32	$220.94	$1,010.42	$1,566.79	$3,435.28	$8,740.92	$20,776.53
Total Roads								
Roadway Lengths (Miles)	1	2	7	9	12	19	37	50
Distribution	2.0%	4.0%	14.0%	18.0%	24.0%	38.0%	74.0%	100.0%

Table A5-50:
Single Occurrence Damages by Annual Exceedance Probability (AEP) Event
B60-A75 Project Condition
2Q2013 (FY13) Structure Inventory Update and Values in $1,000's

	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 Damage								
Residential Property	$ 0.00	$ 106.03	$ 736.41	$ 2,171.16	$ 4,036.50	$ 8,872.67	$ 16,467.40	$ 26,474.45
Commercial Property	$ 0.00	$ 7.68	$ 367.56	$ 1,492.19	$ 2,329.33	$ 3,847.38	$ 6,218.56	$ 10,832.49
Public Property	$ 0.00	$ 0.00	$ 1.83	$ 14.75	$ 34.73	$ 42.87	$ 246.51	$ 568.55
Hospital	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00
Content Damage								
Residential Property	$ 0.00	$ 70.82	$ 454.87	$ 1,332.65	$ 2,479.48	$ 5,127.69	$ 9,643.93	$ 15,296.30
Commercial Property	$ 0.00	$ 25.80	$ 1,475.44	$ 6,008.34	$ 10,167.91	$ 17,006.05	$ 27,106.97	$ 47,551.10
Public Property	$ 0.00	$ 0.00	$ 0.00	$ 5.60	$ 20.33	$ 40.64	$ 134.61	$ 479.57
Hospital	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00
Totals								
Residential Property	$ 0.00	$ 176.85	$ 1,191.27	$ 3,503.81	$ 6,515.98	$ 14,000.35	$ 26,111.32	$ 41,770.75
Commercial Property	$ 0.00	$ 33.48	$ 1,843.00	$ 7,500.53	$ 12,497.25	$ 20,853.43	$ 33,325.53	$ 58,383.59
Public Property	$ 0.00	$ 0.00	$ 1.83	$ 20.35	$ 55.06	$ 83.50	$ 381.12	$ 1,048.12
Hospital	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00
Total Property Damages	**$ 0.00**	**$ 210.34**	**$ 3,036.10**	**$ 11,024.69**	**$ 19,068.29**	**$ 34,937.28**	**$ 59,817.97**	**$ 101,202.46**
Post Disaster Costs	$ 0.00	$ 212.79	$ 874.93	$ 2,189.99	$ 4,381.04	$ 7,141.43	$ 11,969.93	$ 24,720.07
Road Damages	$ 9.83	$ 34.08	$ 72.92	$ 168.93	$ 366.58	$ 518.34	$ 772.51	$ 1,264.16
Utility Damages	$ 0.00	$ 5.17	$ 21.26	$ 53.29	$ 106.77	$ 174.10	$ 292.92	$ 601.16
Vehicle Damages	$ 0.00	$ 1.85	$ 36.41	$ 246.42	$ 463.46	$ 1,003.69	$ 2,233.27	$ 5,002.38
Total by Event	**$ 9.83**	**$ 464.23**	**$ 4,041.62**	**$ 13,683.33**	**$ 24,386.14**	**$ 43,774.85**	**$ 75,086.61**	**$ 132,790.23**

	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"
Percent Distribution								
Residential Property	0.00%	38.10%	29.48%	25.61%	26.72%	31.98%	34.77%	31.46%
Commercial Property	0.00%	7.21%	45.60%	54.82%	51.25%	47.64%	44.38%	43.97%
Public Property	0.00%	0.00%	0.05%	0.15%	0.23%	0.19%	0.51%	0.79%
Hospital	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Post Disaster Costs	0.00%	45.84%	21.65%	16.00%	17.97%	16.31%	15.94%	18.62%
Road Damages	100.00%	7.34%	1.80%	1.23%	1.50%	1.18%	1.03%	0.95%
Utility Damages	0.00%	1.11%	0.53%	0.39%	0.44%	0.40%	0.39%	0.45%
Vehicle Damages	0.00%	0.40%	0.90%	1.80%	1.90%	2.29%	2.97%	3.77%
Total by Event	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Table A5-51:
Distribution of Average Annual Equivalent Value (AAEV) Residual Damages by Reach
B60-A75 Project Condition
2Q2013 (FY13) Structure Inventory Update and Values in $1,000's
FY2014 Interest Rate – 3.50 Percent

Reaches	Residential	Commercial	Public	Hospital	Post-Disaster	Road	Utility	Vehicle	Total	Percent Distribution
D	$0.00	$0.00	$0.00	$0.00	$0.00	$0.86	$0.00	$0.00	$0.86	0.0%
H	$0.00	$0.00	$0.00	$0.00	$0.00	$0.06	$0.00	$0.00	$0.06	0.0%
L	$2.90	$0.00	$0.00	$0.00	$0.00	$0.30	$0.00	$0.14	$3.34	0.1%
M	$39.12	$7.07	$0.45	$0.00	$7.88	$0.55	$0.19	$6.95	$62.21	1.1%
O	$3.61	$0.00	$0.23	$0.00	$0.00	$0.00	$0.00	$0.41	$4.25	0.1%
P	$1.83	$2.40	$0.00	$0.00	$0.00	$0.15	$0.00	$0.13	$4.51	0.1%
R-Left	$19.90	$237.84	$0.00	$0.00	$6.37	$0.98	$0.16	$0.56	$265.81	4.9%
R-Right	$125.21	$185.35	$0.55	$0.00	$27.27	$2.66	$0.66	$11.44	$353.14	6.5%
T-Left	$151.40	$1.07	$0.00	$0.00	$34.89	$1.29	$0.85	$6.23	$195.73	3.6%
T-Right	$522.69	$2.69	$3.90	$0.00	$196.49	$3.27	$4.78	$39.91	$773.73	14.3%
U-Left	$5.98	$2.87	$0.00	$0.00	$0.00	$0.04	$0.00	$0.15	$9.04	0.2%
U-Right	$111.41	$0.00	$0.00	$0.00	$22.91	$0.00	$0.56	$3.93	$138.81	2.6%
V	$0.00	$7.21	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$7.21	0.1%
X	$34.12	$90.61	$0.00	$0.00	$13.89	$2.38	$0.34	$2.19	$143.53	2.7%
Z	$70.84	$107.65	$1.81	$0.00	$25.43	$1.52	$0.62	$1.55	$209.42	3.9%
AE	$4.44	$1,597.17	$0.01	$0.00	$10.71	$8.52	$0.26	$0.81	$1,621.92	30.0%
AF	$56.35	$564.41	$2.11	$0.00	$46.97	$10.52	$1.14	$3.06	$684.56	12.7%
AG	$59.32	$41.27	$0.40	$0.00	$6.03	$2.21	$0.15	$1.12	$110.50	2.0%
AH	$0.36	$5.25	$0.00	$0.00	$0.11	$1.34	$0.00	$0.02	$7.08	0.1%
AI	$15.60	$33.92	$1.55	$0.00	$4.85	$2.44	$0.12	$0.34	$58.82	1.1%
AL	$15.22	$26.05	$0.30	$0.00	$8.32	$2.11	$0.20	$1.33	$53.53	1.0%
AP	$234.28	$39.97	$12.89	$14.87	$204.69	$6.68	$4.98	$25.09	$543.45	10.0%
AZ	$51.13	$23.80	$4.73	$0.00	$68.24	$6.47	$1.70	$2.38	$158.45	2.9%
Total	**$1,525.71**	**$2,976.60**	**$28.93**	**$14.87**	**$685.05**	**$54.35**	**$16.71**	**$107.74**	**$5,409.96**	**100.0%**
Percent Distribution	28.2%	55.0%	0.5%	0.3%	12.7%	1.0%	0.3%	2.0%	100.0%	

Colors designate lower, middle, and upper stream segments

Figure A5-4:
Average Annual Equivalent Inundation Damages in the Without Project (WOP) and With B60-A75 Conditions

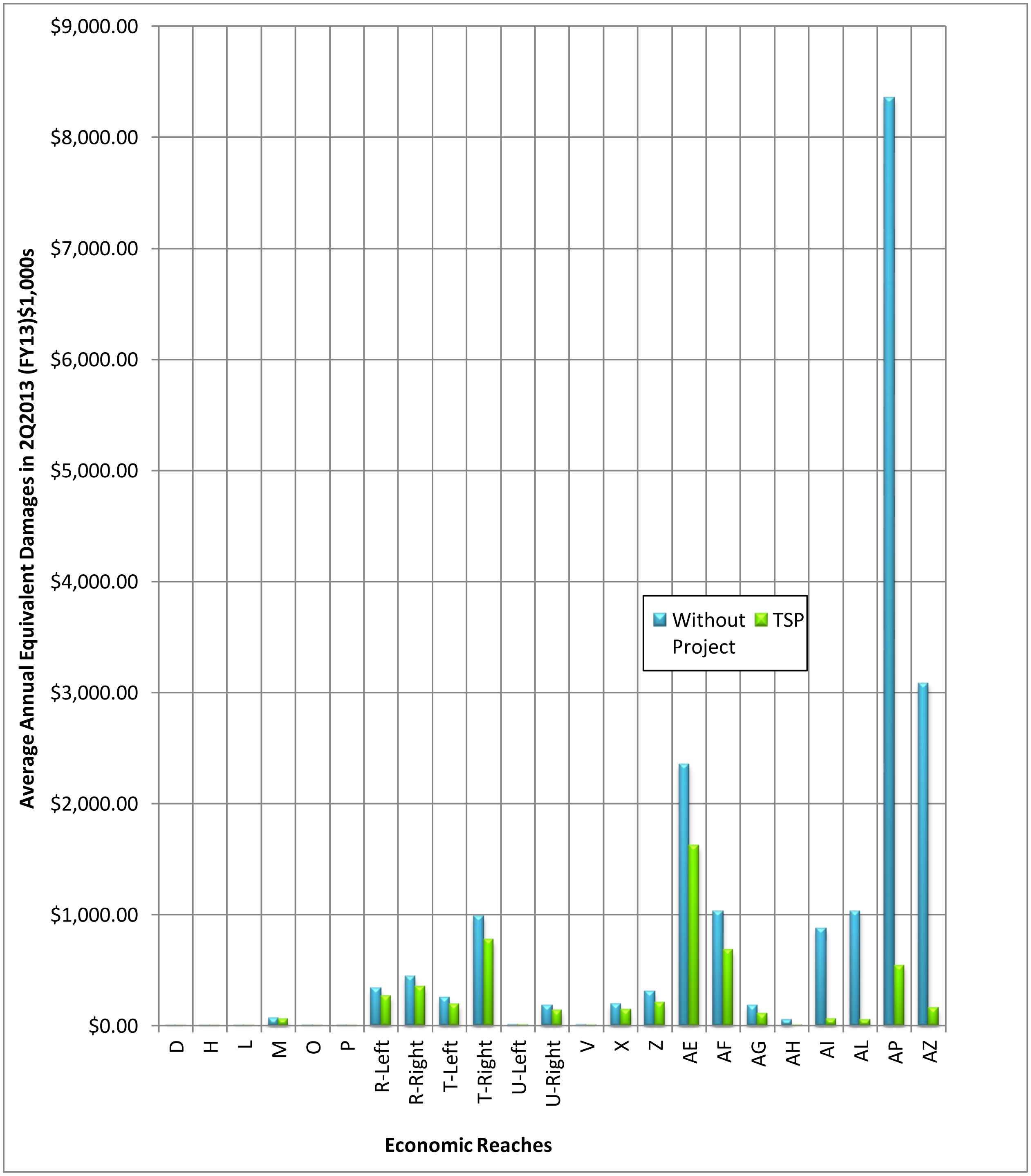


Table A5-52:
Distribution of AAEV Damages by Reach With and Without Uncertainty
B60-A75 Condition
2Q2013 (FY13) Structure Inventory Update and Values in $1,000s

Reach Name	With No Uncertainty	With Uncertainty	Difference	Percent Difference
D	$0.87	$0.86	-$0.01	-1.15%
H	$0.06	$0.06	$0.00	0.00%
L	$1.03	$3.34	$2.31	224.27%
M	$29.24	$62.21	$32.97	112.76%
O	$1.26	$4.25	$2.99	237.30%
P	$1.01	$4.51	$3.50	346.53%
R-Left	$72.16	$265.81	$193.65	268.36%
R-Right	$112.20	$353.14	$240.94	214.74%
T-Left	$70.14	$195.73	$125.59	179.06%
T-Right	$465.25	$773.73	$308.48	66.30%
U-Left	$0.99	$9.04	$8.05	813.13%
U-Right	$49.09	$138.81	$89.72	182.77%
V	$0.01	$7.21	$7.20	72000.00%
X	$68.69	$143.53	$74.84	108.95%
Z	$63.94	$209.42	$145.48	227.53%
AE	$650.12	$1,621.92	$971.80	149.48%
AF	$281.60	$684.56	$402.96	143.10%
AG	$27.59	$110.50	$82.91	300.51%
AH	$1.64	$7.08	$5.44	331.71%
AI	$11.47	$58.82	$47.35	412.82%
AL	$11.69	$53.53	$41.84	357.91%
AP	$216.36	$543.45	$327.09	151.18%
AZ	$49.38	$158.45	$109.07	220.88%
Total	$2,185.79	$5,409.96	$3,224.17	147.51%
Manual Integration EAD	$2,116.52			

Table A5-53:
Distribution of Average Annual Equivalent Value (AAEV) Damages Reduced by Reach
B60-A75 Condition
2Q2013 (FY13) Structure Inventory Update and Values in $1,000s
FY 2013 Interest Rate—3.50 Percent

Reaches	Residential	Commercial	Public	Hospital	Post-Disaster	Road	Utility	Vehicle	Total	Percent Distribution
D	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	0.0%
H	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	0.0%
L	$0.16	$0.00	$0.00	$0.00	$0.00	$0.02	$0.00	$0.01	$0.19	0.0%
M	$3.38	$0.42	$0.03	$0.00	$0.92	$0.03	$0.02	$0.47	$5.27	0.0%
O	$0.64	$0.00	$0.04	$0.00	$0.00	$0.00	$0.00	$0.07	$0.75	0.0%
P	$0.34	$0.47	$0.00	$0.00	$0.00	$0.00	$0.00	$0.03	$0.84	0.0%
R-Left	$5.20	$61.30	$0.00	$0.00	$1.75	$0.13	$0.04	$0.12	$68.54	0.5%
R-Right	$32.28	$49.21	$0.14	$0.00	$6.73	$0.52	$0.17	$2.96	$92.01	0.6%
T-Left	$45.56	$0.32	$0.00	$0.00	$10.76	$0.39	$0.26	$1.92	$59.21	0.4%
T-Right	$146.07	$0.81	$1.10	$0.00	$53.74	$0.88	$1.30	$11.84	$215.74	1.5%
U-Left	$1.92	$0.96	$0.00	$0.00	$0.00	$0.02	$0.00	$0.05	$2.95	0.0%
U-Right	$35.03	$0.00	$0.00	$0.00	$7.50	$0.00	$0.18	$1.31	$44.02	0.3%
V	$0.00	$3.08	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$3.08	0.0%
X	$12.13	$36.74	$0.00	$0.00	$4.37	$0.43	$0.10	$0.82	$54.59	0.4%
Z	$32.63	$51.72	$0.76	$0.00	$12.92	$0.59	$0.31	$0.68	$99.61	0.7%
AE	$1.91	$724.26	$0.00	$0.00	$4.12	$3.86	$0.10	$0.41	$734.66	5.1%
AF	$26.79	$291.60	$1.04	$0.00	$21.19	$4.57	$0.52	$1.69	$347.40	2.4%
AG	$39.40	$26.64	$0.24	$0.00	$4.82	$1.24	$0.11	$0.40	$72.85	0.5%
AH	$2.37	$38.87	$0.00	$0.00	$0.96	$2.14	$0.03	$0.20	$44.57	0.3%
AI	$167.54	$517.12	$24.20	$0.00	$83.81	$10.38	$2.04	$12.57	$817.66	5.7%
AL	$254.24	$477.35	$8.34	$0.00	$170.92	$10.55	$4.16	$50.58	$976.14	6.8%
AP	$2,976.21	$708.63	$241.59	$735.33	$2,478.21	$64.47	$60.27	$551.79	$7,816.50	54.3%
AZ	$1,217.23	$498.19	$86.92	$0.00	$906.14	$51.40	$22.31	$143.38	$2,925.57	20.3%
Total	**$5,001.03**	**$3,487.69**	**$364.40**	**$735.33**	**$3,768.86**	**$151.62**	**$91.92**	**$781.30**	**$14,382.15**	**100.0%**
Percent Distribution	**34.8%**	**24.3%**	**2.5%**	**5.1%**	**26.2%**	**1.1%**	**0.6%**	**5.4%**	**100.0%**	

15.6 Refinement of Project Costs

MII cost estimates were developed for two NED Plan scales, B50-A25 and B60-A75 and are shown in Table A5-54. The 1990 Authorized Plan was also brought to current prices, discount rate and period of analysis. The first cost of the Authorized Design was escalated to current prices using EM1110-2-1304 with 2Q88 and 2Q13 quarterly composite indices and then adjusted using the FY14 discount rate of 3.50 percent and 50-year period of analysis. Table A5-54 displays the 1990 Authorized Plan at the authorized cost and at current cost.

Table A5-54:
Cost Estimates for NED Plan Scales B50-A25 and B60-A75 and 1990 Authorized Plan

	B50A25 3.50%	B50A25 7%	B60A75 3.50%	B60A75 7%	Authorized Plan	Authorized Plan
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						
Lands and Damages, Relocations	$67,675,191	$67,675,191	$74,085,922	$74,085,922		
PED and Construction Management	$26,581,919	$26,581,919	$28,476,919	$28,476,919		
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	$134,827,006	$134,827,006	$154,319,628	$154,319,628	$59,581,000	$125,523,114
IDC	$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[2]	n/a	n/a	n/a	n/a	$441,000	$929,083
Total Economic Cost	$166,200,707	$193,941,051	$183,473,758	$219,537,405	$60,022,000	$126,452,197
AAEV Total First Cost						
Flood Control	$7,085,753	$14,052,939	$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	$0	$0	$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	$7,085,753	$14,221,695	$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	1.97	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	$6,867,000	($268,729)	$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: MII cost estimate for B50-A25 and B60-A75
^2 The authorized data is taken from Buffalo Bayou and Tributaries, Texas Feasibility Report, House Document 101-208 (1990).
^3 Updated based on EM1110-2-1304
^4 Non-federal sponsor, HCFCD, is not exercising its recreational authority at the present time.

With the project costs for B50-A25 and B60-A75 developed using the MII cost estimator program and adhering to COE policy and practices for cost estimation, the costs of the two NED Plan scales, when compared against the estimated AAEV economic benefits, produce results that are somewhat different from the planning level estimates. The total first cost for construction is estimated to be $134.8 million for the NED Plan scale B50-A25 and $154.3 million for the TSP, B60-A75; a $19.5 million difference.

While B50-A25 still costs less, B60-A75 produces greater net excess benefits than B50-A25. The difference between net excess benefit production is 9 percent lower for B50-A25 than for B60-A75. *Table A5-55* presents a comparison of the overall performance characteristics of the NED Plan scale B50-A25 and the TSP scale B60-A75.

Table A5-55:
Project Performance for NED Plan Scales B50-A25 and B60-A75
3.5 percent interest rate, 2(Q)13 price levels, 2013 conditions

Performance Variables	NED Plan Scales		B60-A75
	B60-A75	B50-A25	Difference
Structures with Reduced Risk			
from 0.2 percent flood event	4,287	3,331	+956
from 1 percent flood event	4,465	4,021	+444
Residential Structures with Reduced Risk			
from 0.2 percent flood event	3,971	3,110	+861
from 1 percent flood event	4,061	3,672	+389
Population with Reduced Risk			
from 0.2 percent flood event	10,047	7,868	+2178
from 1 percent flood event	10,274	9,290	+984
Single Occurrence Damages in $1,000s			
from 0.2 percent flood event	$132,790	$168,251	-$35,461
from 1 percent flood event	$43,775	$53,069	-$9,294
AAEV Benefits in $1,000s	$15,364	$13,953	$1,411
AAEV Net Excess Benefits in $1,000s	$7,373	$6,863	$510

15.7 Characterization of the Residual Floodplain and Project Performance of the Tentatively Selected Plan (TSP)

15.7.1 Aerial Extent of the Residual Floodplain of the Tentatively Selected Plan (TSP)

The TSP is the SMART planning revised reference to what was formerly known as the Recommended Plan. By implementing the TSP, the "most likely" future 0.2 percent AEP floodplain will cover approximately 4,500 acres. This reduction represents a 33 percent reduction in the spatial coverage of the "most likely" future" WOP 0.2 percent AEP floodplain. The difference in the extents of the two floodplains is shown in *Figure A5-5*.

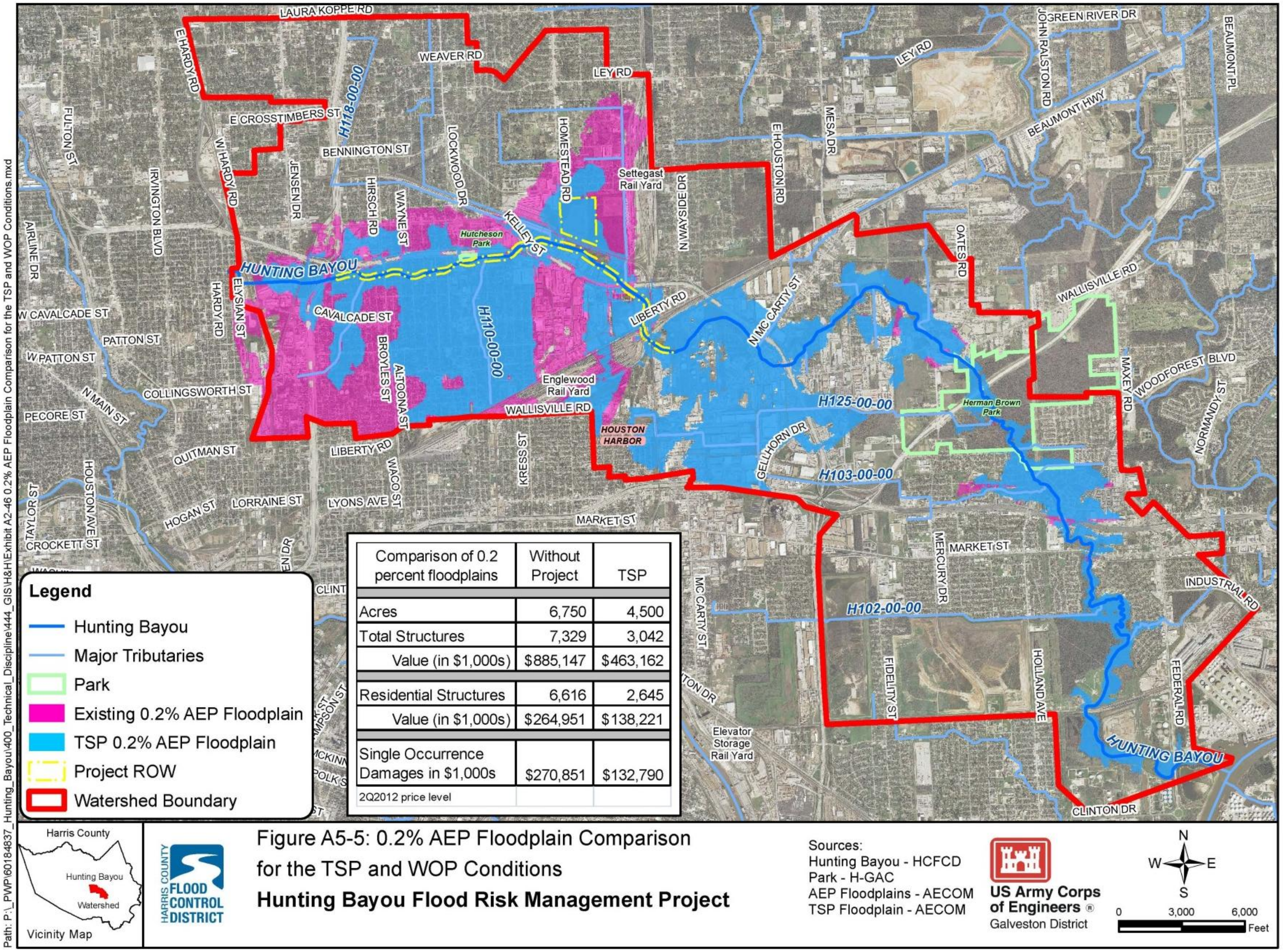
15.7.2 Population within the Residual Floodplain of the TSP

The population impacted by a 0.2 percent AEP flood is expected to be reduced by 60 percent with the implementation of the TSP. Currently an estimated 16,700 persons reside within the 0.2 percent AEP floodplain of Hunting Bayou based on a residential structure count of 6,600 residences. The TSP residual 0.2 percent AEP floodplain is projected to contain, 6,700 persons living in 2,600 residences.

However, 66 residential structures, housing an estimated 165 persons, are part of the structure inventory allowed under Section 575, WRDA 1996 for preservation of economic benefits. When these structures are not counted in the residual floodplain, the corrected estimate of residual population and housing in the TSP condition is more likely to be about 6,500 persons and 2,500 residences.

The population living within the residual floodplain of the TSP remains at risk for flooding and shares the same social and economic characteristics that indicate high vulnerability to hazards. The residual population is 95 percent minority, predominantly either Hispanic or black American. Like the population within the "most likely" future WOP 0.2 percent AEP floodplain, the residual population contains proportionately more younger and older persons than Harris County in general, which is another indicator of social vulnerability. Also over 30 percent of the population within the residual floodplain lives below the poverty level.

Figure A5-5:
0.2% AEP Floodplain Comparison for the TSP and WOP Conditions



Comparison of 0.2 percent floodplains	Without Project	TSP
Acres	6,750	4,500
Total Structures	7,329	3,042
Value (in $1,000s)	$885,147	$463,162
Residential Structures	6,616	2,645
Value (in $1,000s)	$264,951	$138,221
Single Occurrence Damages in $1,000s	$270,851	$132,790
2Q2012 price level		

15.7.3 Long-term Risk within the Residual Floodplain of the TSP

The HEC-FDA model calculates long-term risk as part of the report on project performance. Long-term risk is the probability of a target stage being exceeded over a 10-, 30-, and 50-year period. The target stage is typically associated with the start of significant damage in the WOP condition. Target stage AEP is the median and expected AEP associated with the target stage. The target stage is determined as the stage associated with the percent of residual damage of a specific exceedance probability event on a reach-by-reach basis. The Hydrologic Engineering Center (HEC) set this criterion at 5 percent of the total damage of the 1 percent AEP event because HEC considers minor, i.e., 5 percent, damage to the infrastructure as acceptable. Experience at HEC has shown a 5 percent residual damage associated with a 1 percent AEP event is normally an acceptable target stage. Conditional non-exceedance probability by event is the chance of containing the specific .10, .04, .02, .01, .004, and .002 AEP events within the target stage, should that event occur and is another indicator of project performance across these specified flood events. Unlike levee projects where the target stage is different for WOP and with project conditions, the TSP promotes no levee features. Therefore, the target stages shown on *Table A5-57* are identical for the WOP and TSP conditions.

The TSP impact area, Economic Reaches AH through AZ, is located in the upper stream segment of the Hunting Bayou floodplain upstream from the Englewood Rail Yard. *Table A5-56* provides a long-term risk comparison between the WOP condition and the TSP and the NED conditions. Within the project impact area, target stages are expected to be exceeded as a near certainty over time in the WOP condition with exceedance probability between 77 and 95 percent within 10 years and approaching and reaching 100 percent over 30 and 50 years. Under the TSP condition, the target stages set for the economic reaches within the project impact area have reduced expectations for exceedance that range from 10 to 30 percent within 10 years; from 23 to 58 percent in 30 years; and from 41 percent to 83 percent within 50 years.

*Table A5-58*demonstrates that, in any one year, the expected exceedance probability of the target stages within the project impact area ranges from 14 to 26 percent in the WOP condition. That expected AEP drops to a range of 1 to 3 percent in the TSP condition.

Table A5-56 displays the probability that various AEP events will be contained by the target stage in the WOP condition and the TSP and NED project conditions. As shown in the table, the chances of containing the various probabilistic flood events are improved in the TSP condition within the project impact area, where the 10 percent event is highly likely to be contained by the target stages and slowly diminish in likelihood of nonexceedance as events become larger and less frequent. In contrast, the WOP condition offers slight or no chance of the target stages containing any of the flood events beyond the 10 percent AEP event.

Table A5-56:
Comparison of Long-Term Risk - Without Project (WOP) Condition and TSP
Shaded area is project impact area.

Economic Damage Reach	Long-Term Risk (years)								
	10			30			50		
	WOP	TSP	NED	WOP	TSP	NED	WOP	TSP	NED
D	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
H	0.9970	0.9997	0.9997	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
L	0.5515	0.5150	0.5193	0.8653	0.8362	0.8398	0.9818	0.9732	0.9743
M	0.8204	0.7799	0.7840	0.9863	0.9773	0.9783	0.9998	0.9995	0.9995
O	0.6165	0.5597	0.5656	0.9089	0.8714	0.8756	0.9917	0.9835	0.9845
P	0.5014	0.4430	0.4474	0.8244	0.7685	0.7730	0.9692	0.9464	0.9485
R-Left	0.6316	0.5452	0.5511	0.9176	0.8605	0.8650	0.9932	0.9805	0.9818
R-Right	0.7279	0.6417	0.6485	0.9614	0.9231	0.9268	0.9985	0.9941	0.9946
T-Left	0.7489	0.6593	0.6672	0.9684	0.9323	0.9361	0.9990	0.9954	0.9959
T-Right	0.9089	0.8524	0.8593	0.9975	0.9916	0.9926	1.0000	0.9999	0.9999
U-Left	0.6736	0.5711	0.5775	0.9391	0.8796	0.8840	0.9963	0.9855	0.9865
U-Right	0.7989	0.7079	0.7175	0.9819	0.9539	0.9576	0.9997	0.9979	0.9982
V	0.5844	0.4642	0.4707	0.8887	0.7899	0.7962	0.9876	0.9558	0.9585
X	0.9649	0.9157	0.9233	0.9998	0.9979	0.9984	1.0000	1.0000	1.0000
Z	0.8855	0.7832	0.8050	0.9956	0.9781	0.9832	1.0000	0.9995	0.9997
AE	0.9345	0.8513	0.8731	0.9989	0.9915	0.9943	1.0000	0.9999	1.0000
AF	0.9325	0.8415	0.8671	0.9988	0.9900	0.9936	1.0000	0.9999	1.0000
AG	0.8651	0.7036	0.7545	0.9933	0.9522	0.9701	1.0000	0.9977	0.9991
AH	0.8111	0.2954	0.4084	0.9845	0.5832	0.7308	0.9998	0.8263	0.9276
AI	0.7706	0.1442	0.2713	0.9748	0.3225	0.5467	0.9994	0.5410	0.7945
AL	0.8104	0.0991	0.2155	0.9844	0.2297	0.4549	0.9998	0.4067	0.7029
AP	0.9507	0.2304	0.3837	0.9995	0.4804	0.7018	1.0000	0.7301	0.9111
AZ	0.9290	0.2079	0.2840	0.9987	0.4416	0.5662	1.0000	0.6882	0.8119

Table A5-57:
Annual Exceedance Probability (AEP) in the Residual Floodplains of the TSP and NED Conditions

Economic Damage Reach	Target Stage (feet)*			Annual Exceedance Probability (AEP)					
				Median			Expected		
	WOP	TSP	NED	WOP	TSP	NED	WOP	TSP	NED
D	2.07	2.07	2.07	0.7683	0.7864	0.7842	0.7615	0.7781	0.7761
H	8.2	8.2	8.2	0.5666	0.5651	0.5653	0.5618	0.5588	0.5592
L	16.07	16.07	16.07	0.0527	0.0493	0.0497	0.077	0.0698	0.0706
M	14.7	14.7	14.7	0.1504	0.132	0.1335	0.1578	0.1405	0.1421
O	16.68	16.68	16.68	0.0627	0.0567	0.0573	0.0914	0.0788	0.08
P	18.09	18.09	18.09	0.0354	0.0331	0.0333	0.0672	0.0569	0.0576
R-Left	23.33	23.33	23.33	0.0655	0.0526	0.0530	0.095	0.0758	0.077
R-Right	22.66	22.66	22.66	0.1039	0.0798	0.0807	0.122	0.0975	0.0993
T-Left	24.21	24.21	24.21	0.1117	0.0839	0.0855	0.1291	0.1021	0.1042
T-Right	22.66	22.66	22.66	0.224	0.18	0.1863	0.2131	0.1741	0.1781
U-Left	26.1	26.1	26.1	0.0746	0.0551	0.0566	0.1059	0.0812	0.0825
U-Right	25.24	25.24	25.24	0.1397	0.104	0.1058	0.1482	0.1158	0.1187
V	29.1	29.1	29.1	0.0461	0.0353	0.0397	0.0841	0.0605	0.0617
X	31.48	31.48	31.48	0.29	0.2271	0.2317	0.2847	0.2191	0.2264
Z	34.02	34.02	34.02	0.2133	0.1375	0.1477	0.1948	0.1417	0.1508
AE	35.76	35.76	35.76	0.2465	0.1802	0.1902	0.2386	0.1735	0.1865
AF	37.25	37.25	37.25	0.2431	0.17	0.1818	0.2363	0.1682	0.1827
AG	39.16	39.16	39.16	0.2	0.105	0.1260	0.1815	0.1145	0.131
AH	41.99	41.99	41.99	0.1476	0.0177	0.0408	0.1535	0.0344	0.0511
AI	43.63	43.63	43.63	0.1249	0.0073	0.0194	0.1369	0.0154	0.0312
AL	44.51	44.51	44.51	0.1407	0.0058	0.0135	0.1532	0.0104	0.024
AP	44.21	44.21	44.21	0.2507	0.0144	0.0302	0.26	0.0258	0.0472
AZ	46.36	46.36	46.36	0.2337	0.0125	0.0195	0.2324	0.023	0.0329

Shaded area is project impact area.
*Elevations are referenced to NGVD 1929, 1973 adjustment.

Table A5-58:
Conditional Non-Exceedance Probability by Event
Without Project (WOP) Condition and TSP Condition

Economic Damage Reach	Conditional Non-Exceedance Probability by Event																	
	10%			4%			2%			1%			0.4%			0.2%		
	WOP	TSP	NED	WOP	TSP	NED	WOP	TSP	NED	WOP	TSP	NED	WOP	TSP	NED	WOP	TSP	NED
D	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H	0.0002	0.0002	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
L	0.6765	0.7078	0.7052	0.4245	0.4360	0.4346	0.2754	0.2826	0.2800	0.1790	0.1861	0.1832	0.1026	0.1103	0.1077	0.0680	0.0755	0.0734
M	0.3203	0.3571	0.3550	0.1456	0.1572	0.1562	0.0774	0.0843	0.0832	0.0431	0.0478	0.0467	0.0210	0.0246	0.0238	0.0126	0.0154	0.0147
O	0.6125	0.6621	0.6585	0.3939	0.4024	0.4007	0.2694	0.2673	0.2647	0.1838	0.1760	0.1728	0.1147	0.1091	0.1059	0.0831	0.0783	0.0749
P	0.7284	0.7788	0.7766	0.5157	0.5354	0.5346	0.3756	0.3824	0.3803	0.2712	0.2682	0.2649	0.1789	0.1764	0.1728	0.1338	0.1306	0.1266
R-Left	0.5974	0.6756	0.6727	0.3928	0.4306	0.4286	0.2753	0.2939	0.2907	0.1899	0.1925	0.1888	0.1130	0.1196	0.1157	0.0773	0.0786	0.0757
R-Right	0.4817	0.5622	0.5584	0.2918	0.3247	0.3225	0.1943	0.2086	0.2056	0.1279	0.1301	0.1268	0.0723	0.0768	0.0736	0.0478	0.0487	0.0465
T-Left	0.4568	0.5415	0.5418	0.3065	0.3273	0.3147	0.2169	0.2231	0.2114	0.1513	0.1568	0.1469	0.0788	0.0808	0.0757	0.0411	0.0424	0.0401
T-Right	0.2030	0.2574	0.2531	0.1153	0.1239	0.1141	0.0729	0.0736	0.0663	0.0463	0.0469	0.0417	0.0210	0.0209	0.0184	0.0098	0.0096	0.0086
U-Left	0.5499	0.6455	0.6477	0.3902	0.4246	0.4138	0.2897	0.3056	0.2933	0.2087	0.2235	0.2129	0.1164	0.1237	0.1178	0.0628	0.0681	0.0657
U-Right	0.3918	0.4807	0.4773	0.2520	0.2778	0.2637	0.1750	0.1855	0.1729	0.1199	0.1283	0.1182	0.0605	0.0642	0.0592	0.0306	0.0331	0.0308
V	0.6474	0.7587	0.7554	0.4704	0.5259	0.4920	0.3521	0.3831	0.3549	0.2492	0.2568	0.2610	0.1388	0.1467	0.1483	0.0818	0.0727	0.0503
X	0.0634	0.1161	0.0937	0.0273	0.0387	0.0258	0.0138	0.0182	0.0118	0.0069	0.0083	0.0062	0.0024	0.0029	0.0022	0.0010	0.0010	0.0006
Z	0.2300	0.3599	0.2894	0.1181	0.1607	0.0960	0.0826	0.0807	0.0573	0.0542	0.0477	0.0398	0.0370	0.0248	0.0099	0.0265	0.0037	0.0020
AE	0.1263	0.2429	0.1558	0.0524	0.0856	0.0365	0.0392	0.0383	0.0192	0.0185	0.0179	0.0128	0.0143	0.0078	0.0023	0.0116	0.0010	0.0005
AF	0.1137	0.2525	0.1397	0.0417	0.0716	0.0219	0.0200	0.0254	0.0040	0.0095	0.0090	0.0010	0.0034	0.0008	0.0003	0.0017	0.0003	0.0002
AG	0.2467	0.4938	0.3487	0.1117	0.2022	0.0866	0.0610	0.0896	0.0221	0.0327	0.0382	0.0056	0.0143	0.0045	0.0017	0.0075	0.0015	0.0008
AH	0.3588	0.9228	0.8497	0.2018	0.7256	0.5008	0.1408	0.5476	0.3045	0.1092	0.3677	0.1800	0.0800	0.1292	0.0875	0.0638	0.0554	0.0471
AI	0.3618	0.9822	0.9431	0.1100	0.9086	0.7110	0.0465	0.8067	0.5068	0.0239	0.6056	0.3459	0.0104	0.3021	0.1904	0.0048	0.1586	0.1125
AL	0.3060	0.9972	0.9649	0.0548	0.9626	0.8195	0.0121	0.8478	0.6251	0.0037	0.6603	0.4111	0.0012	0.3938	0.2106	0.0005	0.2553	0.1227
AP	0.0367	0.9581	0.8607	0.0019	0.8005	0.6017	0.0004	0.6003	0.3943	0.0001	0.3989	0.2246	0.0000	0.2037	0.1092	0.0000	0.1278	0.0649
AZ	0.1229	0.9672	0.9302	0.0311	0.8249	0.7262	0.0108	0.6394	0.5151	0.0037	0.4356	0.3231	0.0012	0.2342	0.1583	0.0006	0.1306	0.0825

Shaded area is project impact area.

15.7.4 Non-Federal Actions to Remediate Risk in the Residual Floodplain of the TSP

Governing entities that have jurisdictional authority within the Hunting Bayou study area have established and maintain active FRM programs. As noted in the description of the WOP condition, Harris County and the Cities of Houston, Galena Park, and Jacinto City manage flood risk with adherence to NFIP floodplain management practices. COH adopted a local initiative to further reduce risk by elevation ordinances that exceed NFIP criteria and Harris County enforces a “no adverse impact” development policy, a voluntary buyout program, and a sophisticated flood warning system. Furthermore, COH passed Proposition 1 in 2010 to create a utility district to improve the City’s drainage and streets. COH has adopted a policy to impound runoff created from these improvements over time so as to not adversely impact nearby streams. These policies, practices, and programs are all expected to be exercised to manage and reduce the residual flood risk of the TSP over the project life.

15.7.5 Annual Project Cost and Benefit Summary of the TSP

The economic benefits and costs of the TSP and the NED Plan are summarized in *Table A5-59* and *Table A5-60*.

Table A5-59:
Annual Project Cost and Benefit Summary, 2Q2013 TSP

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 A5-60:
Annual Project Cost and Benefit Summary, 2Q2013 NED

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
[4] *O&M annual $123,896 cost includes mowing 116 acres and O&M for a 2-million-gallon-per-day lift station*

16.0 SECTION 575, WRDA 1996 ANALYSIS

Section 575 of WRDA 96 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."

The WRDA 99, Section 575(b) 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 Water Resources Development Act of 1990 (104 Stat. 4610);* and

(3) the project for flood control, Cypress Creek, Texas, authorized by section 3(a)(13) of the Water Resources Development Act of 1988 (102 Stat. 4014).

Section 354 of WRDA 99 amended Section 575 to remove non-structural actions from consideration in addition to the previously excluded "constructed works." As a tributary of Buffalo Bayou, Texas, Hunting Bayou is affected by the analytical requirements of Section 575.

During the study period, activities had been undertaken by non-federal interests to remediate flood damages through voluntary nonstructural buyouts through the Federal Emergency Management Agency's Hazard Mitigation Grant Program (HMGP) and Pre-disaster Mitigation Program (PDM) and other property acquisitions in support of right-of-way (ROW) needed for channel modification. Some property acquisitions involve improved property which removes damageable economic assets from the floodplain. When these actions occur, they fall under the authority of Section 575, WRDA 1996 and are evaluated for their impact on proposed project performance. The structures identified as relocations and/or ROW acquisitions were isolated and HEC-FDA models were executed for AAEV damages in the With and WOP conditions.

In order to meet the intent of the Section 575 WRDA 1996 authority, only full real estate takings of parcels, not partial takings, were considered for this analysis. The operational assumption is that improvements to parcels would be acquired and either demolished or removed from the floodplain with full takings so that damages prevented to those improvements could be realized. Partial takings did not offer the opportunity for removal of damageable structures. Altogether, 84 full real estate takings were identified within the Hunting Bayou economic study area to have occurred during the study period that qualified for Section 575, WRDA 1996 analysis.

The detention basin under construction by the non-federal sponsor, HCFCD, within the watershed was not included in the Section 575 analysis because the basin is not yet functioning for FRM at the time of this analysis. As a result, there are no FRM economic benefits to be realized as yet from this activity.

The 2Q2013 structure inventory records were matched to these full takings and the 84 records identified were evaluated in a HEC-FDA model run to determine their contribution to AAEV damages expected throughout the 50-year project life and to determine the extent of their contribution to the TSP's inundation reduction benefits. These real estate takings are characterized below in *Table A5-61* and *Table A5-62* along with the results of those takings with reference to project economic performance in *Table A5-64*. *Table A5-61* displays the buyouts by primary improvement to the real estate parcel acquired.

Table A5-61:
Distribution of Section 575 Buyouts by Structure Type

Structure Type	Number	Values in $1,000s
Residential		
Single-family	70	$636.19
Multifamily	6	$166.38
Commercial	8	$271.45
Total	84	$1,074.02

It is noted that two-thirds (n=56) of the 84 non-federal sponsor property acquisitions stem from the FEMA HMGP following Tropical Storm Allison which occurred in 2001. Tropical Storm Allison damaged in excess of 8,000 structures within the Hunting Bayou watershed with record level rainfall. Except for one buyout which was acquired for floodplain preservation, the remaining non-federal sponsor's buyouts were acquisitions in support of channel ROW.

The distribution of structures bought out by floodplain designation is shown in *Table A5-62*. While it is noted the majority of buyouts were in response to post-disaster FEMA assistance, it should also be noted the criterion for the HMGP buyouts is extent of structural damage sustained and not location in floodplain as may be the logical assumption. However, *Table A5-62* indicates that, while some of the buyouts were deep in the floodplain and contribute to economic damage reduction, other acquisitions contribute less or none at all.

Table A5-62:
Real Estate Takings/Acquisitions by Floodplain within the Hunting Bayou Study Area

Percent Chance Floodplain	Full Real Estate Takings/Acquisitions		
	Count, not cumulative	Percent	Cumulative Percent
20.00%	15	17.9%	17.9%
10.00%	12	14.3%	32.1%
4.00%	9	10.7%	42.9%
1.00%	12	14.3%	57.1%
0.40%	1	1.2%	58.3%
0.20%	27	32.1%	90.5%
Not in Floodplain	8	9.5%	100.0%
Total	**84**	**100.0%**	

The economic impact of the removal of 84 structures from the Hunting Bayou structure inventory is shown in Table A5-63 and *Table A5-64* where *Table A5-63* shows project performance with all structures in place and *Table A5-64* shows project performance with the 84 structures removed from the inventory. When comparing the two tables, the impact of removing the structures from the inventory is negligible with damages decreasing in the WOP condition by 0.30 percent. Economic performance of the TSP is reduced by 0.32 percent. The BCR for the TSP is 1.92; with the structures removed from the inventory, the BCR is unchanged. These results provide evidence of the lack of impact of the non-federal sponsor, HCFCD's nonstructural activities in the floodplain on the viability of the TSP.

Table A5-63:
Project Performance with All Structures in Place

Project Plan	Equivalent Annual Damages	Damages Reduced	Annual Project Cost	Annual Net Excess Benefits	BCR
	in $1,000s	in $1,000s	in $1,000s	in $1,000s	
WOP	$19,792.10	$0.00	$0.00	$0.00	
B60A75	$5,409.96	$15,363.56	$7,990.92	$7,372.63	1.92
B50A25	$6,820.57	$13,952.95	$7,089.58	$6,863.37	1.97
Authorized Design	$59.35	$19,732.75	$16,724.43	$3,008.32	1.18

** Discount Rate= 3.50%, 2Q2013 (FY13) price level*

Table A5-64:
Analysis of Impact of Removing 84 Structures from Inventory

Project Plan	Damages to 84 Structure Buyouts in Project Conditions	Effect of Removing 84 Structures from Inventory				
		Equivalent Annual Damages with Structure Buyouts	Damages Reduced with Structure Buyouts	Annual Project Cost	Annual Net Excess Benefits with Structure Buyouts	BCR with Structure Buyouts
	in $1,000s	in $1,000s	in $1,000s	in $1,000s	in $1,000s	
WOP	$59.47	$19,732.63				
B60A75	$9.18	$5,400.78	$15,313.27	$7,990.92	$7,322.34	1.92
B50A25	$12.16	$6,808.41	$13,905.64	$7,089.58	$6,816.06	1.96
Authorized Design	$0.11	$59.24	$19,673.39	$16,724.43	$2,948.96	1.18

** Discount Rate= 3.50%, 2Q2013 (FY13) price level*

17.0 Section 902, WRDA 1986

Section 902 of the WRDA of 1986, as amended, legislates a maximum total project cost. Projects to which this limitation applies and for which increases in costs exceed the limitations established by Section 902, as amended, will require further authorization by Congress to raise the maximum cost established for the project. No funds may be obligated or expended nor any credit afforded that would result in the maximum cost being exceeded, unless the House and Senate committees on Appropriations have been notified that Section 106 of the Energy and Water Development Appropriations Act of 1997 will be utilized. *The maximum project cost allowed by Section 902 includes the authorized cost (adjusted for inflation), the current cost of any studies, modifications, and actions authorized by the WRDA of 1986 or any later law, and 20 percent of the authorized cost (without adjustment for inflation).*

Section 211, WRDA 1996 (Public Law 104-303) signed into law October 12, 1996 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(f)(7) authorized the non-federal sponsor, HCFCD, to develop a FRM alternative to the 1990 Authorized Plan for Hunting Bayou. The non-federal sponsor, HCFCD, started implementing the alternative to the Authorized Plan to reduce future flood damage as soon as possible and is doing so at its own risk. Because Hunting Bayou was added to the 211(f) authorization, the non-federal sponsor, HCFCD, may be reimbursed for the efforts taken to reduce flood damages in the Hunting Bayou watershed as approved by the Secretary of the Army. Section 211(e)(2)(a) of WRDA 1996 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 and provide credit for the non-federal share of the project with certain stipulations. The maximum project cost limit imposed by Section 902 is a numerical value specified by law which must be computed in a legally supportable manner. It is not an estimate of the project's current cost. To compute the "legally supportable" computation, the USACE has certified a cost update spreadsheet with which to complete the required Project Cost Increase Fact Sheet as specified in ER 1105-2-100, Appendix G, Exhibit G-11. The results of that spreadsheet computation are presented below in *Table A5-65.* The Project Cost Increase Fact Sheet is attached as *Appendix 5*, Attachment 1. *Table A5-65* presents the 902 limit for the entire Buffalo Bayou and Tributaries project including the alternative to the Authorized Plan for Hunting Bayou with the result being that the current project estimate is within the 902 limit for the Buffalo Bayou and Tributaries, Texas project.

Table A5-65:
Maximum Cost Including Inflation Through Construction

FY 13	-	Thousands Dollars (000's)
Line 1		
a.	Current Project estimate at current price levels:	$1,016,037
b.	Current project estimate, inflated through construction:	$1,095,962
c.	Ratio: Line 1b / line 1a	1.0787
d.	Authorized cost at current price levels:	$1,402,769
	(Column (h) plus (i) from Table G-3)	
e.	Authorized cost, inflated through construction:	$1,513,116
	(Line c x Line d)	
Line 2	Cost of modifications required by law:	$0
Line 3	20 percent of authorized cost:	$145,473
	.20 x (Table G-3, columns (f) + (g)	
Line 4	Maximum cost limited by section 902:	$1,658,589
	Line 1e + line 2 + line 3	

Ref: Table G-4 (ER 1105-2-100 Appendix G)

18.0 RISK AND UNCERTAINTY IN PROJECT OUTPUTS

Economic uncertainty has been established for the Hunting Bayou federal Study as per ER 1105-2-101. Guidance requires that uncertainty with regard to value estimates of key variables be developed for inundation reduction projects and include first floor elevations; depth-percent damage functions; and content and structure values. Uncertainty estimates were entered into the HEC-FDA model along with the uncertainty in key H&H values to which a Monte Carlo sampling routine was applied to generate the uncertainty bounds around economic outputs. The model was adjusted to simulate 1,000 iterations of damage for each structure at each stage in creating the stochastic stage-damage relationship. The Monte Carlo simulation outputs of mean, standard error, and number of iterations were used to develop the standard deviation of the mean value. Z-scores for the 5, 25, 50, 75 and 95 percent cumulative distribution were used to create the exceedance probability estimates in the tables.

Three conditions: the WOP, and two scales of the NED Plan, B50-A25 and B60-A75 are presented in *Table A5-66* with regard to the uncertainty bounds for economic benefits, net excess benefits, and the BCR. Appendix A, ER 1105-2-101, provided the templates for *Table A5-66*.

Table A5-66:
Uncertainty in Economic Performance Results
All tables represent the 2Q2013 Structure Inventory, 2Q2013 (FY13) Price Level and 3.50 Percent Discount Rate
The estimates of uncertainty are based on the HEC-FDA outputs below

Plan	Average Annual Damages in $1,000's	Standard Deviation	Standard Deviation Squared	Average Annual Damages Reduced in $1,000's	Annual Project Costs in $1,000's	Annual Net Excess Benefits in $1,000's	BCR
WOP	$19,792	$17,978	32,319,3325				
B60A75	$5,410	$6,539	42,763,500	$15,363	$7,991	$7,372	1.92
B50A25	$6,821	$7,836	61,408,468	$13,952	$7,090	$6,862	1.97

Plan	Average Annual Damages in $1,000s		Average Annual Damages Reduced in $1,000s		Average Annual Damages Reduced Exceeded at Specified Probability in $1,000s				
	Without Plan	With Plan	Mean	St. Dev.	0.95	0.75	0.5	0.25	0.05
B60A75	$19,792	$5,410	$15,363	$19,130	($16,106)	$2,462	$15,363	$28,264	$46,832
B50A25	$19,792	$6,821	$13,952	$19,611	($18,308)	$726	$13,952	$27,178	$46,213

Plan	Expected Annual Benefit and Cost in $1,000s		Net Excess Benefits in $1,000s		Prob. Net Benefit is > 0	Net Benefit Exceeded with Specified Probability in $1,000s				
	Benefit	Cost	Mean	St. Dev.		0.95	0.75	0.5	0.25	0.05
B60A75	$15,363	$7,991	$7,372	$19,130	0.65	($24,097)	($5,529)	$7,372	$20,273	$38,841
B50A25	$13,952	$7,090	$6,862	$19,611	0.64	($25,398)	($6,364)	$6,862	$20,088	$39,123

Plan	Expected BCR		Prob. BCR is > 1	BCR Value Exceeded with Specified Probability				
	Mean	St. Dev.		0.95	0.75	0.5	0.25	0.05
B60A75	1.92	2.39	0.65	(2.02)	0.31	1.92	3.54	5.86
B50A25	1.97	2.77	0.64	(2.58)	0.10	1.97	3.83	6.82

Re: ER 1105-2-101, 3 Jan 2006, Appendix A

19.0 COMPARISON OF THE AUTHORIZED PLAN WITH THE TSP AND NED PLAN

The 1990 Authorized Plan consisted of an earthen channel extending from the confluence of Hunting Bayou with the Houston Ship Channel upstream to the vicinity of US 59 and provided protection from a 4 percent storm under future development conditions. With present local drainage conditions in the watershed, the Authorized Plan would provide protection from a flood greater than a 40-year flood or a flood with a 2.5 percent AEP.

The TSP (B60-A75) consists of an earthen trapezoidal channel with a bottom-width of 60 feet running from US 59 to the ERRY; bridge replacements in the upper stream segment; and an offline receiving 75-acre detention basin at Homestead Road.

The NED Plan (B50-A25) consists of an earthen trapezoidal channel with a bottom-width of 50 feet running from US 59 to the ERRY; bridge replacements in the upper stream segment; and an offline receiving 25-acre basin at Homestead Road. Benefits and costs for the Authorized Plan, the TSP and NED Plan are shown in *Table* A5-67.

Table A5-67 provides a comparison of the economic performances of the TSP, NED Plan and the 1990 Authorized Plan. Project performance with the period of analysis, federal discount rate, and price level as reported in the authorizing document of the Authorized Plan is presented as well as the Authorized Plan's project performance under current conditions and guidance requirements. The TSP and NED Plan are presented at the period of analysis, price level, and federal discount rate that is current and that conforms to guidance requirements. The TSP and NED Plan 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 A5-67:
Comparison of the NED, TSP and the 1990 Authorized Plan

	B50A25 3.50%	B50A25 7%	B60A75 3.50%	B60A75 7%	Authorized Plan	Authorized Plan
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	$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	$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[2]	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] Non-federal sponsor, HCFCD, is not exercising the project's recreational authority at this time.
[3] Update to 1990 Authorized Plan followed budget program process of escalating costs with CWCCIS indices to current prices and adjusting for differing project life and discount rate.

20.0 Economic Update Plan

The Economic Update Plan can be found in the Project Management Plan for the Hunting Bayou Integrated General Re-Evaluation and Environmental Assessment Report.

Attachment 1

Project Cost Increase Fact Sheet

(ER 1105-2-100, Appendix G, Amendment #1, Exhibit G-11, 30 Jun 2004)

1. Name of Project:
   Buffalo Bayou and Tributaries, Texas

2. Section and Law that Authorized or Modified the Project:
   WRDA 1990 (Public Law 101-640) Section 101(a)(21), authorized the Buffalo Bayou and Tributaries, Texas project (including the1990 Hunting Bayou Authorized Plan)

3. Section 902 Limit on Project Cost
   a. Authorized project cost (w/ price level): **$727.364 million (Oct 1989)**
   b. Price level increase from date of authorized cost (line 1e, Table G-4, less authorized cost): **$785.752 million**
   c. Current cost of studies, modifications, and action authorized by WRDA 1986 or any later law: **$0.0 million**
   d. 20 percent of line 3a.: **$145.473 million**
   e. Maximum project cost limited by Section 902 (line 4, Table G-4): **$1,658.589 million**

4. Current Project Cost including Inflation through Construction (line 1b, Table G-4):
   $1,016.037 million

5. Computation of Percentage Increase:
   a. Current estimate (line 4): **$1,016.037 million**
   b. Less total of lines 3a, b, and c: **-$1,513.116 million**
   c. Subtotal: **- $479.079 million**
   d. Percent increase (line 5c/3a): **- 68.0 percent**
   *e. Less total of lines 3a, b, c, and d: (**-$1,658.259 million**)*
   *f. Subtotal: (**-$642.222 million**)*
   *g. Percent increase (line 5f/3a): **- 88.3 percent***

6. Explain cost indices used in 3b.
   a. For construction: EM 1110-2-1304, Amendment #2, (31 Mar 13) Civil Works Construction Cost Index System, CWCCIS, Table A-1, Quarterly Cost Indexes by CWBS Feature Code, Base Year 1967, Composite Index (Weighted Average)
   b. For real estate: Bureau of Labor Statistics, Consumer Price Index, All Urban Consumers, U.S. City Average, Not Seasonally Adjusted, “Rent of Primary Residence,” data series: CUUR0000SEHA, October 1 (M10), Yearly.

7. Explain increases in 3c; Legislation requiring the modifications, and how accommodated.
   N/A

Information used to compile this fact sheet was developed with the USACE Section 902 Analysis Certified Tool, 2010. 5.e, 5.f, and 5.g added to include 20 percent of uninflated authorized cost to maximum project cost calculation.

8. Explain reasons for cost changes other than inflation:
   N/A

9. Explain any changes in benefits and provide current BCR.
   With regard to Hunting Bayou portion of the Buffalo Bayou and Tributaries, Texas federal Project, benefits reflect the current conditions and structure inventory in the damageable 0.2 percent AEP floodplain of Hunting Bayou. The current benefits are equivalent to an average annual value of **$15.364 million**, computed at the current federal discount rate of 3.50 percent and at a Jan 2013 (2Q13) price level. The BCR is **1.93** with average annual equivalent economic costs of $7.965 million.

10. Provide detailed explanation of status of the project.
    The draft General Reevaluation Report and Integrated Supplemental Environmental Assessment is currently under review. An Alternative Formulation Briefing was held August 2013 with ASA(CW) approval anticipated by March 2015.

11. The non-federal sponsor, HCFCD, has undertaken PED studies and has begun acquisition of real estate requirements to implement the Tentatively Selected Plan. The non-federal sponsor, HCFCD, is not exercising the recreation authority provided in WRDA 1990 at this time. Construction of the TSP is scheduled for completion by end of year 2020.

Information used to compile this fact sheet was developed with the USACE Section 902 Analysis Certified Tool, 2010. 5.e, 5.f, and 5.g added to include 20 percent of uninflated authorized cost to maximum project cost calculation.

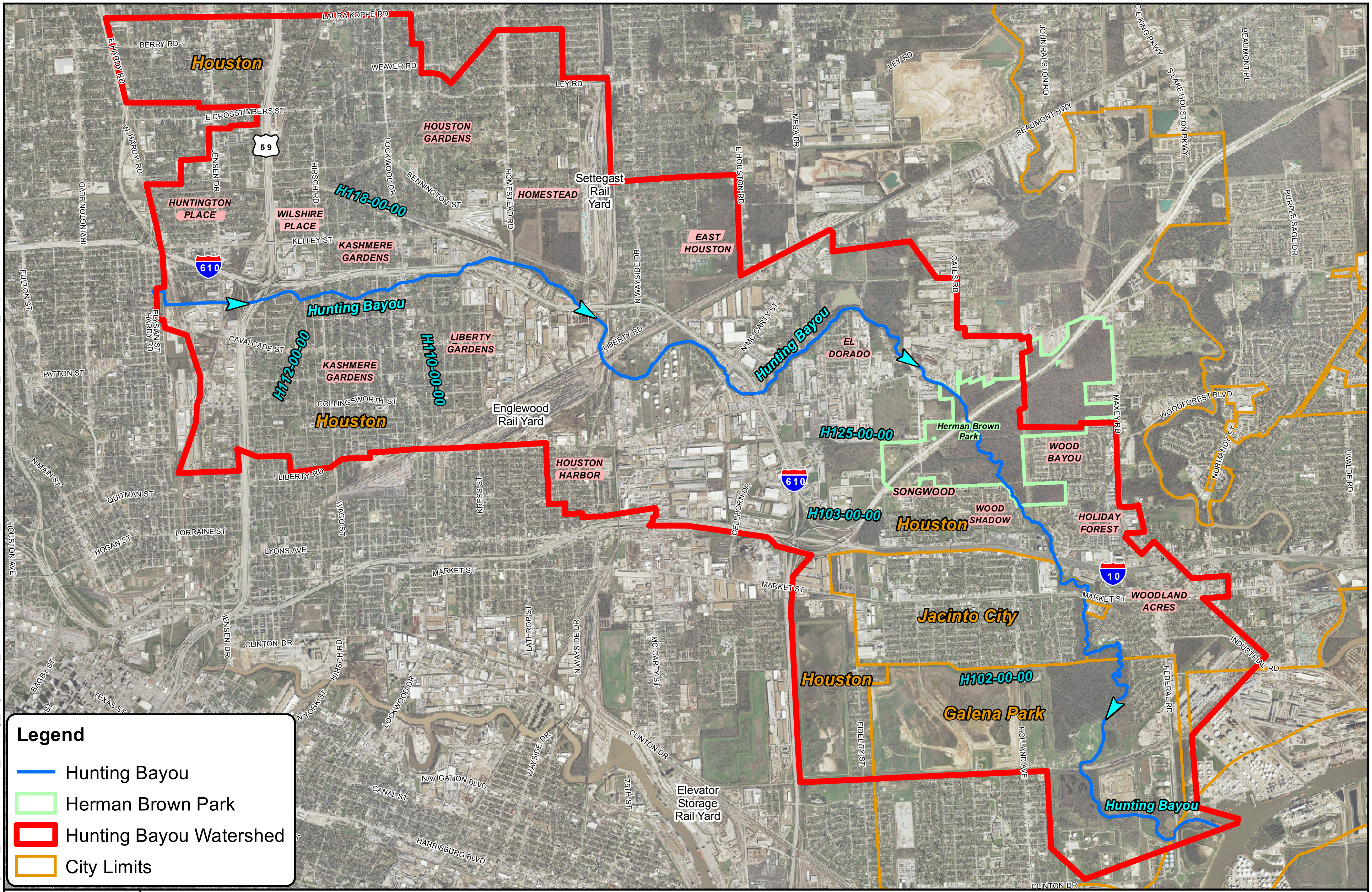
Table G-4 (ER 1105-2-100 Appendix G)

MAXIMUM COST INCLUDING INFLATION THROUGH CONSTRUCTION

FY 13 **Thousands Dollars (000's)**

Line 1		
a.	Current Project estimate at current price levels:	$1,016,037
b.	Current project estimate, inflated through construction:	$1,095,962
c.	Ratio: Line 1b / line 1a	1.0787
d.	Authorized cost at current price levels:	$1,402,769
	(Column (h) plus (i) from Table G-3)	
e.	Authorized cost, inflated through construction:	$1,513,116
	(Line c x Line d)	
Line 2	Cost of modifications required by law:	$0
Line 3	20 percent of authorized cost:	$145,473
	.20 x (Table G-3, columns (f) + (g)	
Line 4	Maximum cost limited by section 902:	$1,658,589
	Line 1e + line 2 + line 3	

Information used to compile this fact sheet was developed with the USACE Section 902 Analysis Certified Tool, 2010. 5.e, 5.f, and 5.g added to include 20 percent of uninflated authorized cost to maximum project cost calculation.



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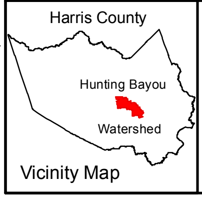

HARRIS COUNTY FLOOD CONTROL DISTRICT

Exhibit A5-1: Watershed Map

Hunting Bayou Flood Risk Management Project

DRAFT

Sources:
Hunting Bayou - HCFCD
Park - H-GAC
Aerials - H-GAC (2012)

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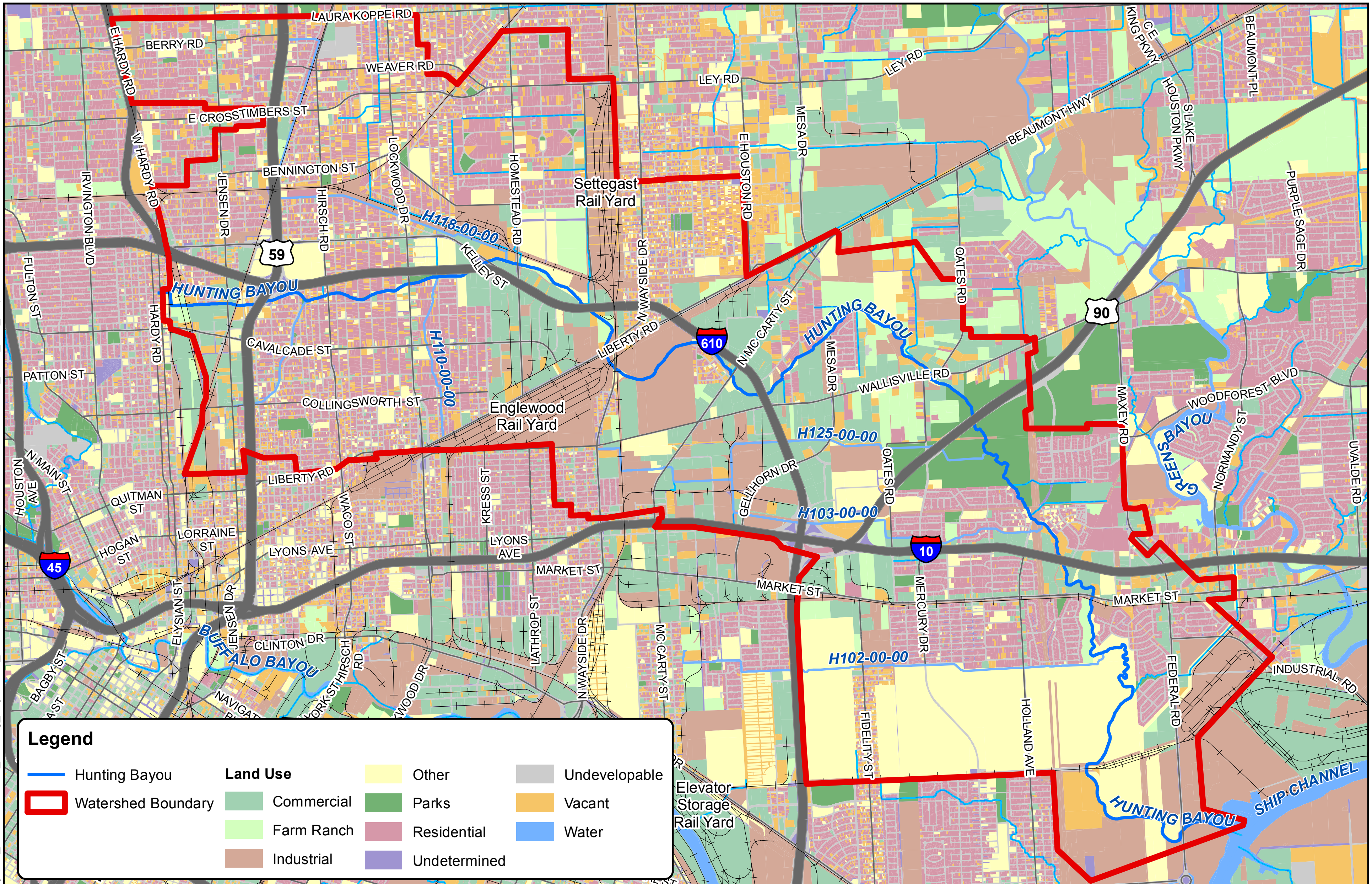

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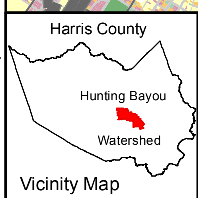

HARRIS COUNTY FLOOD CONTROL DISTRICT

Exhibit A5-2: Land Use

Hunting Bayou Flood Risk Management Project

Sources:
Land Use - H-GAC parcel land use (2010)
Streams - HCFCD

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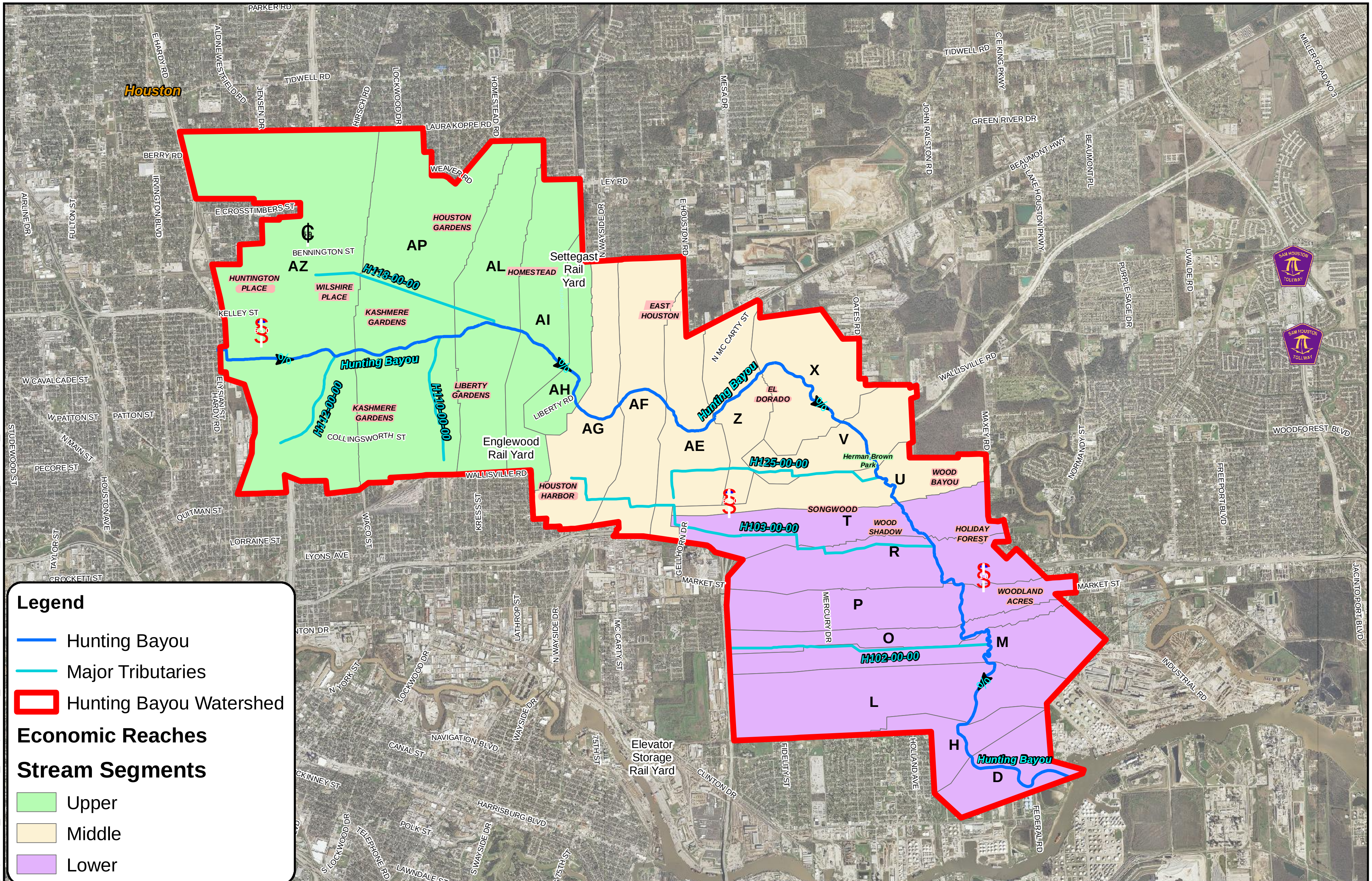

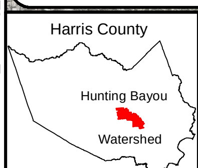

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HARRIS COUNTY FLOOD CONTROL DISTRICT

Exhibit A5-3: Economic Reaches

Hunting Bayou Flood Risk Management Project

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Sources:
Hunting Bayou - HCFCD
Park - H-GAC
Aerials - H-GAC (2012)

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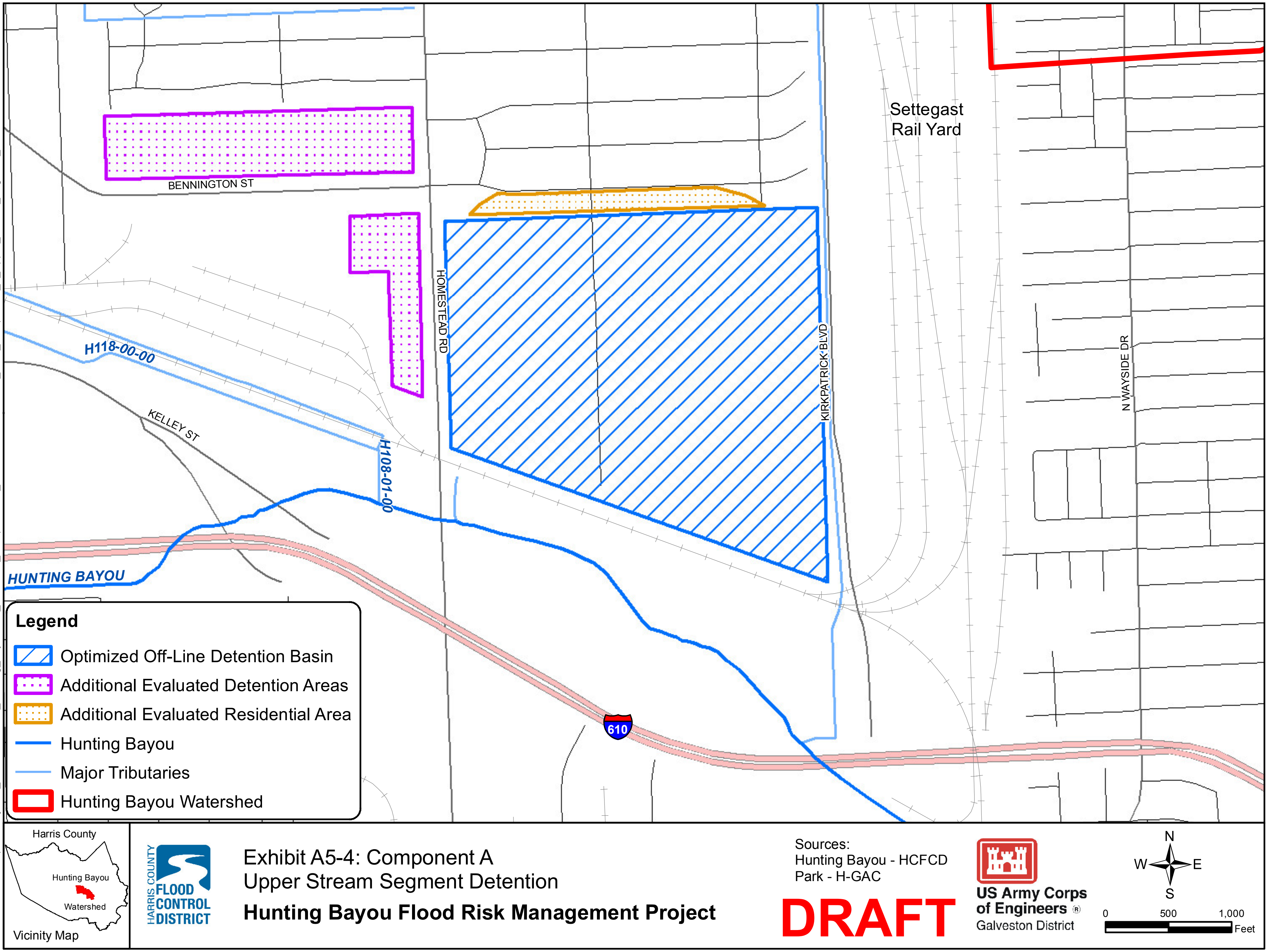

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HARRIS COUNTY FLOOD CONTROL DISTRICT

Exhibit A5-4: Component A
Upper Stream Segment Detention

Hunting Bayou Flood Risk Management Project

Sources:
Hunting Bayou - HCFCD
Park - H-GAC

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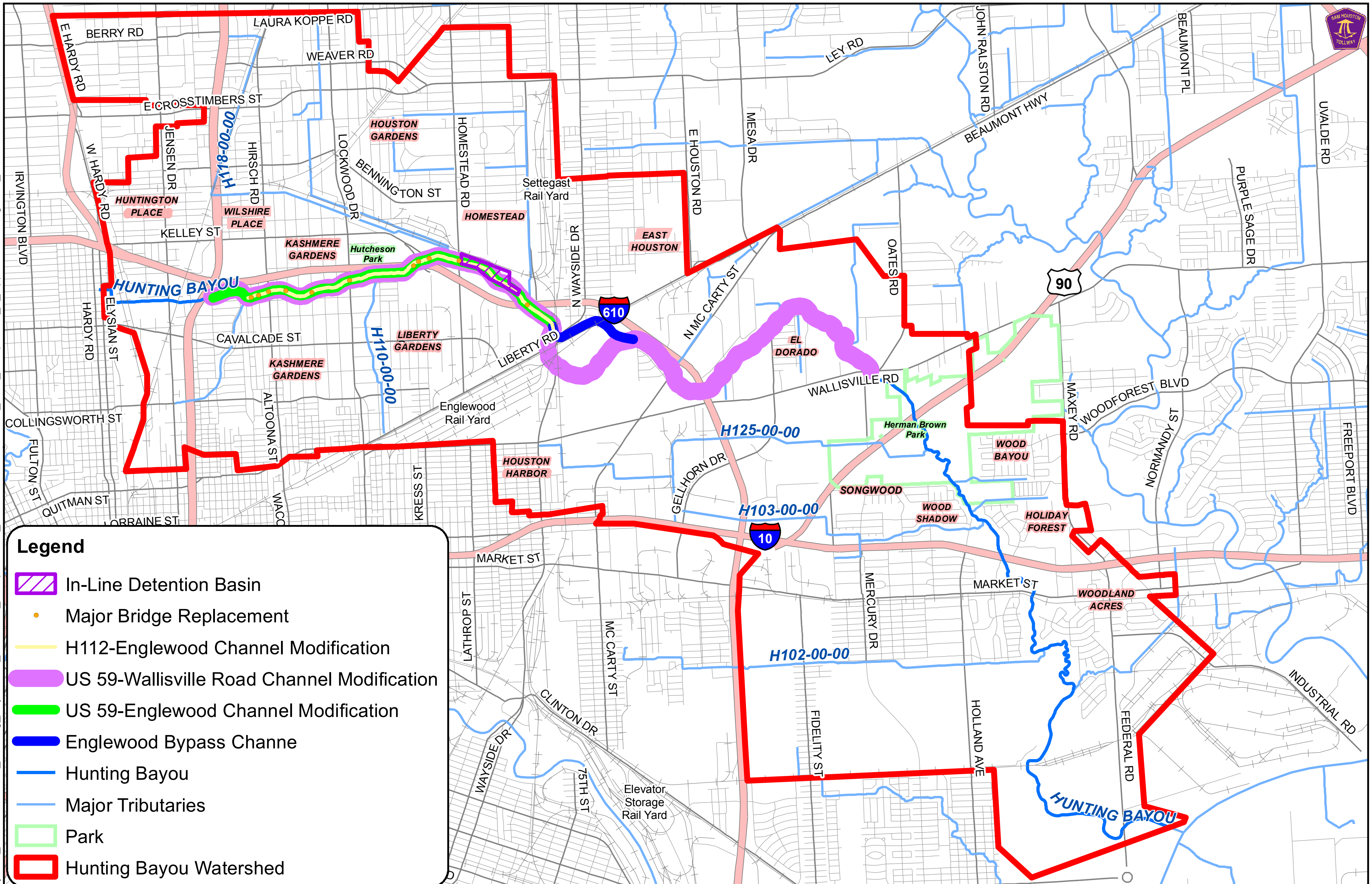

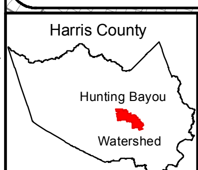

Vicinity Map

HARRIS COUNTY FLOOD CONTROL DISTRICT

Exhibit A5-5: Component B
Upper Stream Segment Channel Modification

Hunting Bayou Flood Risk Management Project

Sources:
Hunting Bayou - HCFCD
Park - H-GAC

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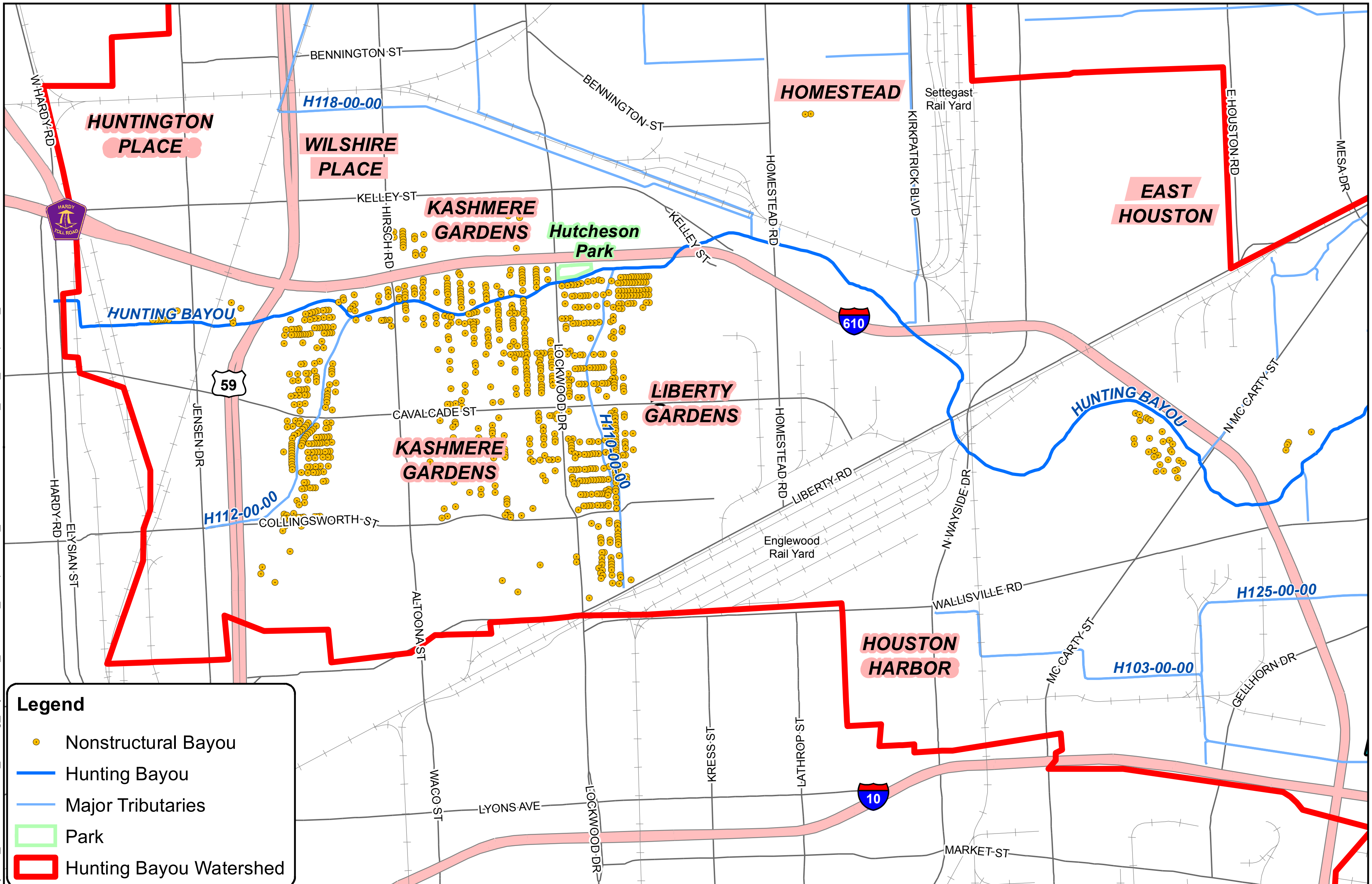

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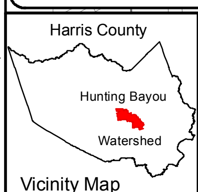

HARRIS COUNTY FLOOD CONTROL DISTRICT

Exhibit A5-6: Component C
Upper Stream Segment Buyout with Recreation Features

Hunting Bayou Flood Risk Management Project

Sources:
Hunting Bayou - HCFCD
Park - H-GAC

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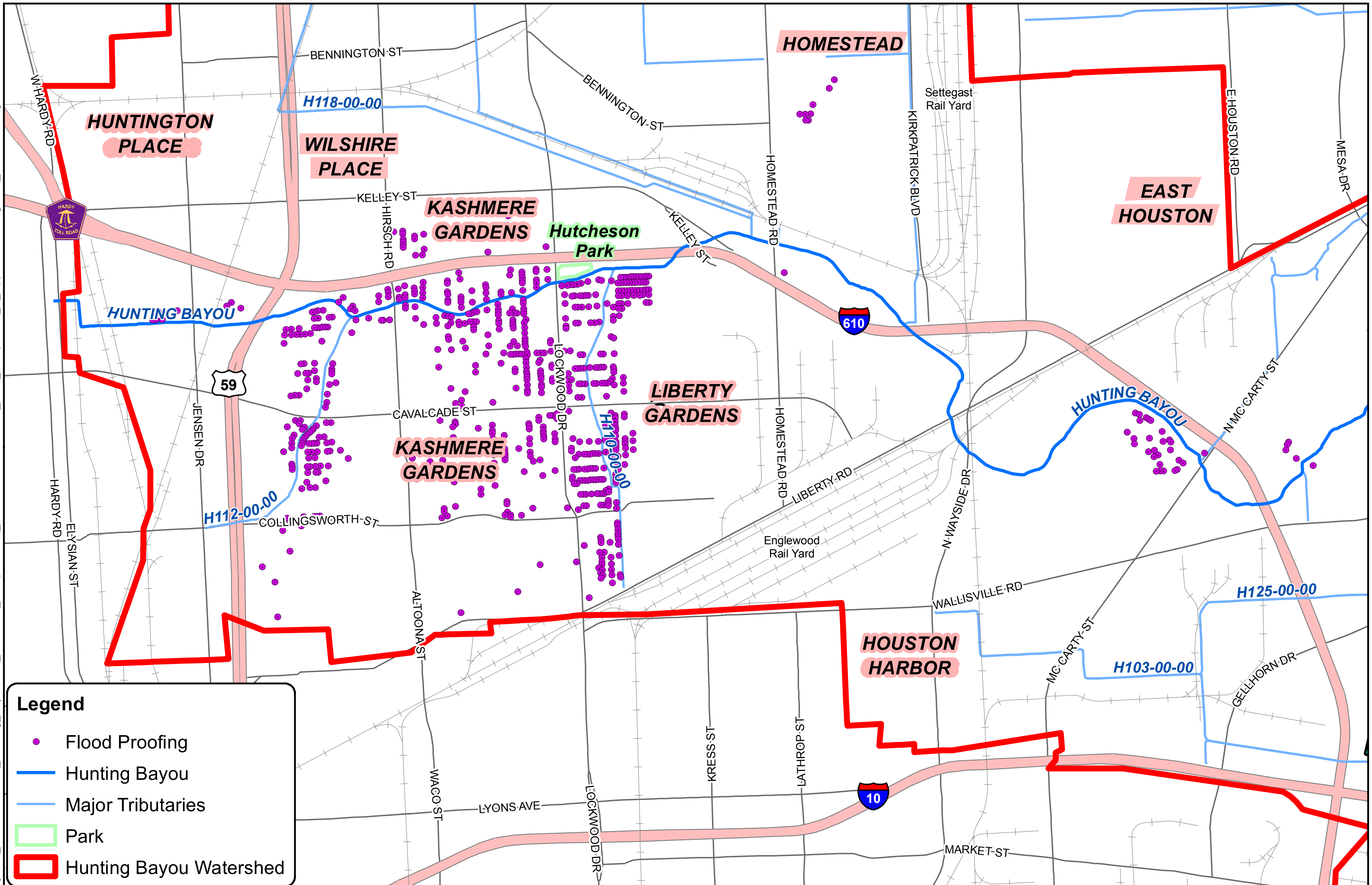

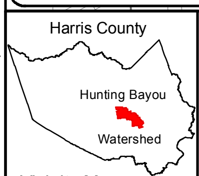

Vicinity Map

HARRIS COUNTY FLOOD CONTROL DISTRICT

Exhibit A5-7: Component D
Upper Stream Segment Flood Proofing

Hunting Bayou Flood Risk Management Project

Sources:
Hunting Bayou - HCFCD
Park - H-GAC

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Galveston District

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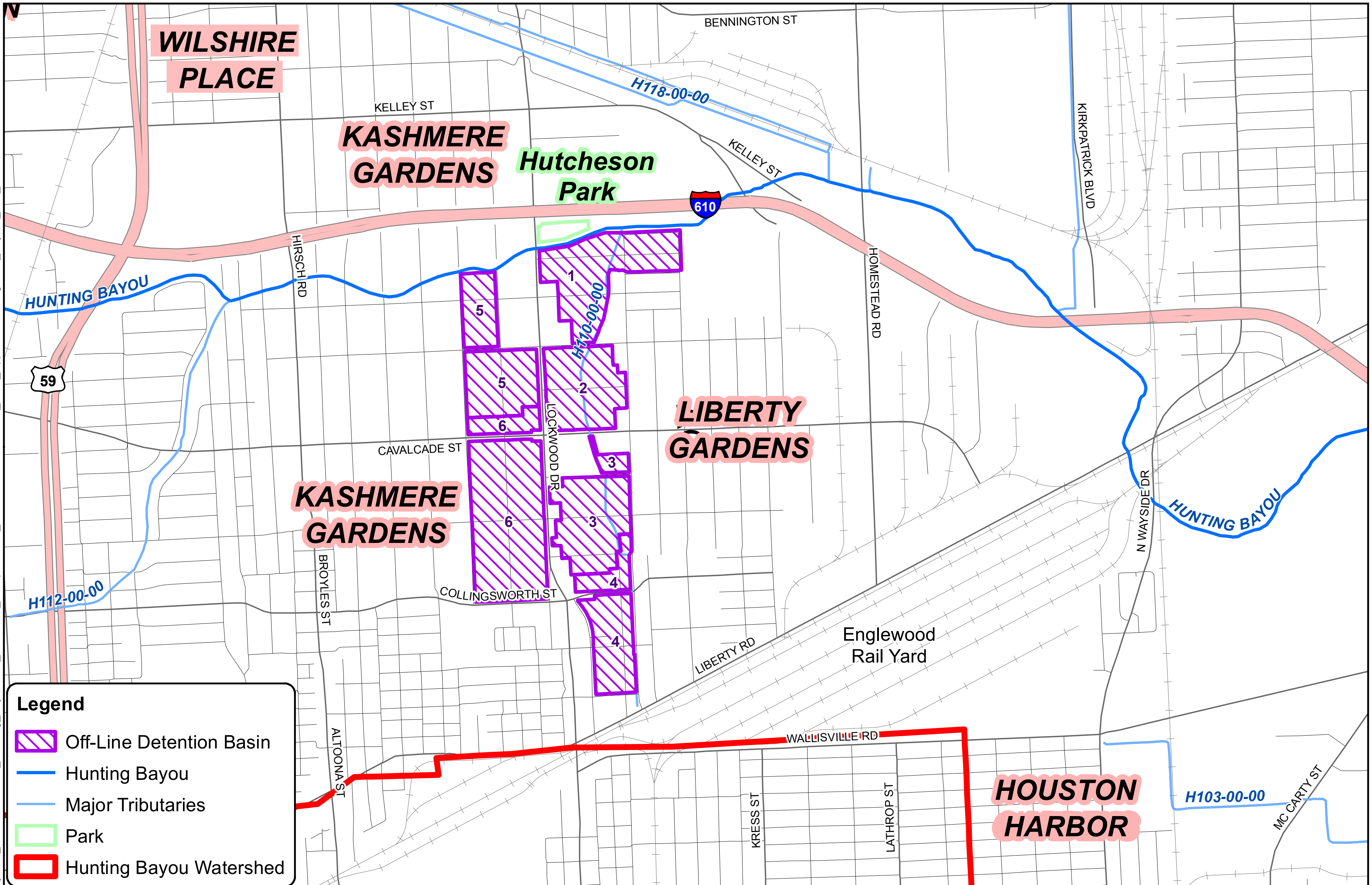

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HARRIS COUNTY FLOOD CONTROL DISTRICT

Exhibit A5-8: Component X
Upper Stream Segment Buyout with Detention

Hunting Bayou Flood Risk Management Project

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Sources:
Hunting Bayou - HCFCD
Park - H-GAC

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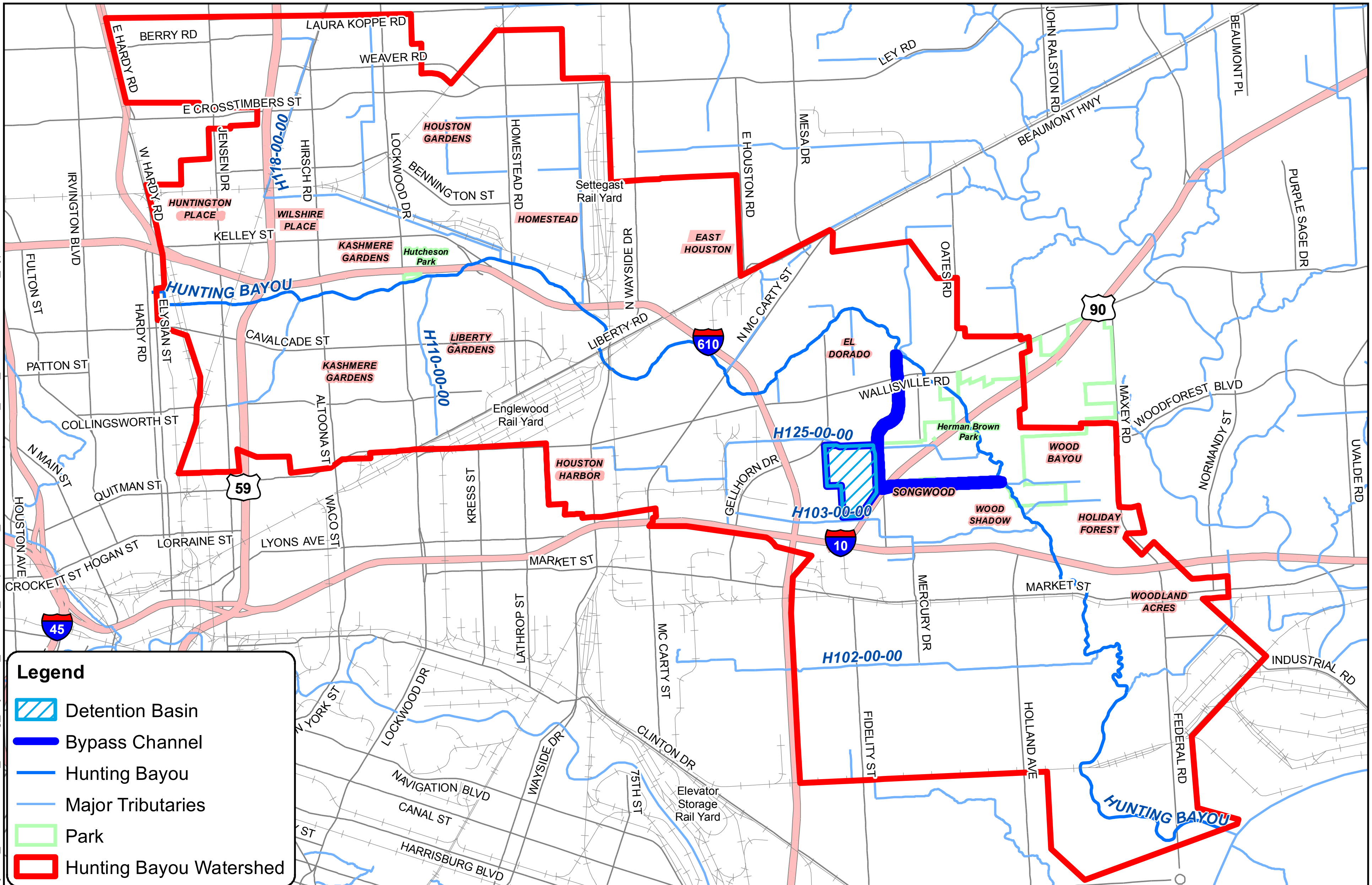

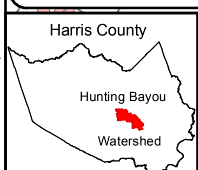

Vicinity Map

HARRIS COUNTY FLOOD CONTROL DISTRICT

Exhibit A5-9: Component E
Middle Stream Segment Herman Brown Park Bypass

Hunting Bayou Flood Risk Management Project

Sources:
Hunting Bayou - HCFCD
Park - H-GAC

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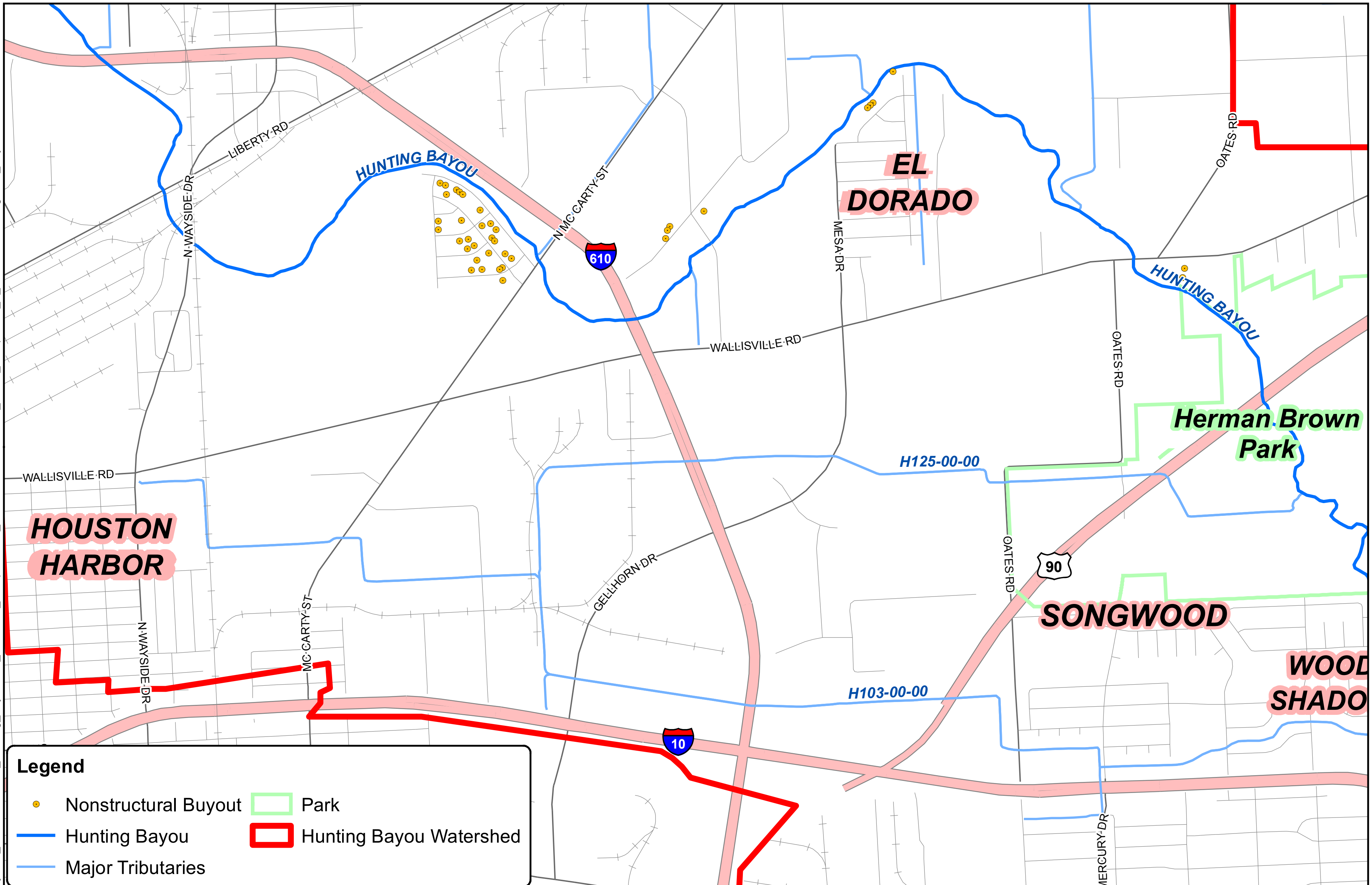

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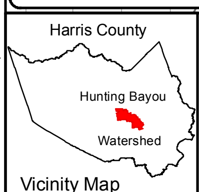

Vicinity Map

HARRIS COUNTY FLOOD CONTROL DISTRICT

Exhibit A5-10: Component F
Middle Stream Segment Buyouts

Hunting Bayou Flood Risk Management Project

Sources:
Hunting Bayou - HCFCD
Park - H-GAC

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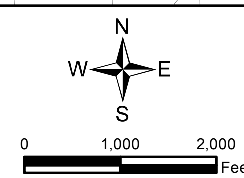

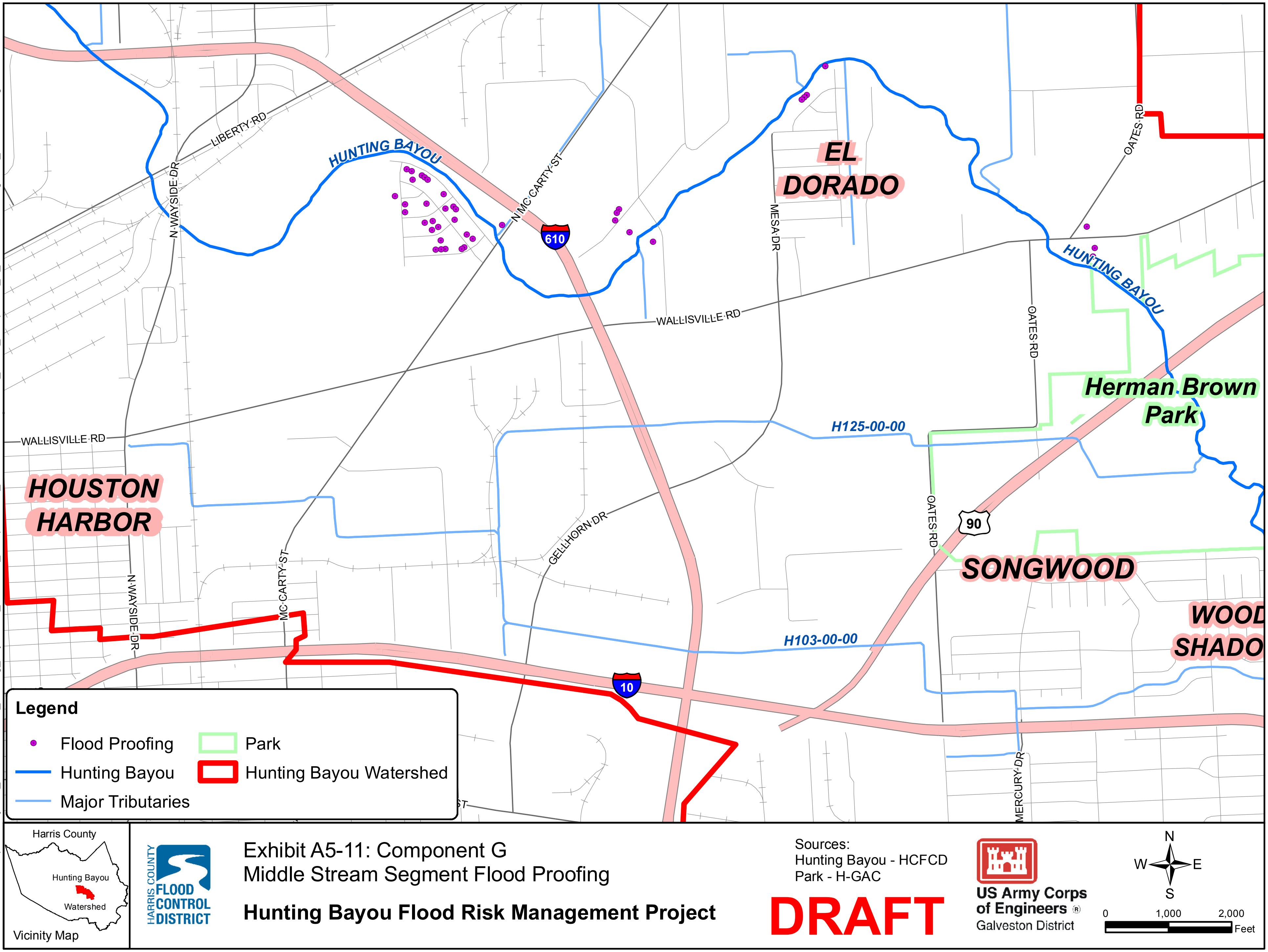

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HARRIS COUNTY FLOOD CONTROL DISTRICT

Exhibit A5-11: Component G
Middle Stream Segment Flood Proofing

Hunting Bayou Flood Risk Management Project

Sources:
Hunting Bayou - HCFCD
Park - H-GAC

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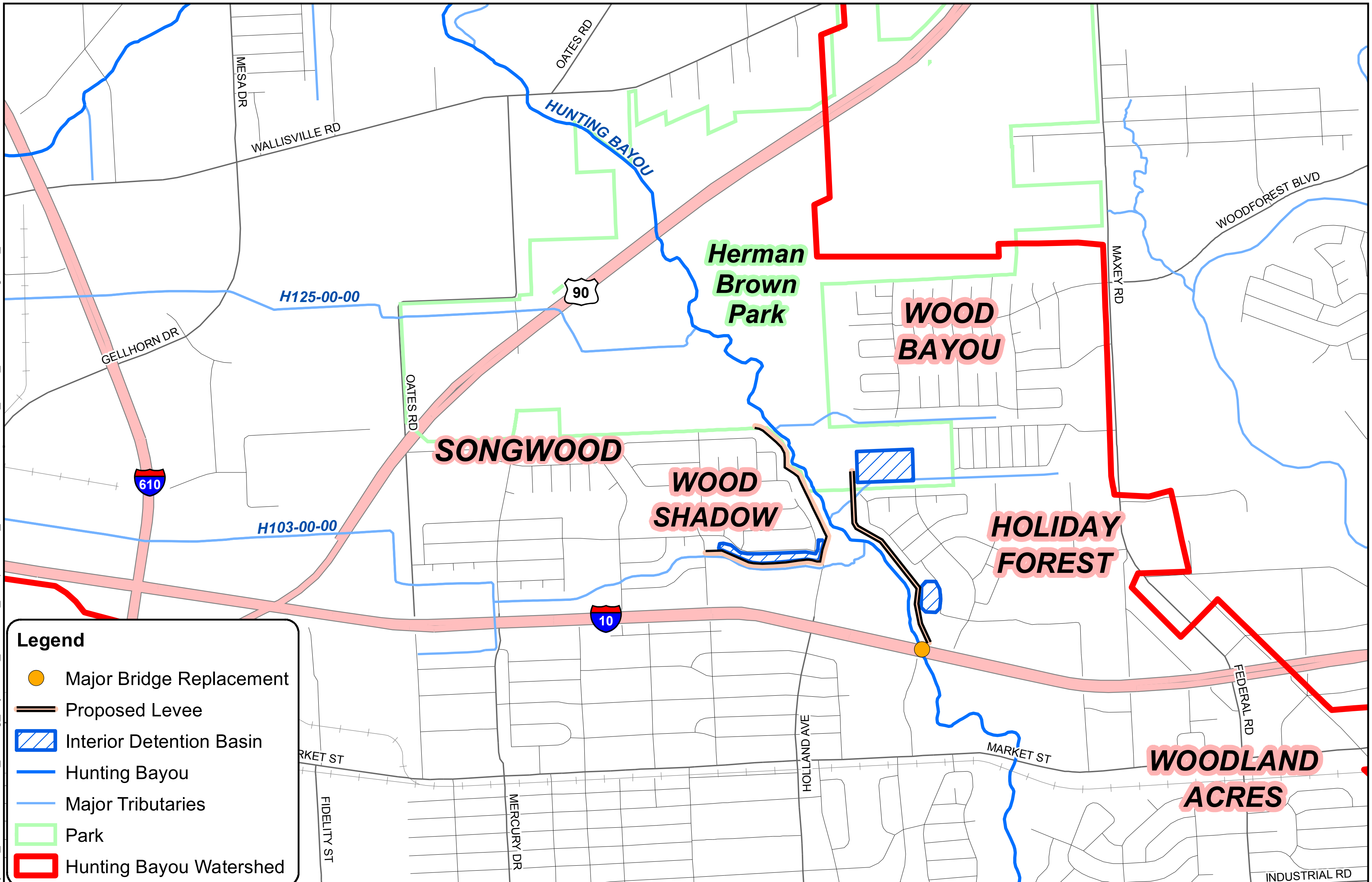

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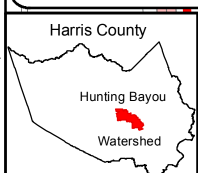

Vicinity Map

HARRIS COUNTY FLOOD CONTROL DISTRICT

Exhibit A5-12: Component H
Lower Stream Segment Levee

Hunting Bayou Flood Risk Management Project

Sources:
Hunting Bayou - HCFCD
Park - H-GAC

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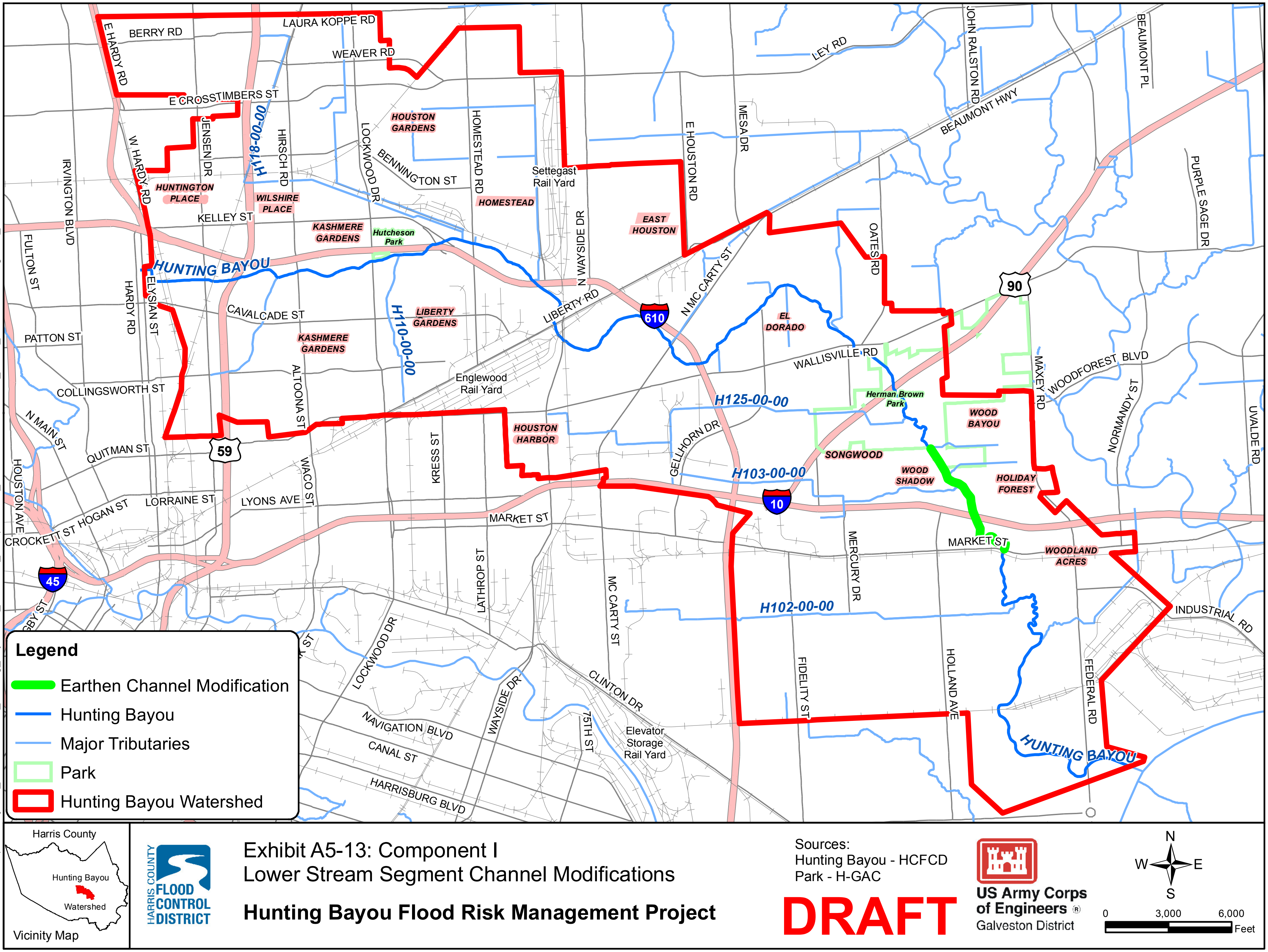

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HARRIS COUNTY FLOOD CONTROL DISTRICT

Exhibit A5-13: Component I
Lower Stream Segment Channel Modifications

Hunting Bayou Flood Risk Management Project

Sources:
Hunting Bayou - HCFCD
Park - H-GAC

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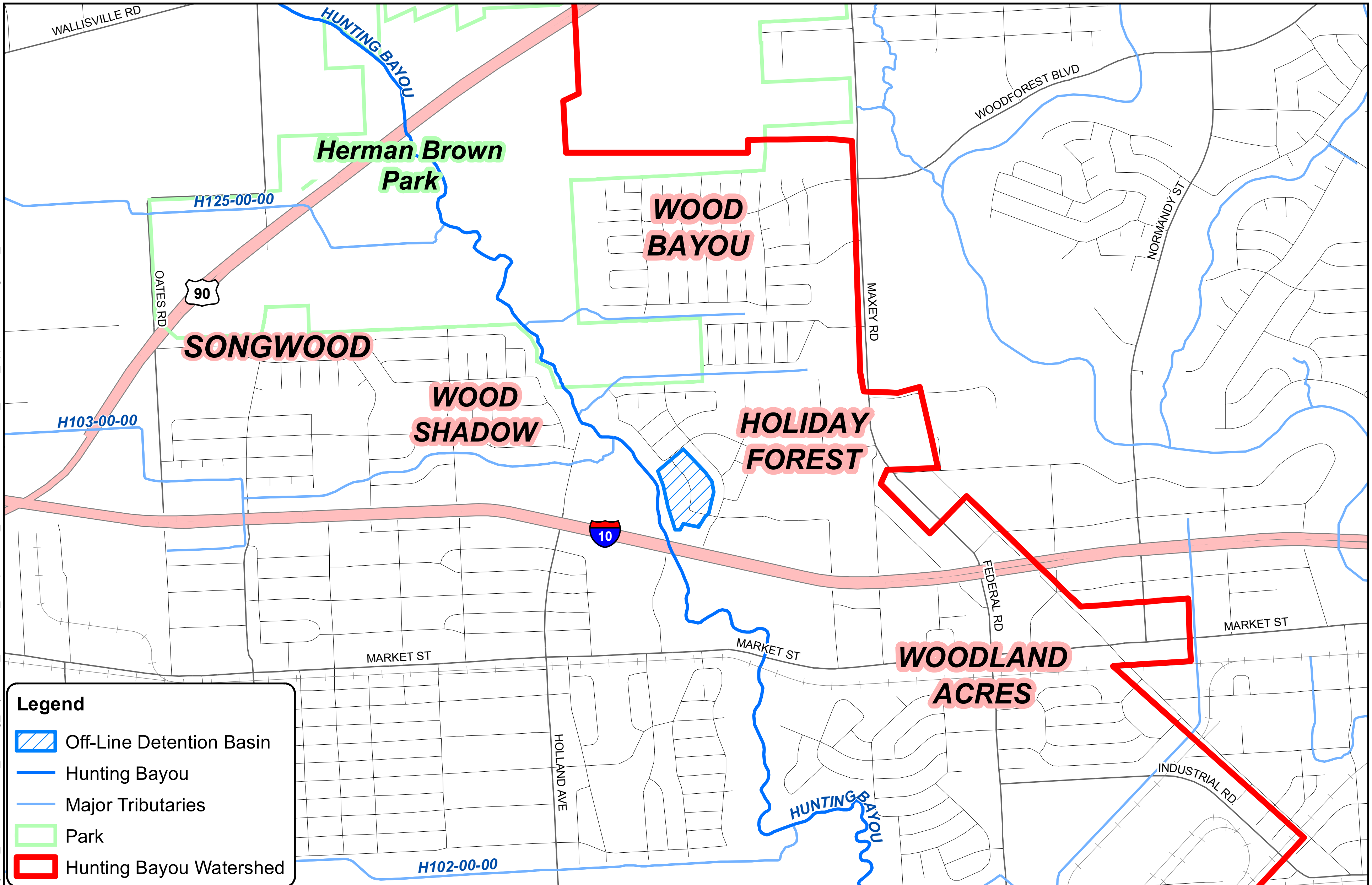

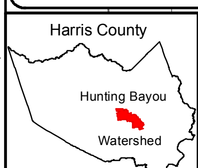

HARRIS COUNTY FLOOD CONTROL DISTRICT

Exhibit A5-14: Component J
Lower Stream Segment Detention

Hunting Bayou Flood Risk Management Project

Sources:
Hunting Bayou - HCFCD
Park - H-GAC

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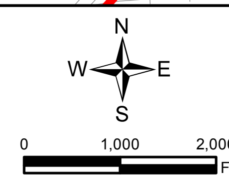

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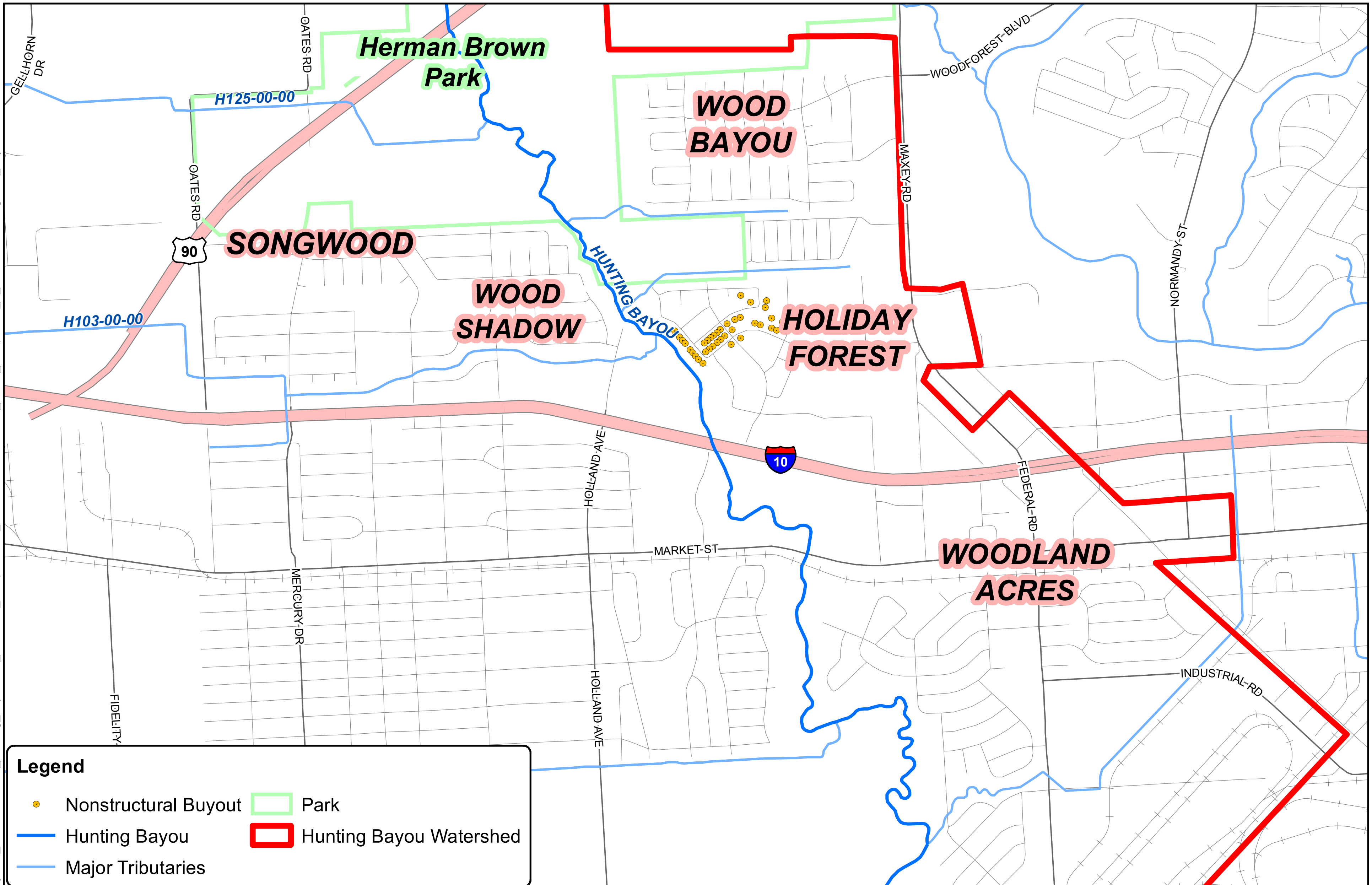

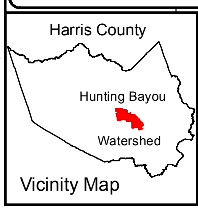

HARRIS COUNTY FLOOD CONTROL DISTRICT

Exhibit A5-15: Component K
Lower Stream Segment Buyouts

Hunting Bayou Flood Risk Management Project

Sources:
Hunting Bayou - HCFCD
Park - H-GAC

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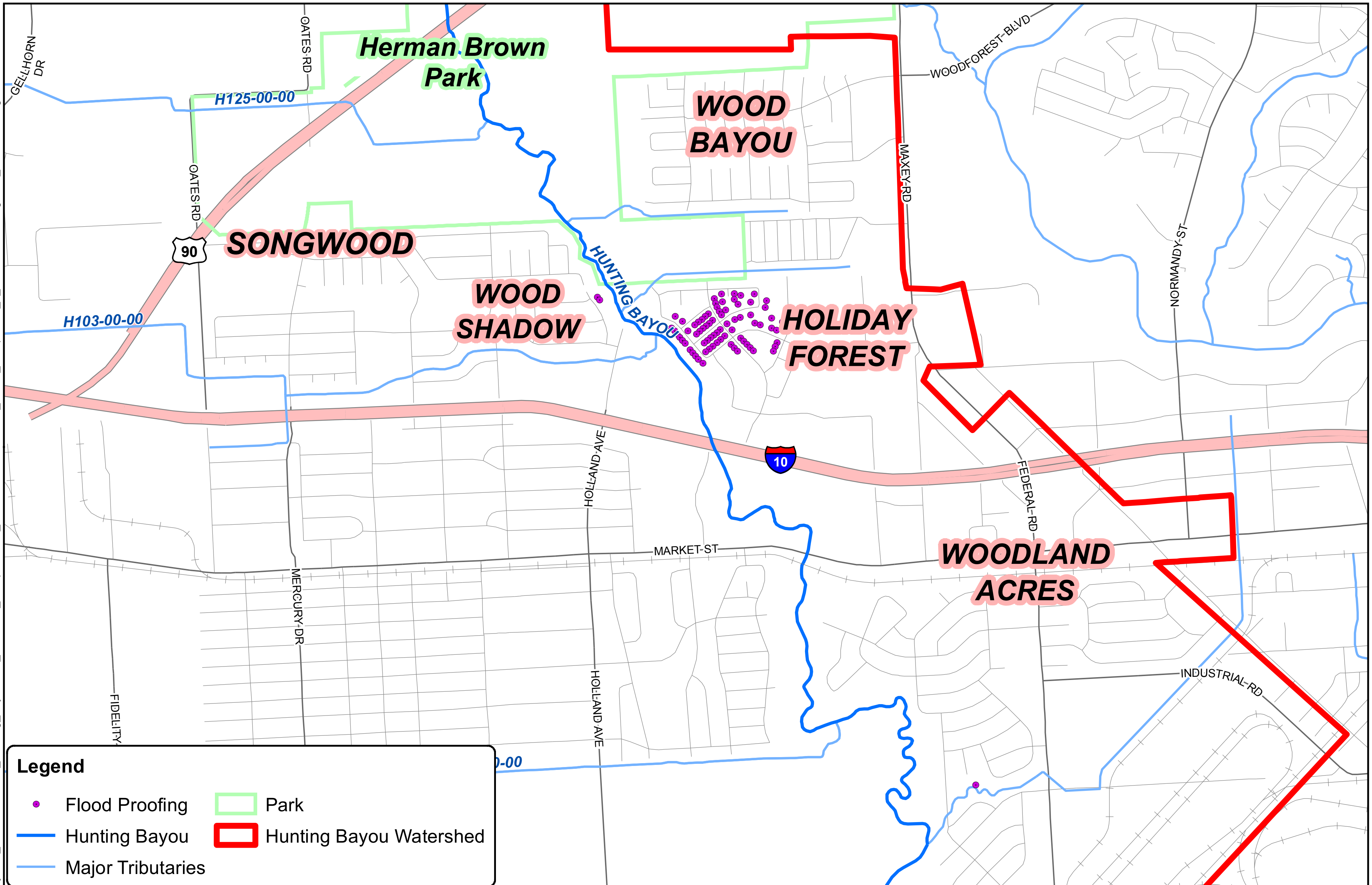

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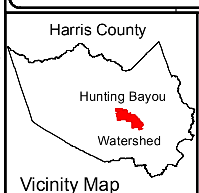

HARRIS COUNTY FLOOD CONTROL DISTRICT

Exhibit A5-16: Component L
Lower Stream Segment Flood Proofing

Hunting Bayou Flood Risk Management Project

Sources:
Hunting Bayou - HCFCD
Park - H-GAC

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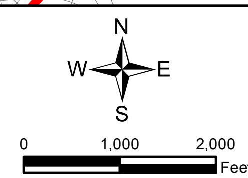

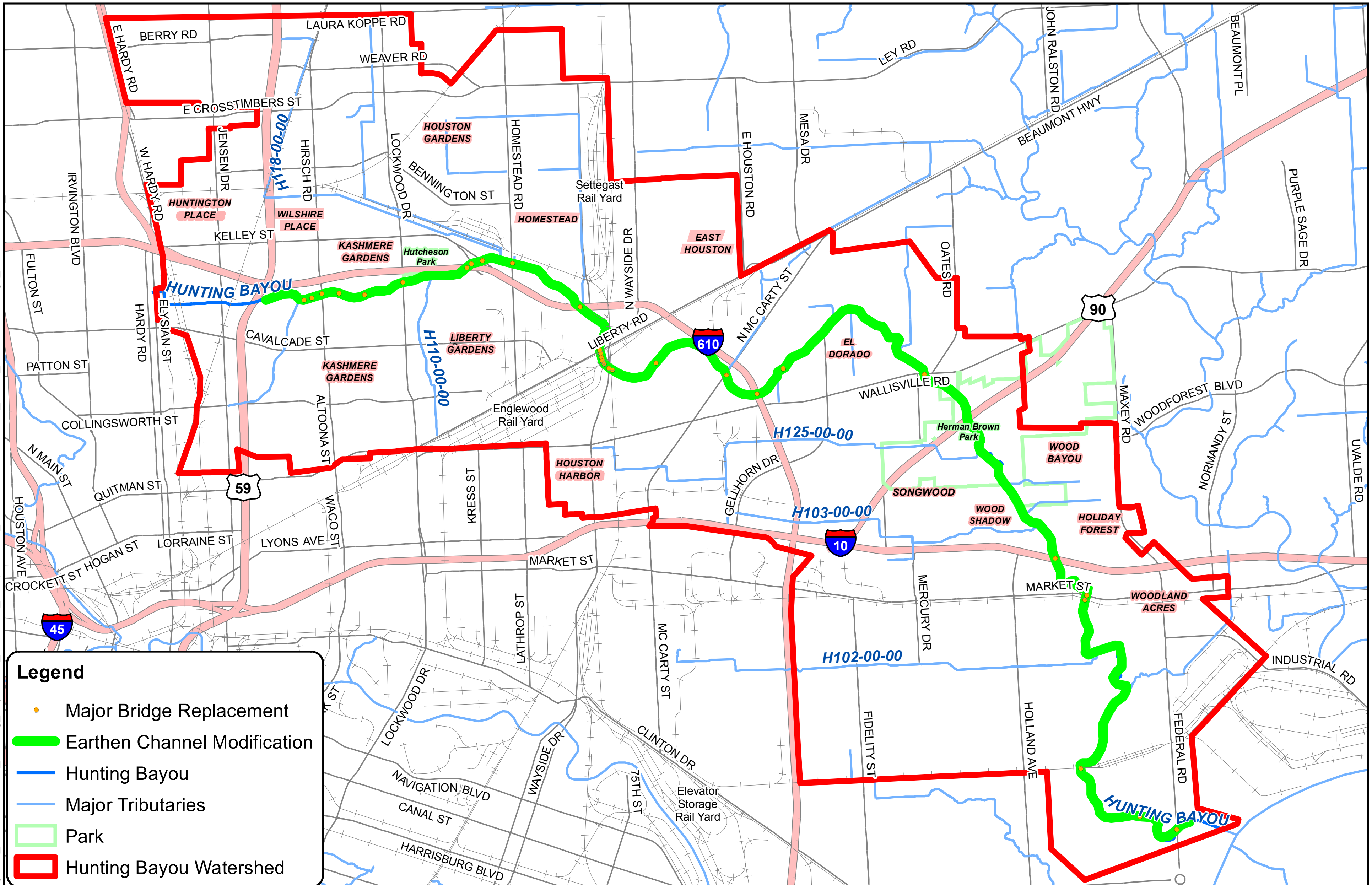

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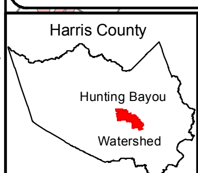

Vicinity Map

HARRIS COUNTY FLOOD CONTROL DISTRICT

Exhibit A5-17: Alternative 1
Authorized Design (Full Channel Modification)

Hunting Bayou Flood Risk Management Project

Sources:
Hunting Bayou - HCFCD
Park - H-GAC

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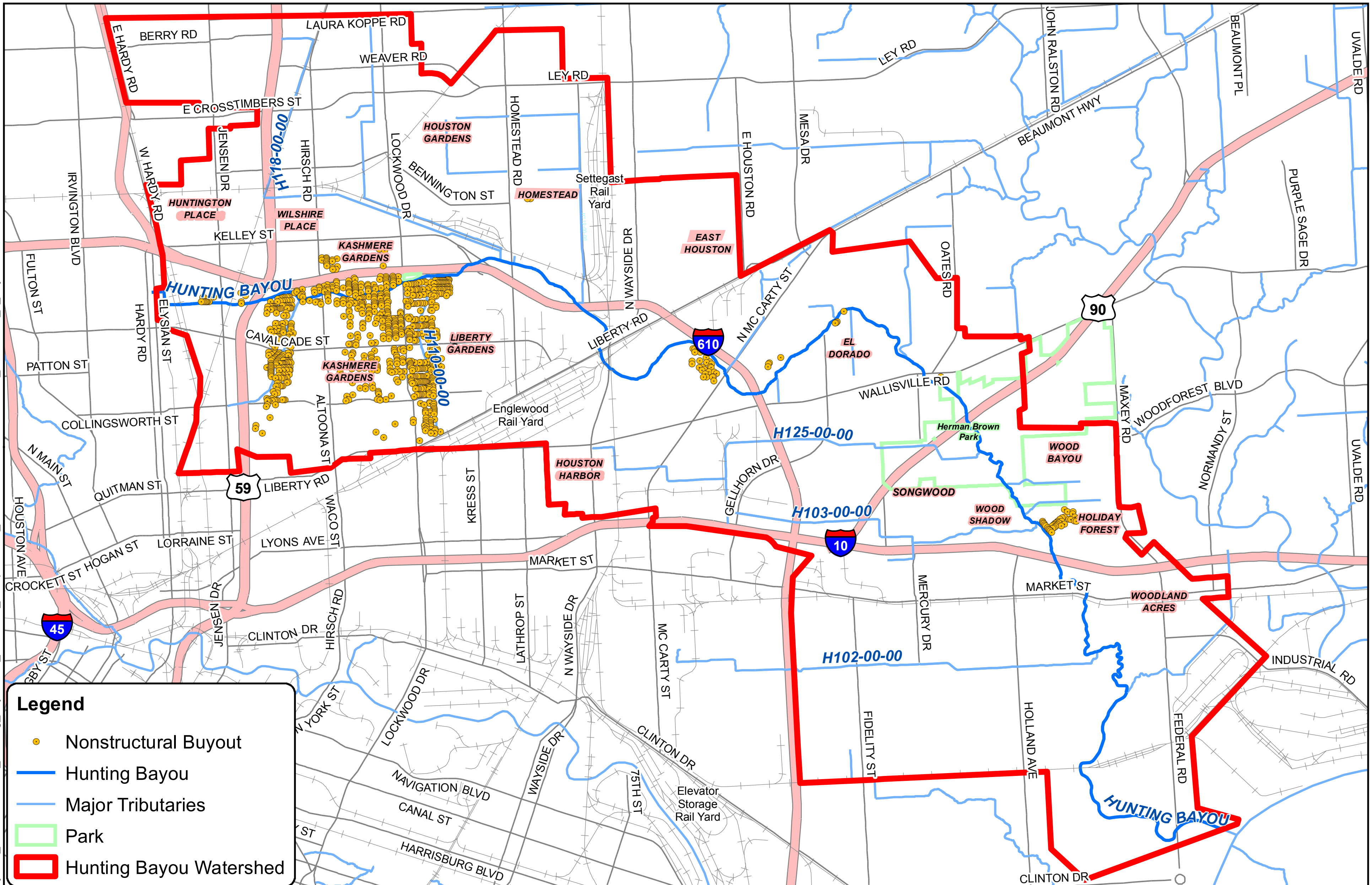

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HARRIS COUNTY FLOOD CONTROL DISTRICT

Exhibit A5-18: Alternative 2

Buyouts

Hunting Bayou Flood Risk Management Project

Sources:
Hunting Bayou - HCFCD
Park - H-GAC

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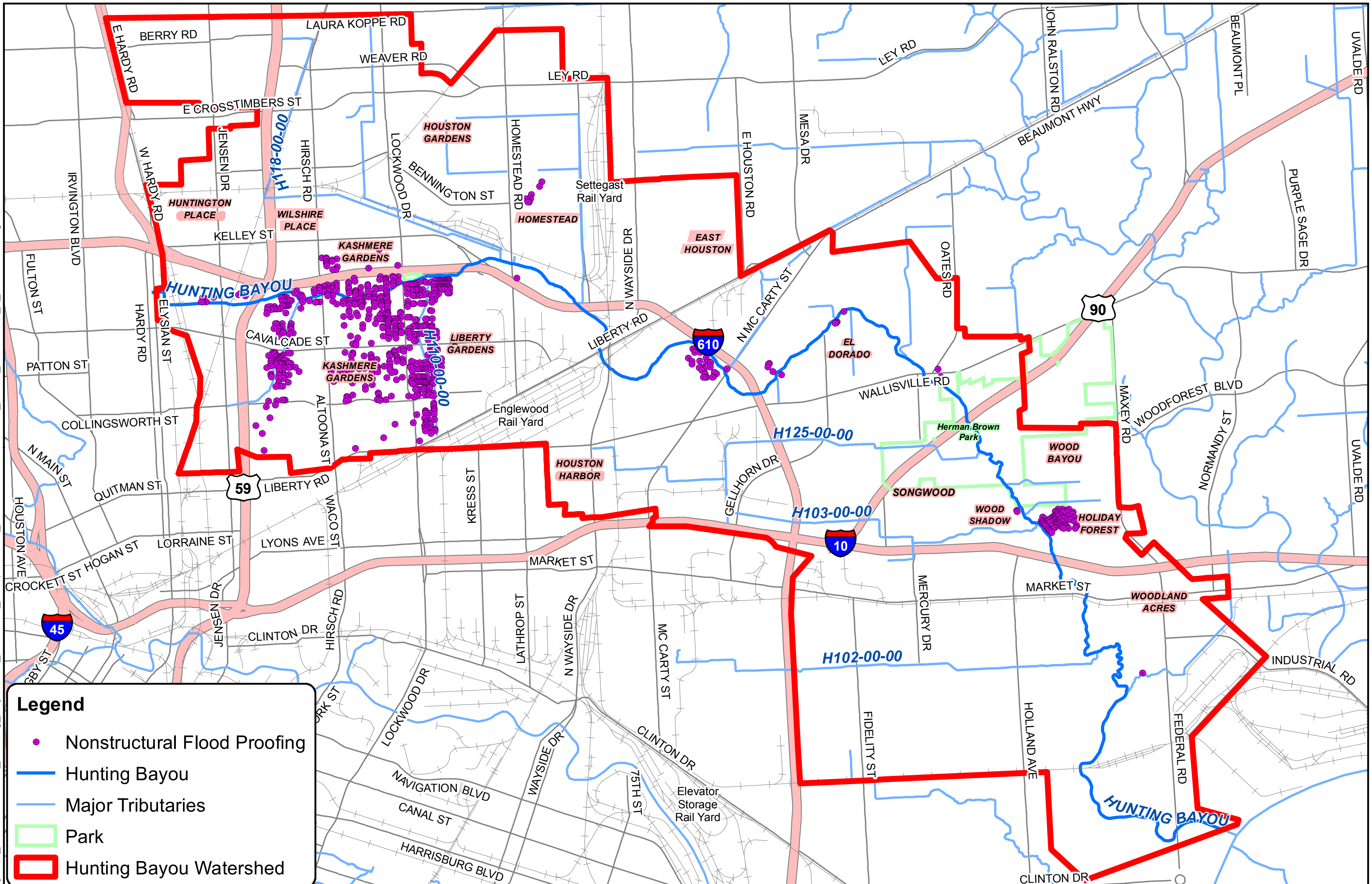

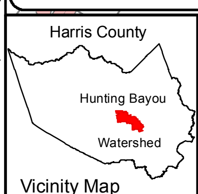

HARRIS COUNTY FLOOD CONTROL DISTRICT

Exhibit A5-19: Alternative 3

Flood Proofing

Hunting Bayou Flood Risk Management Project

Sources:
Hunting Bayou - HCFCD
Park - H-GAC

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Galveston District

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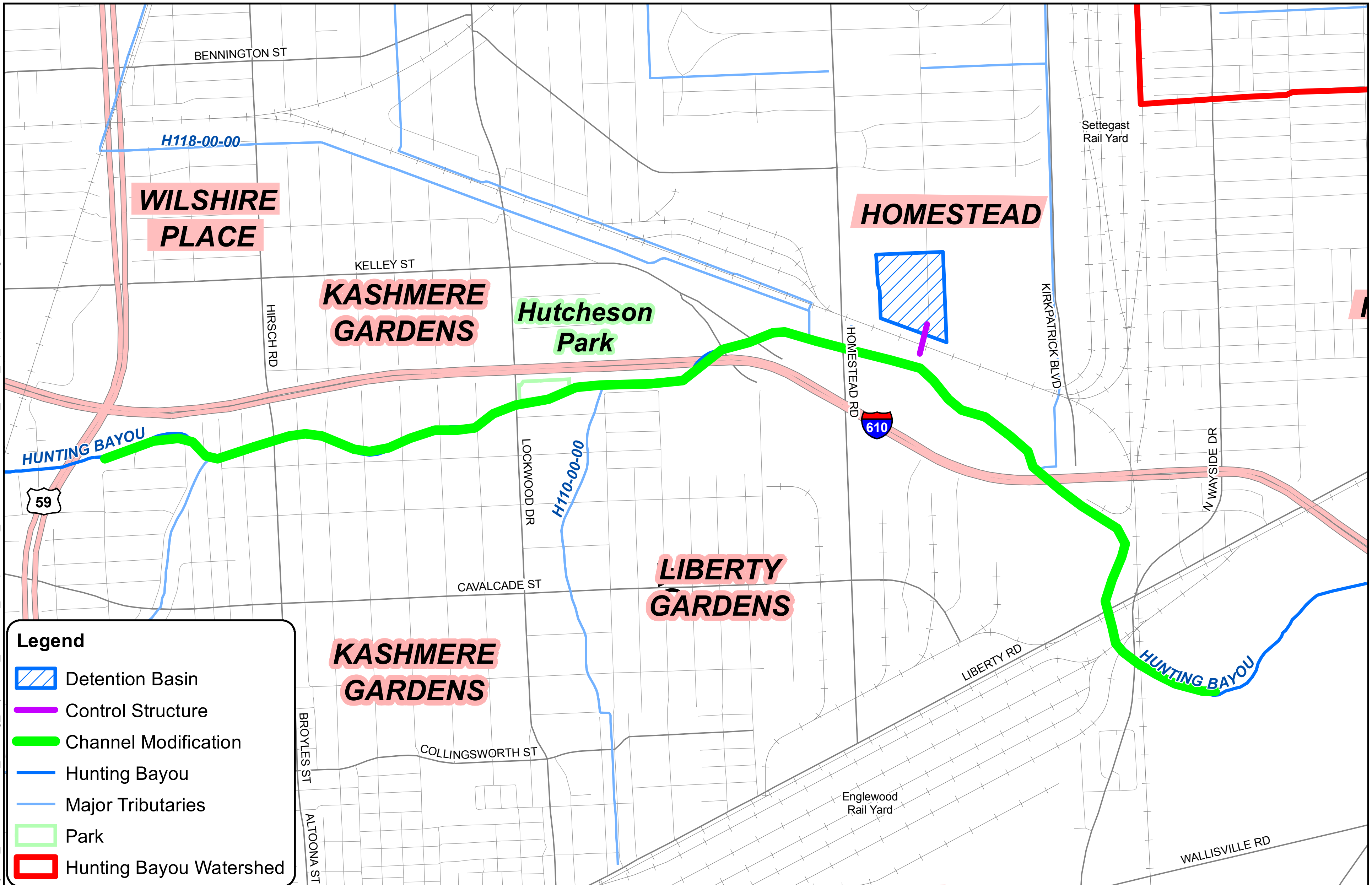

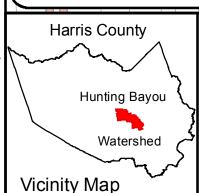

HARRIS COUNTY FLOOD CONTROL DISTRICT

Exhibit A5-20: Alternative 5

B50-A1

Hunting Bayou Flood Risk Management Project

Sources:
Hunting Bayou - HCFCD
Park - H-GAC

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Galveston District

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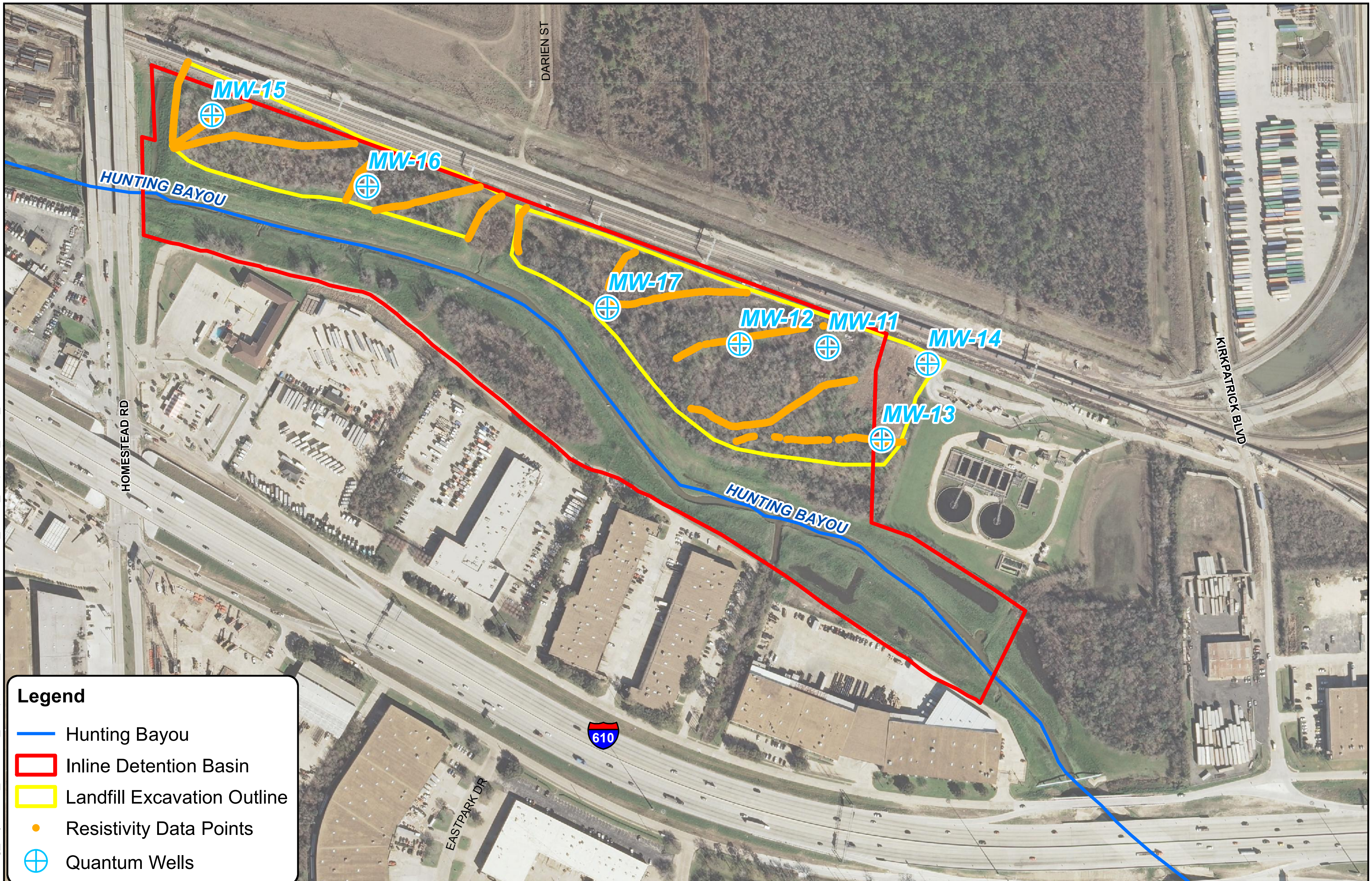

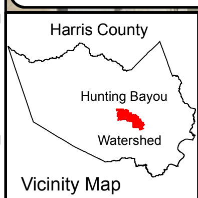

Exhibit A5-21 Proposed Inline Detention **Hunting Bayou Flood Risk Management Project**

Sources:
Hunting Bayou - HCFCD
Aerials - H-GAC (2012)

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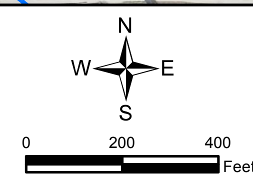
HARRIS COUNTY FLOOD CONTROL DISTRICT



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