HUNTING BAYOU FLOOD RISK MANAGEMENT, HARRIS COUNTY, TEXAS

DRAFT GENERAL REEVALUATION REPORT AND INTEGRATED ENVIRONMENTAL ASSESSMENT

APPENDIX 4
COST ESTIMATES

June 2014

HARRIS COUNTY FLOOD CONTROL DISTRICT

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Acronyms

AEP	Annual Exceedance Probability
ATR	Agency Technical Review
BCE	Baseline Cost Estimate
CAD	Computer Aided Design
COH	City of Houston
CSRA	Cost and Schedule Risk Analysis
CWCCIS	Civil Works Construction Cost Indexing System
CY	Cubic Yard
DI	Ductile Iron
ERRY	Englewood Railroad Yard
GIS	Geographic Information System
gpm	Gallons Per Minute
GRR	General Reevaluation Report
H&H	Hydrology and Hydraulics
HCAD	Harris County Appraisal District
HCFCD	Harris County Flood Control District
HDD	Horizontal Directional Drilling
HDPE	High-Density Polyethylene
HEC-RAS	Hydrologic Engineering Center's River Analysis System
IDC	Interest During Construction
LERRD	Lands, Easements, Rights-of-Way, Relocations and Disposal Areas
LF	Linear Feet
MCACES	Micro-Computer Aided Cost Estimating System, Version 4.1
MCX	Mandatory Center of Expertise
mgd	Million Gallons per Day
MII	MCACES Second Generation, Version 4.1
NED	National Economic Development (Plan)
O&M	Operation and Maintenance
RCP	Reinforced Concrete Pipe
ROW	Rights-of-Way
SF	Square Foot
SY	Square Yard
TPCS	Total Project Cost Summary
TSP	Tentatively Selected Plan
TxDOT	Texas Department of Transportation
UPRR	Union Pacific Railroad
USACE	U.S. Army Corps of Engineers
WSEL	Water Surface Elevation

1.0 COMPONENT COST ESTIMATE CATEGORIES AND ASSUMPTIONS

The unit cost factors used to produce cost estimates for component and alternative formulation engineering analysis were originally derived at a 1999 price level. Many of the unit costs originated from bid and project cost data from past non-federal sponsor, Harris County Flood Control District (HCFCD) projects, tabulated to display high, low and average costs. These costs provided a starting point, where adjustments within the data range were evaluated based on the particular site conditions and study team knowledge and experience with particular similar project items. Where other data was needed or to compare to the non-federal sponsor, HCFCD, data, cost tabulation from other projects or estimated costs were obtained from various public and private entities and analyzed to determine the most appropriate unit or item costs. In this document, the term "component" refers to various flood risk management measures. Components were combined to form alternatives.

In some cases, a consistent unit price point for major cost items, such as excavation and disposal, was determined from the non-federal sponsor, HCFCD, bid tab data for use in all ongoing Section 211(f) studies being conducted by non-federal sponsor, HCFCD. Cost indexing was used to advance these factors for price updates during the latter part of alternative analysis. Cost estimate sheets are provided in *Attachment A4-1* for a selection of the best performing components for each measure type. The following sections discuss the assumptions and present cost factors at their original 1999 price level for the component cost estimates.

1.1 Mobilization

This is a lump sum bid item associated with the initial establishment of contractor's facilities and equipment for starting the project, removing and cleaning up these facilities, equipment and the site at the project's end. The cost was assumed as 3 percent of the construction cost, based on local civil works project experience to allow contractors sufficient job site start-up costs, while keeping up-front costs manageable.

1.2 Earthwork

Excavation and Haul – Excavation and haul costs were calculated for the required earthwork for all component types including channel modification and detention basins. The following discusses the basis for the unit costs and quantities for earthwork.

- The excavation cost was based on the estimated in-place volume to be excavated and a $4.00 per cubic yard (CY) unit cost. The unit cost was determined from non-federal sponsor, HCFCD, historical bid tab data.

- Excavation volumes for channel modification were provided by cut and fill analysis from Hydrologic Engineering Center's River Analysis System (HEC-RAS) software which contained existing and proposed cross sectional data. Volumes for detention components were estimated based on the in-place excavation volume for the detention basin design, calculated through Computer Aided Design (CAD) software. Volumes for new drainage swales and channels needed for levee interiors were calculated by the typical design cross sections and length of drainage swale or channel needed.

- A $1.50/CY-mile unit cost was assumed for hauling and placement at disposal sites. The unit cost was determined from non-federal sponsor, HCFCD, historical bid tab and project cost data.

- The $1.50/CY-mile unit cost expresses haul costs to within a 1-mile radius. At the start of the study, and through most of the alternative evaluation phase, several undeveloped tracts were available for soil disposal very near the component project areas, with most potential disposal tracts within 1 mile. It was initially assumed the 1-mile haul radius implicit in the unit cost would be sufficient given the availability of disposal lands. Therefore, for simplicity, the excavation and disposal haul unit costs were combined into a $5.50/CY excavation and disposal factor and multiplied by the in-place excavation for component cost estimation.

- Disposal land quantities were initially determined assuming a 12.5 percent bulking factor and 8-foot maximum stacking heights for residential-adjacent tracts, and 20-foot for other tracts. After considering allowable placement heights in past municipal projects, this was revised to 12 feet high for all tracts, and assumed a maximum 3 (horizontal):1 (vertical) placement slope ratio.

Clearing and Grubbing – A $1,500 per acre unit cost, based on non-federal sponsor, HCFCD, historical bid tabs and local project costs, was applied to the wooded acreage to be cleared for the construction activity. The area was estimated based on reviewing aerial photography.

Turf Establishment – A $1,500 per acre unit cost based on historical bid tabs and local project costs was used to estimate the cost to establish turf, assuming hydroseeding. This was multiplied by the acreage to be cleared.

1.3 Structures

Back Slope Drainage – Back slope drainage systems consisting of drainage structures, pipe and interceptors were assumed to be needed for erosion protection placed along the channel's length at 1,000-foot intervals. A $3,000 unit cost obtained from non-federal sponsor, HCFCD, historical bid tabulations was used for each drainage system.

Erosion Protection at Tributaries – Tributary laterals to Hunting Bayou were observed to require protection based on existing protection observed in the field and in available non-federal sponsor, HCFCD, record drawings, or based on non-federal sponsor, HCFCD, design criteria for protection at confluences dependent on velocity and intersection angles. Protection methods in accordance with non-federal sponsor's, HCFCD, design criteria were assumed, unless existing protection was more stringent than that required, in which case the existing protection methods were used. The protection methods were either 18-inch riprap at $35 per square yard (SY) based on non-federal sponsor, HCFCD, bid tab data, or 6-inch concrete slope paving at $50/SY, based on analyzing historical bid tabs and were adjusted considering local project experience and project site conditions. The quantities were calculated to conform to non-federal sponsor, HCFCD, design criteria.

Concrete Channel Slope Paving – Based on historical bid tab data, 6-inch thick concrete for lining channels was estimated using a $55/SY unit cost. Quantities were calculated based on the area required for the side slope length plus a 2-foot toe for the proposed concrete section's length, assuming a 2:1 side slope ratio and both banks are paved. Weep holes at $200 each were assumed to be required at a rate of three every 15 feet for each bank in accordance with non-federal sponsor, HCFCD, design criteria.

Paving Removal and Repair – Repairing streets to be cut, removed or impacted by project components was estimated at $60/SY, based on local project bid tabs with quantities determined by either aerial photography review or street length multiplied by standard street widths. The unit cost included base course and asphalt.

Bridges and Paving Approaches – For component formulation cost estimates, upper reach channel modification components all assumed the bridges would be replaced with structures raised 18 inches above the resultant existing conditions with project 1 percent annual exceedance probability (AEP) water surface elevation (WSEL), in accordance with City of Houston (COH) design criteria. Approaches to bridges would be revised with replacements. Also, certain components affected just bridge approaches. The following discusses the basis for the bridge replacement and approach costs.

- Replacement was assumed in lieu of analyzing the need for extension versus replacement for each individual bridge and is conservative with respect to accounting for costs.

- A structural engineer was consulted to help determine appropriate unit cost information for the five different bridge types encountered in the modification reach: pedestrian, city street, freeway mainlane, freeway feeder and railroad.

All-inclusive bridge replacement unit costs ($/square feet [SF]) were obtained from the Texas Department of Transportation's (TxDOT) annual summary of unit costs for various on- and off-system concrete and steel-span bridge types reflecting the study area street and road bridge types. The TxDOT data reflect statewide average project bid costs adjusted as needed using ratios and comparisons between engineers' cost estimates and low bids to compensate for unbalanced bid data. Off-system unit costs were typically used to review unit costs for this study, since most bridges were COH and Harris County bridges. Existing street and road bridge types were typically pre-stressed precast or cast-in-place concrete slab or precast beam bridges. It was assumed the number of spans, and therefore in-stream piers, would be minimized for hydraulic efficiency. A practical 130-foot breakpoint for requiring steel-design bridges was set for bridge lengths longer than this breakpoint. A $40/SF unit cost was used for bridges equal to or less than 130 feet in length, and $95/SF for those longer than 130 feet. Based on similar local railroad project data, a $4,000/LF unit cost which includes structure and track was determined for railroad bridges.

- Bridge replacement lengths were generally determined by the existing top width plus the change in top width resulting from the proposed channel modification.

- General approach lengths for bridge replacements ranging from 75 feet to 200 feet were assigned based on the bridge type (pedestrian bridges excluded), with longer lengths assigned for larger road types. These lengths were anticipated to cover the majority of actual lengths required based on previous study component analysis for bridge replacement-only measures. Overall, this assumption was deemed to be conservative with respect to accounting for costs.

- For existing approaches not involved in bridge replacements, existing quantities were assumed to be replaced in kind.

- Paving approaches were estimated using unit costs that varied from $55/SY for pedestrian bridges to $70/SY for city streets, based on local project experience.

Using conservative cost assumptions for bridges affect only upper reach channel modification components, and do not change the fact these upper reach components are the best net performing components. If more specific analysis would result in lower costs, this would only serve to increase the net benefit on the set of components which already achieve the highest net benefits.

Culverts and Pipes – Various culvert and pipe sizes were identified as part of diversion structures to detention basins, for connecting multiple basins, or for connecting or providing outfall for other flood damage reduction features such as bypasses and levee interiors to existing channels or drainage networks. The type and size for connecting or diversion (or inlet/outlet) structures used for a given component was determined by the hydrology and hydraulics (H&H) analysis. The following describes the basis for costs to install new culvert and pipe for these features.

- Reinforced Concrete Box Culverts – These were estimated using unit costs based on analyzing historical bid tabs and non-federal sponsor, HCFCD, project cost data. The unit costs ranged from $180/linear feet (LF) to $850/LF for sizes from 4-foot by 4-foot to 15-foot by 15-foot, and were adjusted in consideration of economies of scale for larger quantities required for a given component. These costs assumed open cut and were adjusted higher if installation via tunneling was required.

- Reinforced Concrete Pipe (RCP) – These were estimated using unit costs and lump sum costs based on analyzing historical bid tabs and non-federal sponsor, HCFCD, project cost data. Connecting RCP unit costs ranged from $50/LF to $175/LF for diameter sizes from 24 inches to 96 inches. RCP outfall structure unit costs ranged from $350/LF to $480/LF for 60-inch and 72-inch diameter sizes, respectively. A 72-inch outfall structure with a flap gate was estimated with a $125,000 lump sum.

Quantities were determined via CAD or within a Geographic Information System (GIS) to provide the required lengths to connect features to each other, the channel or existing drainage networks.

Detention Basin Control Structures – The type and size for detention basin control and outlet structures used for a given component was determined by the H&H analysis. These structures were one of the following types (or combinations thereof), with the cost estimate basis explained.

- Diversion Structure, Concrete Weir – This was calculated using the previously discussed $55/SY unit cost assumed for 6-inch channel slope paving for varying length side weirs, or a $45/CY unit cost for structures assuming 40-foot long x 30-foot wide x 2.5-foot deep dimension based on local project cost data and experience.

- Diversion Structures – Various sizes and configurations for other diversion structure types were estimated based on the following lump sum costs: $50,000 each and $75,000 each based on local project cost data and experience.

- Drop Structures – Various drop structure sizes and configurations were estimated based on the following lump sum costs: 4-foot drop assuming 20-foot bottom width, 3:1 side slopes, 5-foot high, 2-foot thick at $10,000 each, 60 CY drop structures at $50,000 each and 7-foot drop structure at $125,000 each. The lump sum costs were based on local project cost data and experience.

- Flow reduction structure – $15,000 each based on historical local project bid tabs and experience.

- Drop structure riprap – 24-inch at $45/SY based on historical local project bid tabs and experience.

For weir structures based on unit costs, quantities were based on weir dimensions determined by the H&H analysis. For structures determined on lump sum or single item costs, the number and size were determined by the H&H analysis.

Concrete Low Flow Channel – A concrete low flow (pilot) channel was examined as part of earlier versions of detention facilities for draining the basins and was estimated using the same $55/SY unit cost for 6-inch thick concrete slope paving. Components were subsequently revised to not include paving in low-flow channels.

Levee Infrastructure – Various levee component features were estimated using the unit costs discussed elsewhere in this section such as excavation for interior detention basins, and pipes, culverts and outfall structures for drainage facilities. The following discusses the basis for cost estimates for levee-specific features.

- Levee Walls – The unit cost for fill including material, placement, compaction and rolling to build levee walls was $7/CY, based on non-federal sponsor, HCFCD, historical bid tab and project cost data for fill, spreading and compaction. Quantities were calculated based on a cross sectional geometry defined by levee height (target elevation minus existing ground elevation), 3:1 side slopes and 12-foot wide levee top width for the levee alignment's planned length.

- Pump Stations – Pump facilities were estimated for enhanced interior drainage to determine optimal levee configurations. These involved various capacity pumps and the accompanying facilities (housing, power, etc.), providing total capacities between 20,000 gallons per minute (gpm) and 111,300 gpm. The estimates were calculated assuming firm capacity would be provided, with required capacity typically defined by the 50 percent exceedance probability peak discharge for interior drainage areas. The capacity was determined by the H&H analysis and is discussed in more detail in *Appendix 2 – Hydrology and Hydraulics*' discussion about levee modeling. The pump costs were estimated using lump sum costs based on local waterworks design, project cost data and experience, and were the following.

  - Pumps: 5,000 gpm pumps estimated at $25,000 each, 25,000 gpm and 28,000 gpm estimated at $80,000 each

  - Structural Work: For housing, foundation, etc. Varied between a $52,000 and $180,000 lump sum depending on total pump capacity

  - Architectural Work: For architectural design and detail. Varied between a $30,000 and $80,000 lump sum depending on total pump capacity

  - Mechanical Work: For piping, mounting, manifolds etc. Varied between a $70,000 and $225,000 lump sum depending on total pump capacity

  - Electrical Work: For power, controls, and lighting. Varied between a $40,000 and $140,000 lump sum depending on total pump capacity

- Civil Work: For site work and drainage. Varied between a $15,000 and $35,000 lump sum depending on total pump capacity

1.4 General Items

A comprehensive list with normally required cost items for civil works projects was estimated for component cost estimates.

Traffic Control – A lump sum item for controlling traffic in and out of construction site during construction including signage and barricades was calculated at approximately 4 percent of bridge and culvert construction costs. Since most of the work will be along the channel, a minimal amount of traffic control is expected. A cost for a dedicated flag person was calculated at $1,400 per day and is assumed to be needed each working day.

Construction Fencing – Construction fencing costs were calculated using $5/LF unit costs based on historical bid tabs and cost estimate information from local projects, with 1,000 feet of fencing assumed to be a suitable enclosure for a temporary job site holding equipment and field office.

Trash Removal and Disposal – This item is for removing trash within the channel and properly disposing those trash items. Trash typically found in the bayou includes furniture, tires, appliances, dead animals and other goods. This item does not include hazardous material items. The quantity was calculated assuming a trash generation rate of 2/3 of a cubic yard per foot of channel length and a $20/CY unit cost based on historical bid tabs and cost estimate information from local projects.

Channel Linings Removal and Disposal – This item accounts for removing any existing channel concrete paving and was calculated using a $35/SY unit cost based on reviewing non-federal sponsor, HCFCD, and local historical bid tab and project cost data.

Site Preparation and Restoration, Including Facility for Engineers – This item is for preparing the site for temporary facilities (field office, etc.), renting those facilities, and for returning the site to its original condition after construction. A lump sum varying between $50,000 and $70,000 was assumed based on analyzing historical bid tab data and local project experience.

Care and Control of Water – This item accounts for site surface and groundwater management (dewatering, drainage, etc.) to ensure constructability and was estimated based on local experience with ditch and stormwater basin public works projects. This item accounts for protecting channels from flooding during channel modification construction including channel bypasses, temporary dam, dewatering, depressurizing, draining, and maintaining trenches. A $75,000 per work site lump sum was used based on analyzing historical bid tab data and local project experience. This cost was later refined in the final alternative analysis involving phased construction to a lump sum of $75,000 per channel modification work site, and $15,000 per detention work site based on detention sites having less exposure to perennial channel flows during construction and smaller areas involving these issues.

Trench Shoring System – This item is for designing and installing trench safety system for channel construction and for the utility removal and/or replacement. A $4.50/LF unit cost was used based on local and non-federal sponsor, HCFCD, historical bid tabs. The quantity was determined from the total linear feet of storm sewer and utility relocations required.

Stormwater Pollution Prevention Measures – Costs for several items to implement required construction for stormwater pollution prevention were estimated and are as follows.

- Standard and Reinforced Filter Fabric Fence – A $3/LF unit cost for filter fabric fence was applied to 75 percent of the channel length being modified plus 1,000 extra feet. Reinforced filter fabric fence at $4.50/LF was applied to the other 25 percent of the channel length being modified plus 500 extra feet, based on the estimated prevalence of channelized flow areas encountered in the project reach and to comply with COH stormwater pollution prevention standard general requirements. Both unit costs were based on analyzing historical non-federal sponsor, HCFCD, bid tabs and local project experience.

- Stabilized Construction Exit – Based on analyzing historical non-federal sponsor, HCFCD, bid tabs and local project experience, a $15/SY unit cost was used to calculate costs for each exit assuming 150 SY per exit. For component formulation, it was assumed an average of four such exits would be needed. This was later refined for alternative analysis involving phased construction to an average of two exits for each channel modification project work site and one exit for detention basins.

1.5 Vegetation Recovery

Vegetation recovery includes planting trees and shrubs, which were anticipated to provide limited landscaping to replace vegetation destroyed by construction at detention sites, along channel modifications and bypass channels, and at disposal sites. Unit costs were based on non-federal sponsor, HCFCD, historical bid tabs. Tree planting was computed assuming one tree was planted on each bank every 50 LF for the length of channel modification at a $120 per tree cost. This cost is commensurate with sizes in the range of 10- to 25-gallon bucketed trees. Shrubs were assumed to be planted at a rate of two shrubs on each bank every 50 LF at a $25 per shrub cost.

1.6 Utility Modification

Existing information concerning the location, type and size for utilities in the proposed construction area was obtained from the known utility providers in the area including COH, Houston Lighting & Power (now Reliant Energy), Entex, Southwestern Bell, cable TV companies, and oil and gas pipeline companies. Available non-federal sponsor, HCFCD, record drawings were also used to supplement this information. The utility information was mapped within GIS to determine the utilities affected by the proposed project or specific component. Estimates were developed for removing, re-routing and other associated costs. The following describe the basis for cost items under the Utility Modification category.

Storm Sewer Outfall – Modifications to existing storm sewer outfalls were needed for those outfalls located within the area of proposed channel modifications. Unit costs for the different construction elements involved in outfall replacement were developed using average cost data from then-recent non-federal sponsor, HCFCD, construction projects and are explained as follows.

- A unit cost table variable by pipe diameter from 18 inches to 120 inches was developed for the following elements: removal and disposal ($15/LF to $30/LF), new pipe required ($25/LF to $210/LF) assuming corrugated metal pipe, timber bent support ($1,885 to $2,500 each) as needed dictated by pipe diameter in accordance with non-federal sponsor, HCFCD, design criteria, and band couplers to join new pipe to existing line ($16 to $34 each).

- Pipe quantities were calculated using lookup tables to define lengths to satisfy non-federal sponsor, HCFCD, design criteria to align with and empty at a 30º angle with the main channel, and to outfall 1 foot above the modified channel's anticipated normal water depth, provided by the hydraulic models. These lengths were calculated to clear proposed channel top of bank widths assuming a 3:1 side slope ratio, plus 35 feet to clear the 30-foot maintenance berm right-of-way (ROW) requirement to join to the storm sewer network, in accordance with non-federal sponsor, HCFCD, design criteria.

- Riprap was calculated as needed, dictated by location in a grass-line channel section in accordance with non-federal sponsor, HCFCD, design criteria. Riprap costs were developed using a $35/SF unit cost. Riprap quantities were calculated using lookup tables to define quantities in accordance with non-federal sponsor, HCFCD, design criteria as follows. Riprap lengths were calculated based on revised channel cross sectional bottom widths plus 12 feet to clear 1 foot above the anticipated revised normal water depth on both sides of the channel. Riprap widths were calculated depending on pipe diameter.

- To simplify spreadsheet implementation and calculation duplication, an aggregated unit cost for each relocation was derived by multiplying material cost by the required linear footage, then adding timber bent, band couplers and riprap cost single item costs, then dividing the total by the linear footage required. Hence the unit cost slightly differs for a 24-inch 110 linear footage pipe compared to a 24-inch 130 linear footage pipe.

Water Lines – Costs were estimated for removing and replacing existing water lines, most of which were crossings located on bridges to be removed/replaced or separate crossings over the bayou where channel modifications were proposed. The following explains developing the costs for the different construction elements involved in water line replacement:

- Water line above-ground crossings were assumed to be replaced with similar crossings. Similarly, underground pipe crossings were assumed to be similarly replaced.

- Local bid tabs for water line replacement work were used to tabulate costs for pipe sizes ranging from 2 inches to 84 inches for the following unit and single item cost elements. Unit costs for pipe construction (material included) ranged from $29/LF to $950/LF. For each relocation, the single item costs were wet connections which ranged from $350 to $15,000, cutting and plugging and/or abandonment ranged from $230 to $10,000, and air and vacuum release valves ranged from $2,200 to $25,000. Pier costs ranged from $10,000 to $25,000 each. Hangers used for on-bridge crossings ranged from $60 to $500 each and were assumed applicable for 2-inch to 12-inch lines. For convenience of calculation, the individual unit and single item costs were aggregated into a single unit cost applied for each relocation, so the total pipe quantity needed times the aggregated unit cost produces the correct total cost. Therefore, the aggregated unit cost varies from relocation to relocation, as the number of single item costs (i.e., piers or hangers) reflected in the unit cost, varies.

- Pipe length quantities were calculated depending on replacement as above or underground crossing, with lengths determined based on each channel modification component's cross sectional geometry. Aboveground lengths were determined to clear revised top of bank widths plus allowance for length into the side slope. Maximum allowable spans depending on pipe size were part of the tabulated data and were used to calculate numbers of piers or hangers needed to traverse the top of bank width. Underground lengths were determined to transition to below the revised channel invert, plus 4 to 5 feet of cover. For relocations not involving channel crossings, such as for detention basins, the length was generally determined by replacement along the same existing alignment, but accounting for length to relocate the facility below the basin bottom if practicable. If the required depth was deemed too deep, then length was calculated to reroute the facility around the basin along the shortest practical route. All connections were assumed to be done via wet connection.

- Similar to storm sewers, a unit cost specific to the relocation was calculated to simplify spreadsheet implementation and calculation duplication, by multiplying material unit cost by the required linear footage of pipe, adding the relevant single item costs, then dividing with the total by linear footage obtain an aggregated unit cost. This allowed mass automated duplication of cost calculation formulas and maintained the cost assumptions integrity. This explains the slight difference in unit costs observed in cost spreadsheets between two pipes of the same size (diameter), but different lengths.

Sanitary Sewer Lines – Sanitary sewer lines encountered in the study area are either gravity relief sewer collector lines or force mains, with most required relocations crossing the bayou above or below ground. Unit costs for the different construction elements involved in sewer replacement were developed using local project bid tab data and are explained as follows.

- A unit cost table variable by pipe diameter was developed to tabulate costs for the following: gravity relief sewer lines from 4 inch to 84 inch at $30/LF to $402/LF, force mains from 4 inch to 42 inch at $57/LF to $384/LF, and siphon structures from 4 inch to 48 inch from $5,650 to $6,600 each. Pier costs for pipe sizes from 4 inch to 36 inch ranged from $10,000 to $20,000 each. Hanger costs (for crossings on bridges), deemed applicable for pipe sizes from 4-inch to 12-inch ranged from $148 to $500 each. The maximum allowable span length for aboveground pipes was also tabulated for the pipe sizes.

- Gravity relief sewer crossings were assumed to be replaced with gravity relief sanitary sewer crossings. It was confirmed with the COH (owner of sanitary sewers) that siphons should be avoided whenever possible.

- Existing siphons would be replaced in kind with costs calculated using the unit cost for each siphon pipe size times the required crossing length plus the siphon structure item cost.

- Existing force mains on bridges would be replaced in kind. Costs were determined by the required pipe size unit cost times the required aboveground crossing length, plus hanger numbers and costs determined by the required crossing length and maximum allowable span for the given pipe size.

- Costs for existing aboveground force main crossings were calculated similarly to the above bullet, but pier costs were calculated instead of hangers.

- Similar to waterlines, for calculation convenience, the individual unit and single item cost elements were aggregated into a single unit cost for each relocation.

Pipe quantities for required crossing lengths came from tables developed for different components containing calculated lengths at each major channel cross section station for under and aboveground pipe crossings based on the proposed cross sections, which vary by component. Pipe quantities for detention basins or other relocations not related to channel crossings were determined in CAD or GIS to either follow the same existing alignments but transition to depths below proposed basin bottoms, or if impractical, reroute the alignment around the basin.

Sanitary Sewer Lift Stations – Some gravity sewer line relocations necessitated sewer lift stations to restore the needed hydraulic head to maintain proper function. A 2 million gallons per day (mgd) lift station was estimated with a $75,000 lump sum cost based on local sewer system design, project cost data and experience. Higher capacities of 5 mgd at $187,500 and 30 mgd at $550,000 were estimated based on the 2 mgd cost, increasing costs commensurate with increase in capacity and when considering economy of scale.

Private Utilities – Private utilities including gas, crude and refined product pipelines and communication lines (telephone, cable, data, etc.) were assumed to be replaced with facilities below the channel invert via horizontal directional drilling (HDD). This was chosen based on conversations with a number of pipeline companies who cited this as a preferred method due to the ease of construction and it is most likely to be chosen by contractors. In addition, HDD allows pipe bundling where two or more pipes can be pulled through one drilled hole saving the crossing costs. Local experience also indicates pipeline companies prefer replacing aboveground crossings with underground facilities because it removes the greater and more frequent inspection burden associated with exposed facilities. Costs for these relocations were determined as follows.

Unit costs were obtained from either consulting with a number of pipeline companies or from a 1994 Port of Houston Authority report to define costs for pipe sizes ranging from 2 inches to 40 inches. The 1994 report, *Pipeline Inventory and Relocation Cost Estimate*, supported the Houston Ship Channel Modernization Project and examined pipeline relocation costs using HDD. These costs were inflated to a 1999 price level. Information from pipeline companies who provided costs to remove and replace their pipelines, such as Arco, Chevron and Entex, was used to adjust the construction costs for other companies whose pipeline replacement costs were not available. The following explains the range of costs and assumptions for the various HDD utility relocation elements.

- Drilling mobilization/demobilization ranged from $11,700 to $23,300 per relocation, assuming four jobs geographically close to one another due to the large number of relocations required.

- Pipe material ranged from $6.58/LF to $113.17/LF, delivered to job site, all assumed to be steel. Sizes 24 inches or less assumed to be seamless 1/2-inch thick, sizes >24 inches assumed to be double submerged arc welded steel pipe 1/2-inch thick. All pipes are assumed to be fusion bonded epoxy coated.

- Drilling and pullback ranged from $130/LF to $330/LF including drilling, reaming and pulling assembled pipe(s) through drilled hole, and use and disposal for all cutting and drilling fluids.

- Pipe assembly and handling ranged from $7.90/LF to $52.60/LF including welding, x-raying welds, coating at joints and hydrostatic testing.

- Existing pipeline removal mobilization/demobilization ranged from $14,700 to $19,700 per relocation.

- Existing pipeline removal and disposal ranged from $101/LF to $342/LF.

- Purging and inserting lines including removed product disposal ranged from $9,000 to $27,000 per relocation.

- Engineering and administrative costs associated with each relocation include surveying, geotechnical investigation, permits, easements, staging areas costs, etc. Information received from companies was widely variable, so an average cost from past local projects was used.

- Similar to water and sewer lines, for calculation convenience, the individual unit and single item cost elements were aggregated into a single unit cost for each relocation.

Required replacement pipe lengths were calculated similar to water and sewer underground relocations, which vary by component according to their cross sectional geometry of the proposed channel. Pipe quantities for detention basins were determined in CAD or GIS to either follow the same existing alignments but transition to depths below proposed basin bottoms, or if impractical, reroute the alignment around the basin.

1.7 Engineering and Design

The Engineering and Design cost is anticipated to cover the engineering design and associated surveys required. This cost was estimated based on COH engineering fee curves for the anticipated alternative project cost magnitude, which was 5 percent of the total construction costs, excluding real estate costs.

Results from the previous value engineering study for the similar Brays Bayou project and the input received from the U.S. Army Corps of Engineers (USACE) Galveston District concerning developing alternatives and engineering methods have been considered in the engineering planning.

1.8 Construction Management

This item was not estimated during component cost estimation, but was added in later alternative analysis stages.

1.9 Real Estate

Real estate costs for Lands, Easements, Rights-of-Way, Relocations and Disposal (LERRD) were determined from the real estate cost analysis for component and alternative formulation analysis discussed in *Appendix 5 – Economic Analysis* and *Appendix 6 – Real Estate Plan*. For component analysis and plan formulation, the cost for real estate including lands and improvements (structures) was based on assessed values from the Harris County Appraisal Data (HCAD) database, adjusted for residential properties (the predominant acquisition) to an estimated fair market value with a global factor determined from real estate sales data for the study area. Fair market value adjustment was done to reduce the variation HCAD appraised land values derived from computer and mass appraisal valuation would have from values indicated by sales data. In isolated cases where values were not appraised for vacant lands, a value per square foot derived from similar nearby vacant land within the same category (residential, commercial, etc.) was used.

The ROW requirements were determined geospatially from component geometry which included the required maintenance berm buffers according to non-federal sponsor, HCFCD, criteria, typically 30-foot width on both sides along channel modifications and proposed detention basin or levee perimeters, and 20-foot and 10-foot widths for concrete lined channels. Aerial imagery was used to analyze the required full and partial real estate parcel acquisitions associated with each channel component. Acquisition costs for each real estate parcel displacing a structure or business also included relocation costs according to the displacement category (residential, commercial, etc.) and administrative costs consisting of appraisal, survey and closing costs. A 15 percent contingency was added to the total acquisition cost. The assumed administrative and relocation costs are detailed in *Appendix 5 – Economic Analysis* under methods for nonstructural buyouts, as the costs to implement these measures are the same as acquiring properties with occupied structures.

1.10 Environmental Mitigation

Hunting Bayou is a rectified, grass-lined channel with little natural geomorphology. Other than Herman Brown Park, a city park with forested and bottomland preserve acreage, Hunting Bayou is in a highly urbanized setting with no wildlife management areas and undeveloped acreage limited to isolated, typically lower quality tracts. Therefore, the predominant foreseeable mitigation costs are associated with wetlands.

Wetland mitigation costs were not analyzed during component formulation or initial alternatives analysis. However, mitigation for existing wetlands does not provide a cost differentiator for the best performing components, which were all upper reach channel modifications. This is because virtually all the existing wetlands within the upper channel modification reach are in the inline detention basin feature common to all upper reach channel modification components analyzed during component formulation. Of all other upper reach detention components, only the Component A offline basin had wetlands identified. However, these and the inline detention wetlands are very small (any individual wetland less is than 1 acre), highly fragmented, mostly ephemeral wetlands and typically low to medium quality. The disposal sites identified to accommodate upper and mid reach component excavation fill also have very small, highly fragmented, mostly ephemeral wetlands, typically low to medium quality.

Subsequent habitat model-based mitigation planning conducted in 2009 included onsite mitigation cost estimates using mitigation and monitoring unit costs from more recent non-federal sponsor, HCFCD, historical cost data from various mitigation projects. This mitigation planning estimated one-for-one habitat unit mitigation costs for the recommended project impacts, which include the inline and offline detention wetlands, to be in the $61,000 range for total cost, and $65,000 (FY09) if disposal site impacts are included. Annualized over 50 years at the USACE discount rate used for most of the plan formulation phase (4.625 percent), these costs are about $3,400 annually or less than 0.1 percent of the net annual benefits for any upper reach component. Considering both National Economic Development (NED) Plan scales, the Tentatively Selected Plan (TSP) and B50-A25, will not include the inline detention basin as discussed in the Draft *General Reevaluation Report (GRR) and Integrated Environmental Assessment* and *Appendix 5 – Economic Analysis*, the impacts and the cost differences would be even smaller. Therefore, these mitigation costs would not provide any significant cost differentiation so as to affect plan selection.

Potentially larger and somewhat higher quality wetlands are in undeveloped tracts in the more downstream reaches including Herman Brown Park and the most downstream undeveloped sections.

Some of these areas also contain some bottomland hardwood acreage for which USACE planning regulations would require mitigation. Therefore, mitigation costs would be expected to be higher for components located in these areas. However, all middle and lower reach components have provided significantly less net benefits than upper reach components (<10 percent of upper reach net annual benefits), even without accounting for mitigation costs. Including mitigation costs would only worsen their performance and not alter plan selection. Therefore, these wetland mitigation costs are not estimated and would not aid plan formulation analysis.

During the last stage of plan refinement, top-performing alternatives with a closer range of net annual benefits were identified, and mitigation costs were analyzed using the 2008-2009 mitigation planning analysis and costs. Cost basis for these is discussed in Section 3.0.

1.11 Contingencies

Contingencies were added to total project costs and calculated as 15 percent of the total for construction costs, mobilization/demobilization, engineering design and LERRDs.

2.0 ALTERNATIVE COST ESTIMATION

Alternative cost estimation was performed combining the cost estimates for the components comprising the alternative. For use during the alternative formulation phase, the component cost estimates were indexed from their 1999 price level to 2001 using the Engineering News Record's 20-city average indices for those years to produce a 4.67 percent inflation factor, which is comparable but more conservative than the 3.86 percent factor derived from the USACE Civil Works Construction Cost Indexing System (CWCCIS) for the category reflecting most of the alternatives, Channels and Canals.

The total alternative construction cost was calculated by adding the total project costs for the components constituting the alternative, calculating Interest During Construction (IDC), and adding both together to provide a total project investment cost. The IDC was calculated by using the following equations.

(1) $$I_{Total} = \sum_{a=0}^{n-1} \left(\frac{C_{Total}}{n} \right) \left(1 + \frac{i}{100} \right)^{n-(a+0.5)}$$

(2) $$IDC = I_{Total} - C_{Total}$$

Where:

IDC	=	Interest During Construction (dollars)
I_{Total}	=	Total Project Investment (dollars)
C_{Total}	=	Total Construction Cost (dollars)
n	=	Duration of Construction (years)
i	=	Interest rate (percent)

The construction duration was estimated by consulting with local contractors for estimating timeframes needed to execute the major construction items for the typical component types being considered. The benchmark for major construction items in terms of duration were utility relocations, bridge replacements and excavation disposal.

Durations for benchmark alternatives (e.g., upstream channel modification plus detention and bridge replacements) were used to scale durations other alternatives would require based on channel modification length, excavation quantities and considering multiple component combinations. The estimated construction durations ranged from 2 years for channel widening through a comparatively short reach, to 7 years typical for upstream channel modification with offline detention, to a 12-year maximum for channelizing Hunting Bayou's full length. *Attachment A4-2* has cost estimate sheets for a selection of the best performing alternatives for each alternative type as the first sub-attachment, and the estimates for the final array of alternatives of the alternative evaluation phase, discussed in Section 4.0 of the GRR Main Report, as the second sub-attachment.

3.0 PLAN REFINEMENT COST ESTIMATE

During the alternative formulation and evaluation phase, the upstream channel modification plus detention alternatives were determined to be the best-performing alternatives. This indicated the basic plan for upstream channel modification plus offline detention would be the basis for identifying the TSP. In the final planning phase, the combination of upstream channel modification plus offline detention was analyzed in more detail to refine the sizes for channel and detention components and determine the most net-beneficial combination. Because the channel size and offline detention increments would be finer than in the previous planning step, costs estimates were also refined. Most of the basic methods used to estimate quantities in the component cost and alternative cost estimate were reused for the plan refinement cost estimate, but updated or refined with newer available data.

The unit costs for most construction items were updated to a 2009 price level, primarily using costs sourced from the Micro-Computer Aided Cost Engineering System, Version 4.1 (MCACES), Second Generation (MII). In general, the MII-generated unit costs were developed using most MII cost estimate elements (labor, equipment, etc.) and supplementing material prices with current, locally obtained quotes for pipe materials. The unit cost update for some items was also supplemented with more current local bid tab-based data. For a few items where costs were not available from MII or current bid tabs, previous unit costs or older bid tab-based unit costs were indexed using the appropriate USACE CWCCIS indices. The costs for most of these items were calculated at the component level. *Attachment A4-3* has the updated component cost estimate sheets. The following subsections described the plan refinement cost estimate in more detail.

3.1 Mobilization

The same assumptions used in the component cost estimate were reused.

3.2 Earthwork

Excavation – Excavation costs were calculated for the required earthwork for channel modification and detention basins. The following discusses the basis for the unit costs and quantities for excavation:

- The excavation cost was based on a MII derived $3.35/bank cubic yards unit cost.
- Quantity – Channel excavation quantities were obtained in the same manner as component cost estimates using AutoCAD and channel HEC-RAS models to determine the excavation amount for each channel component. For detention components, the grading plan was analyzed in conjunction with existing LiDAR topographical data to determine a cut volume. The excavation amount was calculated as the situ volume (i.e., bank cubic yards) with no swelling or compaction assumed.

Excavation Haul and Disposal – The haul and disposal land required were analyzed for each alternative's total excavated volume. As discussed in *Appendix 3 – Engineering Analysis*, the non-federal sponsor, HCFCD, intends to dispose as much excavated soil as possible through reuse in other local projects such as roadway improvements. However, as a planning contingency, disposal sites were identified for the plan refinement cost estimate. The potential disposal sites were updated considering current availability determined through updated aerials, site visits and property tax records. The following discusses the basis for the unit costs and quantities for hauling and disposing excavated soils.

- The alternatives were assumed to be implemented through five contracts constructing the offline detention basin first in one contract, followed by the channel from downstream to upstream in four segments corresponding to each contract.

- Five sites were identified for use. The order in which the sites were used was determined by proximity to the construction site. On one site adjacent to the detention basin, the Union Pacific Railroad (UPRR) is expanding its intermodal rail yard and using a fixed volume of offline detention basin excavation as fill for this expansion. Therefore disposal site acquisition costs only reflect purchasing the other four sites identified for analysis.

- The total volume provided at each disposal site was determined by calculating the disposal volume and placement area required assuming a 12-feet high pile with 3(Horizontal):1(Vertical) side slopes and a 30-feet wide access/maintenance buffer on the perimeter.

- The haul volume was calculated from excavation volumes using a 30 percent swell factor. The volume requiring placement was calculated by multiplying the haul volume by 0.9 to assumed 90 percent compaction at the disposal site. In keeping with non-federal sponsor's, HCFCD, intent to reuse soils for local projects, it was assumed 20 percent of the total volume would be sold or given away rather than placed at disposal sites. This quantity was subtracted from the amount calculated for haul and disposal.

- Disposal site use was calculated by subtracting the calculated disposal volumes for each component from the available volume at each disposal site, using the identified sites sequentially according to distance until the required placement volume was satisfied. This was used to determine which sites were used and how much of each site was used.

- The percent usage for each disposal site was then applied to the total site acreage to calculate disposal site acquisition costs in a similar fashion to that described for real estate, using HCAD 2009 data and market value adjustment factors for commercial vacant land.

- Haul mileage was determined using the Google Earth aerial imagery and measurement tool to get an average over-street distance from the project's upstream/downstream end to each disposal site. A volume-weighted haul distance was then calculated for each alternative by using the volumes and average distances for each contract.

- The haul unit cost was calculated using the various MII-derived unit costs ranging from \$2.37/CY to \$6.80/CY provided for 1-, 2-, 3- and 10-mile trips, and interpolating a specific haul unit cost within this range for each alternative using the haul volume-weighted average distance computed above. A \$3.94/CY loading and disposal (i.e., handling) cost was isolated from an MII-derived unit cost for excavation, loading, hauling and disposal and added to the haul cost to provide a total haul and disposal unit cost for each alternative. Directly loading excavated material into haul trucks was assumed in this unit cost.

- Costs were determined by multiplying the haul and disposal unit costs by the haul volumes.

Clearing and Grubbing – A $7,500/acre unit cost from the White Oak Bayou GRR was applied to the wooded acreage to be cleared, estimated based on aerial photography review. Area to be cleared for channels was based on area quantities derived by taking the difference between the existing and proposed channel ROW.

Turf Establishment – A $3,157/acre MII-derived unit cost assuming hydroseeding was used for turf establishment costs. Quantities were calculated using the total acreage needed to be cleared and grubbed plus the total standard 30-foot wide maintenance berm area along the channel length.

3.3 Structures

Back Slope Drainage – For the channel components, back slope drainage swale quantities were determined for the length of both channel sides minus the small segment where concrete lining would be replaced through Englewood Railroad Yard (ERRY). Back slope drain pipe and structure numbers were determined as before, but using the more current local criteria of a drainage structure every 600 feet. For the detention components, the quantity for the swale was determined by the basin's perimeter. The quantity for the back slope drain pipe and structure was also calculated using the newer criteria for a drainage structure every 600 feet. The unit cost for the back slope swales item was derived from MII and was rounded up to $2/LF to account for possible variations in swale size, assuming a 6-foot wide, 6-inch deep swale. A $2,656 each MII-derived unit cost was used for back slope drain structures.

Erosion Protection at Tributaries – The quantities and assumptions for tributary laterals to Hunting Bayou were the same as those used in the component cost estimate, but updated with more current non-federal sponsor, HCFCD, design criteria.

Concrete Channel Slope Paving – Slope paving quantities for the short downstream segment of the channel modification through the ERRY was determined using the same assumptions and methods as before. One weep hole for every 5 feet of lining was determined according to non-federal sponsor, HCFCD, design criteria. A $46.89 MII-derived unit cost was used for the slope paving. The unit cost for weep holes was indexed from 1999 unit prices.

Bridge Spans – For plan refinement cost estimate, bridge costs were further specified according to the need for replacement or extension. The same assumptions and calculation methods used before in component cost estimate to determine quantities for bridge deck replacement were used, except with updated project 1 percent AEP with project WSEL data to determine the need to raise bridges in accordance with COH criteria. Lengths were determined using with-project HEC-RAS model bridge cross section. In the lower project reach, modifications involve removing culvert segments or transitioning upstream modifications to existing channel geometry, but no substantial widening. For these bridge crossings, HEC-RAS cross section data differed from existing bridge length data gathered earlier in the study. Existing lengths were revised and verified for reasonableness with Google Earth and GIS aerial measurements.

Recent TxDOT roadwork and the revised channel ROW configured to avoid impacting Lockwood Drive (as explained in *Appendix 3 – Engineering Analysis*) were taken into account in determining the need for bridge replacement or extension. This precluded Lockwood Drive and Kelley Street Eastbound needing replacement, and the most upstream IH 610 crossing needing only extension. A revised review of raising and widening needs with the revised WSEL and ROW resulted in the Homestead Road main lane and Liberty Road being identified as not needing modification.

The project reach's downstream end requires only minimal transition work and almost no widening to produce the needed channel geometry. Therefore, three ERRY bridges were identified to be left with the existing structures due to practicality considerations including the following: 1) required sloping to achieve low chord raising would be impractical and likely not acceptable to the UPRR given the nature of rail yard operations on these lines; 2) the amount of raising needed is small with the revised with-project WSEL, and 3) equivalent conveyance can be provided by slightly deepening or more culverted geometry. These bridges were designed with pile depths which would allow for small amounts of deepening. These bridges were not included for replacement in the cost estimate.

Three ERRY bridges were deemed to require replacement due to deepening, despite no need for widening or raising. Although the overall deepening amount is small compared to most standard bridge pile depths, any deepening for these older timber bridges would likely require replacement or at the very least detailed structural assessment for this problem, after consulting the project structural engineer. During an earlier study phase, previous structural engineer consultation and problems UPRR had with movement caused by previous deepening on these bridges also corroborated this assumption. These bridges were listed for replacement despite only a relatively small amount of deepening required.

Unit costs were updated by a structural engineer's review of TxDOT 2009 Annual Bridge Report Unit Cost data. It was determined bridges greater than 130 feet long would likely require replacement with a steel bridge, and any bridge less than 130 feet long would be replaced with concrete girder and steel I-beam bridge. A steel bridge unit cost was $110/SY and concrete girder and steel I beam bridge unit cost was $90/SY. A 20 percent increase was included for the replacement cost to account for the demolition and removal cost. A 25 percent increase was included for bridges being lengthened/expanded. For railroad bridges being replaced due to deepening, unit costs from a previous data review by the structural engineer were indexed from a previous 2006 price level to a 2009 price level using the USACE CWCCIS.

Bridge Approaches – Approach lengths were specifically calculated for each crossing based on the required bridge raising complying with COH criteria, using the revised with-project 1 percent WSEL and the previous bridge width information from the component cost estimation. Grade approach percentages were set at either 3 percent or 5 percent, ensuring no conflicts with streets or other road infrastructure would result, with the less-steep grade used where possible. As channel improvements increased in bottom width for different plan alternatives, the 1 percent AEP WSEL was lowered. This resulted in shorter approach lengths needed for wider channel alternatives. Approach unit costs previously obtained from the structural engineer reviewing data were indexed from a previous 2006 price level unit cost to a 2009 price level using the CWCCIS.

Detention Basin Control Structures and Drop Structures – For the plan refinement phase, diversion structures were limited to the offline detention basin control structure and a drop structure at the channel modification's upstream end. The offline detention basin outfall control structure was based on a revised design being considered for project implementation, which consists of a slotted weir riser box structure that connects to Hunting Bayou by the three existing 96-inch RCP culverts and an added 72-inch RCP to be pipe-jacked under the railroad. This structure and its dimensions are described in detail in *Appendix 3 – Engineering Analysis* for the TSP offline basin control structure. A $250,000 lump sum item cost generated in MII for a cast-in-place structure of the same dimensions and the required 450 feet of 72-inch RCP piping was used.

The cost for a drop structure necessary for transitioning the existing flowline upstream from the project reach with the proposed deepened flowline in the project reach was updated by indexing the previous 1999 single item cost and assumed the same 4-foot, 3(Horizontal):1(Vertical) side-sloped concrete wall drop structure.

3.4 General Items

All the following construction items generally applicable to all major tasks were estimated using the same assumptions and quantity estimating methods used in the component estimate, except the previous 1999 unit costs were indexed to 2009.

- Traffic Control
- Construction Fencing
- Trash Removal and Disposal
- Channel Lining Removal and Disposal
- Site Preparation and Restoration, Including Facility for Engineers
- Water Care and Control
- Trench Shoring System

Stormwater Pollution Prevention Measures – Filter fabric fencing was estimated at 75 percent of the total lengths for both channel sides, while 25 percent was allocated for the reinforced filter fabric fencing. The previous unit costs for both were indexed to 2009 from the previous 1999 unit costs. For stabilized construction exits, the quantity was calculated assuming there would be eight exits (two exits per channel modification project work site and two per detention basin). A 150 SY area per exit was assumed based on local project experience. An MII-derived unit cost for a 6-inch aggregate access path was used, since this exit is a temporary item and a concrete or asphalt mat would be overdesigning, and the mat would be removed after completing the project.

Paving Repair – For detention work sites, since extensive excavation haul travel was expected, it was assumed two 30-foot by 100-foot areas would need to be replaced in the event existing paving was damaged (for instance, near the construction exit locations). The original cost for paving repair was indexed from 1999 unit costs.

3.5 Vegetation Recovery

Tree and shrub planting costs were estimated using the same assumptions and quantity estimating methods used in component cost estimates, except the previous 1999 unit costs were indexed to 2009 using the CWCCIS.

3.6 Utility Modification

The previous utility information was updated with more current available geospatial data, primarily from COH (water, storm, sanitary) and Texas Railroad Commission (petroleum and other product pipelines), and mapped within a GIS to determine the utilities affected by the specific refined alternative components. Removal, re-routing and other associated costs were estimated primarily using the same techniques used in component cost estimating. Pipe material type for each relocation type was identified to further specify unit costs. Unit costs were updated mainly through MII-generated unit costs, but also through indexing previous 1999 unit costs for auxiliary items such as pipe hangers. The following describe the basis for cost items under the Utility Modification category.

Storm Sewer Outfall – The quantities for pipe, timber bent supports, couplers and riprap were estimated using the previous assumptions and calculations used in the component cost estimation to meet non-federal sponsor, HCFCD, criteria, which was reviewed for updates to requirements. The unit cost table for the various sizes was updated with MII-derived unit costs for pipe material, and for sizes not provided, they were interpolated from the costs for sizes provided. The unit costs ranged from $86.67/LF for 18-inch to $1,013/LF for 120-inch RCP, the predominant material for storm sewer outfalls along Hunting Bayou. For timber bents and couplers, the previous 1999 unit costs were indexed to 2009.

Water Lines – Costs were estimated in the same manner as before, calculating quantities depending on need for aboveground or underground crossings, and whether aboveground crossings were attached to bridges or on their own utility bridge. Quantities were estimated using the same quantity assumptions and calculations used in the component cost estimate for pipe and single items (i.e., quantified as individual items and not by linear feet) such as piers, hangers, couplers and air vacuum release valves. The assumed materials differed, depending on the type of crossing needed. Directionally drilled high-density polyethylene (HDPE) pipe was assumed for underground crossings. Aboveground crossings on piers were assumed to be steel, and pipe attached to bridges on hangers were assumed to be ductile iron (DI) pipe.

The unit cost table for channel components was updated with MII-derived pipe material and replacement (without piers, hangers etc.) costs, which are the major cost elements, and indexing for other elements. MII-derived unit costs for pipe material and replacement were used, and interpolated from this data for sizes not provided ranging from $36/LF for 2-inch DI pipe to $872/LF for 84-inch steel pipe. The wet connection, cut and plug, air vacuum release valve, the pier and the hanger single-item costs were indexed to 2009 from previous 1999 unit costs.

Sanitary Sewer Lines – Sanitary sewer quantities were estimated for gravity relief sewer collector lines and force mains, for above and underground crossings, using the same assumptions and calculations used in component cost estimates. This included piers, hangers and necessary siphons. Similar to water lines, the assumed materials differed, depending on the type of crossing needed. Directionally drilled HDPE pipe was assumed for underground crossings, steel was assumed for aboveground crossings on piers, and pipe attached to bridges on hangers was assumed to be DI pipe.

The unit cost table for channel components was updated with MII-derived pipe material and replacement costs (the major cost elements), and indexing for other elements (single items e.g., piers, hangers, etc.). MII-derived unit costs for material and replacement were used for all three material types (HDPE, steel, DI), and were interpolated for sizes not provided with unit costs ranging from $37.50/LF for 4-inch DI pipe aboveground crossings to $603/LF for 48-inch HDPE directionally drilled underground crossings. Pier and hanger costs were indexed from previous 1999 single item costs. Siphon costs for gravity sanitary lines were revised using more current local project bid tab data. For siphons connecting 42-inch lines, $13,000 per siphon structure was used, and for connecting greater than 42-inch lines, $65,000 per siphon structure was used.

For the detention basin components, unit costs for abandonment and removing existing sewer were indexed from previous 1999 unit costs. Sanitary sewer line materials and replacement used MII-derived unit costs for open cut HDPE pipe, and directional boring 4-inch HDPE for forcemains coming from the needed lift station to tie into the existing sanitary sewer line across the railroad tracks, and single-item manhole costs added on spacing in accordance with local criteria.

Sanitary Sewer Lift Stations – The cost for the needed 2 mgd lift station was updated based on 2009-2010 bid prices. The cost factor was applied to account for the unknowns (no design was performed to determine sizing and appurtenances required) to provide an approximate $694,000 lump sum cost.

Private Utilities – Quantities for gas, crude and refined product pipelines and communication lines (telephone, cable, data, etc.) were estimated using the same assumptions and calculation methods used in component cost estimates. For channel components, replacement for the gas, crude line and communication line conduit was assumed to consist of directionally-drilled steel pipe crossing underneath the channel, in keeping with the local standard requirement and preference for these types of crossings, as explained in Section 1.6. The size for the crossing conduit was determined by the number and size of the individual smaller communication lines to be bundled into the crossing.

For the detention components, it was assumed existing gas lines crossing the basin would be rerouted around the basin's western side. Crude pipeline relocation included an additional 1,000 feet of pipe to account for the additional pipe length likely required to reroute and directionally drill the pipeline around/beneath many facilities south of the basin (overhead electrical with underground foundations, storm sewer, waterline, sanitary sewer, railroad tracks, etc.).

The unit cost table for channel components was updated for each size using MII-derived material and replacement unit costs, and was interpolated for sizes not provided. These unit costs assume purging, inerting and removing replaced line are incorporated, and ranged from $251/LF for 2-inch line to $667/LF for 48-inch line. The 1999 unit costs to abandon and remove existing gas and crude lines were indexed to 2009. For the detention components, new gas and crude line costs were estimated using a rounded $110/LF MII-generated unit cost based on open cut gas line construction for 12-inch DI pipe.

3.7 Engineering and Design

This cost was updated to be consistent with other local Section 211(f) studies being conducted, and assumes 12 percent of the total construction and LERRD cost contained in the White Oak Bayou GRR.

3.8 Construction Management

This cost was updated to be consistent with other local Section 211(f) studies being conducted, including the White Oak Bayou GRR, and assumes 10 percent applied to the total construction, LERRD, plus mobilization and contingency costs.

3.9 Real Estate

The real estate costs were estimated in the same general manner as component cost estimates, except updated HCAD tax record appraisal values and geospatial data for 2009 and an updated market value adjustment factor study were used. The market value adjustment factor study, conducted by an appraiser, was based on recent sales data and identified factors for residential, commercial and industrial property types. The revised geospatial parcel data, revised alternative ROW geospatial data and more current aerial imagery were used to re-analyze the required full and partial real estate parcel acquisitions associated with each channel component. Detail to the takings analysis was added for this phase due to the finer channel width increments. These increments included considering if the alignment caused a parcel to lose street access, and whether only a portion of structures and land could be acquired on residential parcels with multiple separate units instead of assuming whole acquisition for all structures.

Relocation and administrative costs were updated to be consistent with other local Section 211(f) studies being conducted, including the White Oak Bayou GRR. For acquisitions requiring residential relocations, relocation costs to compensate homeowners for moving and other relocation expenses were estimated at $20,000 per living unit for single family residence and $3,500 per unit for multi-family residential. HCAD data was used to verify numbers of living units. A $3.50/sf unit cost for commercial/public structure acquisitions was used in conjunction with HCAD improvement square footage data to calculate non-residential relocation costs. Administrative costs for appraisals, closing costs and consultant fees incurred with property acquisition were added. These were generally estimated as $1,500 per appraisal and consultant fee for residential structures, $8,000 per appraisal and consultant fee for commercial/public structures, and a closing cost of 1 percent of the calculated acquisition cost.

3.10 Environmental Mitigation

The results from mitigation planning with habitat modeling using data collected and models selected in 2008 were used to estimate mitigation costs. The mitigation planning focused on analyzing the required acreage and costs for mitigation alternatives to address the impacts from the B60-A75 alternative being considered to select for recommendation. All the alternatives with the B-component channel modification, including B60-A75, had the inline detention basin feature as part of the channel modifications. The inline feature encompassed virtually all the wetlands impacted by channel modification. The revised channel modification component used during plan refinement excludes the inline detention feature, which reduced the ROW requirements through this segment. A75, the 75-acre basin component, is also the largest offline basin component analyzed, and encompasses all the basin-impacted wetlands. Therefore the previous mitigation planning provided the data necessary to calculate costs for impacts to the revised ROW and basin components during plan refinement.

The cost estimate associated with the most cost-effective alternative that compensates up to the project impacts was used and included creating onsite forested and emergent wetlands. The unit costs for this and all other onsite creation alternatives were based on planting, maintenance and monitoring costs provided by non-federal sponsor, HCFCD, which were based on recent project mitigation and mitigation bank plant harvesting costs. The basic unit costs were approximately $42,300/acre for forested wetland creation, which incorporated basic cost elements of $63 planting and $56 post-planting short-term maintenance costs per tree at a 347 tree/care density. For emergent wetland creation, the basic cost was $29,400/acre, incorporating basic cost elements approximately

$4/plant and $9,945/acre for monitoring and maintenance. Long-term mitigation monitoring costs were calculated for 5 years at $5,500/annual monitoring event to account for monitoring for specific habitat quality indicators to meet mitigation target criteria, and were based on previous non-federal sponsor, HCFCD, project mitigation criteria monitoring costs.

For use in the plan refinement phase, the previous $59,340 total mitigation cost for the cost-effective alternative that included inline impacts was scaled by acreage ratio to remove the wetlands affected only by the inline detention feature. The different channel alternative widths analyzed during plan refinement were also examined for similar scaling to account for the potential difference in wetland acreage affected by the varying channel width.

However, because the widths through this segment were all configured in this phase to minimize impacting the unregistered landfill occupying most of the inline feature, the width differences varied little. Also, all the wetlands lying on the channel ROW boundaries had a high percentage of their individual wetland areas affected, so the whole wetland would be considered to be impacted. Therefore, the mitigation amount did not vary with channel width. The wetland cost was similarly scaled by acreage ratio to vary the amount of wetlands affected in the offline basin by the different basin sizes. Upon examining the wetlands affected and how partially-impacted wetlands would be affected, differences were only identified for the smallest scale basin (A25), while A50 and A75 would have no difference. Despite the finer channel and basin increments examined in the plan refinement phase, the mitigation cost variation (<$8,000) was very small compared to other project cost differences.

3.11 Contingencies

This cost was updated to be more consistent with other local Section 211(f) studies being conducted including the White Oak Bayou GRR. Earthwork including excavation and disposal and bridge modifications constituted the major construction cost portion for the alternatives analyzed during plan refinement. The contingency applied in the White Oak Bayou GRR varied from 10 to 25 percent, with 15 percent earthwork contingencies, and 10 percent bridge structure contingencies identified. Applying a 15 percent global cost contingency was thought to be adequate and would produce similar overall contingency costs with other Section 211(f) studies. This was assumed because the costs in this study were earthwork and bridge-cost heavy, and since lesser contingency for items not receiving the higher 20 to 25 percent contingencies would be made up by the 15 percent applied to bridges instead of the 10 percent used for structures. Therefore, a 15 percent contingency was applied to total construction and mobilization costs.

In July 2013, the Cost and Schedule Risk Analysis (CSRA) was updated based on various Agency Technical Review (ATR) comments. The current Fully Funded Project Cost Estimate is $166.9 million, which includes the recommended 22.6 percent contingency and escalation to the mid-point of construction. The MII cost estimate used in this analysis can be provided upon request.

Specific to the Hunting Bayou Flood Control Project, the estimate prior to escalation and contingency is $131.2 million, which includes $29.4 million costs expended to-date and estimated $101.8 million cost for the remaining work. The CSRA study excludes contingencies and the $29.4 million spent costs, and is expressed in FY 2013 dollars. Based on the results of the analysis, the HCFCD recommends an approximate $23.0 million contingency, which is 22.6 percent of the remaining costs on the project. This contingency was determined through a risk review with the Project Development Team and reviews with the Cost Engineering Mandatory Center of Expertise for Civil Works (MCX; located in Walla Walla District). Section 5.0 in this appendix presents the details of the CSRA.

3.12 Alternative Cost Updates and Interest During Construction (IDC)

Alternative costs were updated in the same manner as before, by combining the costs for the components comprising the alternative. Most updated cost items described above were updated for the individual components comprising the alternatives analyzed during plan refinement. However, some costs were calculated for the alternative because of the way they were analyzed. These included haul and disposal costs for excavated soils, which were analyzed using assumptions about a percentage of the total project (i.e., alternative) excavation being deferred for reuse instead of placement at disposal sites. This also included mitigation amounts calculated during mitigation habitat modeling based on the total average annual habitat units impacted by the alternative. Therefore, these costs were calculated outside the updated component cost sheets and displayed in the alternative cost estimate sheets.

Accordingly, the ancillary costs for mobilization, engineering and design, construction management and contingency were calculated separately for these alternative-level costs. To clarify, these costs were already calculated and included for the component level costs in the component cost estimate sheets. The IDC was calculated for the alternatives in the same manner as alternative cost estimation. For this phase, given the relatively small variation in channel widths between the alternatives, and the duration observed for constructing the first phase of the interim basin, a uniform 5-year construction period was assumed for calculating IDC. *Attachment A4-4* provides the alternative cost estimates for the plan refinement phase.

4.0 FINAL PLAN MICRO-COMPUTER AIDED COST ENGINEERING SYSTEM (MCACES) COST ESTIMATES

MII was used to provide the probable engineering construction cost estimate for the TSP and B50-A25. The MII cost estimate includes a summary and detailed description for the TSP, Attachment A4-A and B50-A25, Attachment A4-B cost estimates.

The features for both NED Plan scales are described in detail in *Appendix 3 – Engineering Analysis.* The MCACES Baseline Cost Estimate (BCE), construction schedule and CSRA were developed by Atkins North America, Inc. in accordance with and subject to the following USACE guidance and ATR requirements:

- ER 1105-2-100, Planning Guidance Notebook
- ER 1110-2-1150, Engineering and Design for Civil Works Projects
- ER 1110-1-1300, Cost Engineering Policy and General Requirements
- ER 1110-2-1302, Civil Works Cost Engineering
- EI 01D010, Engineering Instructions, Construction Cost Estimates
- EC 1110-1-105, Independent Technical Review
- EC 1105-2-408, Peer Review of Decision Documents
- Engineering & Construction Bulletin (ECB) 2006-5, 12 June 06, MCACES Transition Plan
- CECW-CP Memorandum, Peer Review Process, 30 Mar 2007
- ECB 2007-17, 10 Sep 07, Application of Cost Risk Analysis Methods
- EC 11-2-187, Corps of Engineers Civil Works Direct Program, Program Development Guidance, Fiscal Year (specific for budget year)
- ER 1165-2-131, Local Cooperation Agreements for New Start Construction Projects
- EC 1105-2-410, Review of Decision Documents
- ETL 1110-2-573, Construction Cost Estimating Guide for Civil Works

The non-federal sponsor, HCFCD, has already started implementing certain TSP components. The status for the construction components is as follows.

- Component A75, Offline Detention Basin – The property required to implement the full basin has been acquired from UPRR. The first phase has been completed to construct an approximately 50-acre interim basin which will provide more than half the storage of the full basin. The approximately 22-acre cleared area has been excavated to about 5 feet deep, and drains to the existing storm drainage channels and culverts outfalling to Hunting Bayou. Awarding the second phase to complete the 50-acre interim basin is imminent.

- Component B60, Channel Modifications – Approximately 101 of the required property parcels were acquired by the non-federal sponsor, HCFCD, between 2007 and 2012, providing most of the ROW required in the TSP's upper reach. Most of the properties have had due diligence surveys performed, and the existing structures (primarily residential) have been demolished. Preconstruction engineering and design has been initiated for some of the required channel modifications. However, none of the channel modifications, required utility relocations or bridge modifications has been constructed.

The BCE for the TSP prepared using the MCACES is presented in *Attachment A4-5*. The resulting total first cost for the TSP is approximately $131.3 million. No contingencies are included in these costs. The estimate was structured assuming implementation through five contracts to be executed over an approximate 7-year construction period. The schedule is described in more detail in Section 6. In general, for completed work and LERRDs already acquired, actual costs were used and are referred to as costs to date for constructed work, and for construction required to complete implementation, MII-generated costs were used, and are referred to as costs to complete for unconstructed work. This is in accordance with the most recent guidance received from the USACE Civil Works Cost Engineering and ATR MCX.

4.1 Account Codes

The following sections summarize the account structure used for the TSP cost estimate and describe the construction items included in these accounts. The same structure was used for the B50-A25 cost estimate.

4.1.1 01 – Land and Damages

This account includes all the lands, easements and ROWs required. For costs to date, actual acquisition costs including administrative, appraisal and relocation costs provided by the non-federal sponsor, HCFCD, were used. For costs to complete, data from the Gross Appraisal by Cervenka and Associates was used for TSP parcels not yet acquired. This includes disposal lands required using appraised acquisition costs without valuation contingency (as contingency would be calculated in the CSRA). The disposal sites identified were updated to exclude one site due to reduced channel ROW (e.g., eliminated the inline detention feature), to avoid unnecessary upland impacts, and due to the revised assumption 25 percent of the total project excavated volume would be disposed through local project reuse. The administrative costs associated with acquisition and appraisals, and relocation assistance were also estimated and accounted for in the estimate. These costs are described in the real estate BCE in *Appendix 6 – Real Estate Plan*.

4.1.2 02 – Relocations

This account includes the utility relocations necessary for the channel modifications and offline detention basin consisting of water, sanitary sewer, storm sewer and private utilities (e.g., communication lines, gas, crude and other products). For the MII estimate, updated utility information provided by the non-federal sponsor, HCFCD, from project implementation design being conducted and from more recent field and owner/operator verification conducted by the non-federal sponsor, HCFCD, was incorporated into the list of utilities requiring relocation. This resulted in a few downstream product pipelines being removed from the list, and several water, sewer and gas service lines being added to the list. The engineering quantities for the utility list were estimated in accordance with the assumptions and calculation methods described in Section 3.0.

The relocations account also includes bridges to be modified and pavement removal and replacement for approaches to these bridges. Four bridge categories were encountered in the TSP project area:

TxDOT bridges, COH bridges, pedestrian bridges and railroad bridges. The engineering quantities for the bridges needing replacement or extension were estimated in accordance with the assumptions and calculation methods described in Section 3.0. The account also includes the associated traffic control and flagging costs.

The non-federal sponsor, HCFCD, has acquired a majority of the upstream parcels required for the TSP ROW, as discussed in *Appendix 6 – Real Estate Plan*. Actual demolition costs from the information provided by the non-federal sponsor, HCFCD, were used for demolition costs to date, and are included in this account. For LERRDs not yet acquired, demolition costs for removing residential, commercial and other structures in the TSP ROW were also included in this account, with quantities based on HCAD improvement square footage data.

4.1.3 09 – Channels and Canals

This account includes costs for excavating the channel, disposal for excavated materials, and other channel structures and channel site work such as riprap, tributary lateral slope protection and concrete side slope paving needed for the TSP. Channel work costs also include the necessary stormwater pollution prevention measures (e.g., silt fencing), care and control of water (e.g. cofferdams), back slope protection swaling and drainage interception structures. The engineering quantities for these items were estimated in accordance with the assumptions and calculation methods described in Section 3.0. As discussed for the lands and damages account, the disposal site requirements were reduced due to the revised channel ROW eliminating the inline detention feature, and due to revising from 20 to 25 percent the assumption about reusing excavated soils as fill for local projects, which is in keeping with the non-federal sponsor, HCFCD's, intent to dispose as much soil as possible through reuse.

This account also includes general construction activities for site improvements. The general construction items include clearing, grubbing, debris disposal, trench shoring, site office, construction surveys, haul road maintenance and dust control. These items also include mobilizing and demobilizing for site preparation. Site improvements include establishing vegetation such as turf, shrub and tree plantings and other plantings. The engineering quantities for these items were also estimated as described in Section 3.0.

4.1.4 15 – Floodway Control-Diversion Structure

This account includes costs for excavating and constructing the offline detention basin and disposal for the excavated materials. This includes control and diversion structures to control flow into and out of the detention basin from the channel. The 20-foot by 60-foot by 20-foot control structure described in detail in *Appendix 3 - Engineering Appendix* was the basis for the control structure cost. Similar to the channels and canals account, this account included all the necessary stormwater pollution prevention measures, care and control for water, back slope protection swaling and drainage interception structures. The engineering quantities for these items were estimated in accordance with the assumptions and calculation methods described for the offline detention basin in Section 3.0. As discussed for the channels and canals account, the disposal site requirements were reduced due to the aforementioned reasons, and assume reusing 25 percent of the total project excavated volume. Since the detention basin is constructed in the first Contract A for planning purposes, the disposal volume for haul and placement incorporates eliminating 25 percent of the total project excavated volume in this contract. Also similar to the channels and canals account, general items such as clearing, grubbing, debris disposal, trench shoring, site office, construction surveys, haul road maintenance and dust control for implementing the basin are included in this account. Site improvements consisting of vegetation establishment are also included.

4.1.5 30 – Planning, Engineering, and Design

This account includes the fees associated with planning and design for the project. The costs include preparing plans and specifications, field investigations and surveys, cost estimates, engineering during construction and project management. The costs to date for constructed work were listed in this account. Per the USACE Civil Works Cost Engineering ATR MCX guidance, the costs to complete for unconstructed work were calculated and demonstrated in the Total Project Cost Summary (TPCS) outside this account. This was calculated as 20 percent of the total construction cost.

4.1.6 31 – Construction Management

This account includes the fees associated with the project's construction management. The costs include supervising and administering the contracts by construction management and contracting personnel and project management, material testing, quality and schedule control, and other construction management services. The costs to date for constructed work were listed in this account. Similar to preconstruction engineering and design costs, the costs to complete for unconstructed work were calculated and demonstrated in the TPCS outside this account per the USACE Civil Works Cost Engineering ATR MCX guidance. Construction management was calculated as 20 percent of the total construction cost.

4.1.7 Associated General Items and Indirect Costs

Other costs associated with project construction including contractor's field overhead, home office expense, contractor's profit, contractor's bond and other indirect costs were also estimated in the MII BCE, with bond rates and percentages explained in the MII report. IDC was calculated and presented as an economic cost outside the MII estimate, and displayed in the TPCS. Contingency was estimated and displayed in the CSRA and TPCS as explained in Section 5.0.

4.2 Summary for the Tentatively Selected Plan (TSP) Baseline Cost Estimate (BCE)

Table A4-1 summarizes the estimated first construction costs in the BCE for the major civil works accounts, displayed by contract.

Table A4-1:
Tentatively Selected Plan (TSP) Project First Costs

Account	Cost
Cost to Date	
Lands and Damages	$ 11,940,013
Relocations	$ 1,395,447
Planning, Engineering and Design	$ 11,845,311
Construction Management	$ 4,258,608
Cost to Date Total	***$ 29,439,378***
Cost to Complete (values in $1,000's)	
Contract A – Offline Detention Basin (Sta. 610+00)	
Lands & Damages	$ 8,352
Relocations	$ 4,451
Detention	$ 14,093
Planning, Engineering and Design	$ 1,113
Construction Management	$ 1,854
Contract A Total	***$ 29,863***
Contract B – Downstream Channel Construction (Sta. 549+50 to 616+25)	
Lands & Damages	$ 1,482
Relocations	$ 24,964
Channels	$ 4,403
Planning, Engineering and Design	$ 1,762
Construction Management	$ 2,937
Contract B Total	***$ 35,548***
Contract C – Channel Construction (Sta. 616+25 to 705+00)	
Lands & Damages	$ 1,378
Relocations	$ 11,351
Channels	$ 6,426
Planning, Engineering and Design	$ 1,067
Construction Management	$ 1,778
Contract C Total	***$ 22,000***
Contract D – Midstream Channel Construction (Sta. 705+00 to Sta. 732+50)	
Land & Damages	$ 396
Relocations	$ 6,422
Channels	$ 2,165
Planning, Engineering and Design	$ 515
Construction Management	$ 859
Contract D Total	***$ 10,356***
Contract E – Upstream Channel Construction (Sta. 732+50 to Sta. 748+50)	
Lands & Damages	$ 231
Relocations	$ 1,620
Channels	$ 1,669
Planning, Engineering and Design	$ 197
Construction Management	$ 329
Contract E Total	***$ 4,047***
Cost to Complete Total	**$ 101,813**
Total Project First Cost	**$131,312,361**

5.0 COST AND SCHEDULE RISK ANALYSIS (CSRA)

A risk analysis for the TSP project costs was performed using Crystal Ball software and the MII cost estimate. The MII cost estimate total without contingencies is approximately $131.3 million. The Crystal Ball analysis indicates a 22.6 percent contingency for the remaining component construction would be appropriate to ensure there is an 80 percent certainty the total project cost would not exceed $167 million, inclusive of contingency, escalation and $29.4 million in completed work (cost to date). The risk analysis is shown in the CSRA provided as *Attachment A4-6*. The resulting contingency was used to calculate total project costs considering risk in the TPCS.

The TSP was assumed to be implemented through a series of five contracts, A through E. Project construction would start with the offline detention basin in Contract A, then building the channel modifications from downstream to upstream in Contracts B through E. Segmenting the channel contract was based on station limits employed for study and project planning which divided the channel work into manageable lengths. Each contract was assumed to be executed and completed before the next contract started. Effort for each contract was divided into major subtasks for general site preparation, utility relocations, bridge modifications and channel excavation/construction. Some tasks could overlap according to constructability and practicality considerations. All real estate acquisitions are to be obtained prior to commencing any construction activities. The total project schedule duration was approximately 1,546 working days (not including holidays and weekends) or approximately 2,700 calendar days, which is approximately 7 years and 5 months. The schedule is shown as *Attachment A4-7*.

A Value Engineering Workshop was held May 14th through May 16th at AECOM's office in Houston. The attendees included Jose Castro of the USACE; Richard Scott, Gary Zika, and Jennifer Dyke of non-federal sponsor, HCFCD; and Brian Ruck, Bruce Pietkiewicz and Matthew Zeve of AECOM.

6.0 OPERATION AND MAINTENANCE (O&M) COSTS

The non-federal sponsor, HCFCD, will perform all O&M activities. Typical activities anticipated include mowing the ROW and removing debris. Since the non-federal sponsor, HCFCD, already maintains the existing channel, no increase in current O&M costs is anticipated due to the proposed modifications, except for new ROW acreage to mow, maintaining the soil placement sites (if used), and the additional trees and shrubs. These yearly additional O&M costs are estimated at $400/acre/year. The estimated O&M cost for 228 acres is $91,260. These costs were based on reviewing non-federal sponsor's, HCFCD, maintenance program and historical maintenance costs for the watershed. Non-federal sponsor's, HCFCD, maintenance program calls for the channel and detention basin ROW to be mowed multiple times during the season and provides a help line telephone number watershed residents can call to report any debris accumulation in the channel. Non-federal sponsor, HCFCD, has contracts with local construction firms to provide debris removal or other channel cleanouts as needed.

Constructing the offline detention basin results in relocating several utilities, including a sanitary sewer line which crosses through the middle of the proposed basin site. The sanitary sewer will need to be rerouted along Homestead Road and then pumped back into the trunk system via lift station. It was determined a 2 mgd capacity lift station will be required at this location, which will result in additional O&M costs. The costs were originally estimated at a $70,000 FY2001 cost, calculating the annual operational costs from the demand charges from operating the pumps at an approximately 50 percent duty cycle and maintenance costs assumed to be 5 percent of the pump station's construction cost. This cost was indexed to the current price level using CWCCIS. The annual O&M costs for the lift station are estimated to be $77,500. Therefore, the total annual O&M cost for the TSP will be about $168,760.

The roadway bridges are owned, operated and maintained by either COH or TxDOT. No increase in the ongoing maintenance costs for these bridges is anticipated due to the proposed plan. To minimize channel erosion and maintenance costs, slope protection measures, a fully concrete channel through ERRY, and back slope swales and drains have been included in the overall project costs. These design elements will help to control erosion in the channel and prevent slope failures. Slope protection measures such as stone riprap will be placed at the confluence of major storm sewers and lateral channels. Back slope swales will run along the maintenance berms and drain into back slope interceptor structures.

ATTACHMENT A4-1
COMPONENT COST ESTIMATION

Estimates removed based on direction from Cost Engineering ATR Reviewer

ATTACHMENT A4-2
ALTERNATIVE COST ESTIMATION

Estimates removed based on direction from Cost Engineering ATR Reviewer

ATTACHMENT A4-3
PLAN REFINEMENT COMPONENT COST ESTIMATES

Estimates removed based on direction from Cost Engineering ATR Reviewer

ATTACHMENT A4-4
PLAN REFINEMENT ALTERNATIVE COST ESTIMATES

Estimates removed based on direction from Cost Engineering
ATR Reviewer

ATTACHMENT A4-5
Tentatively Selected Plan MII Baseline Cost Estimate

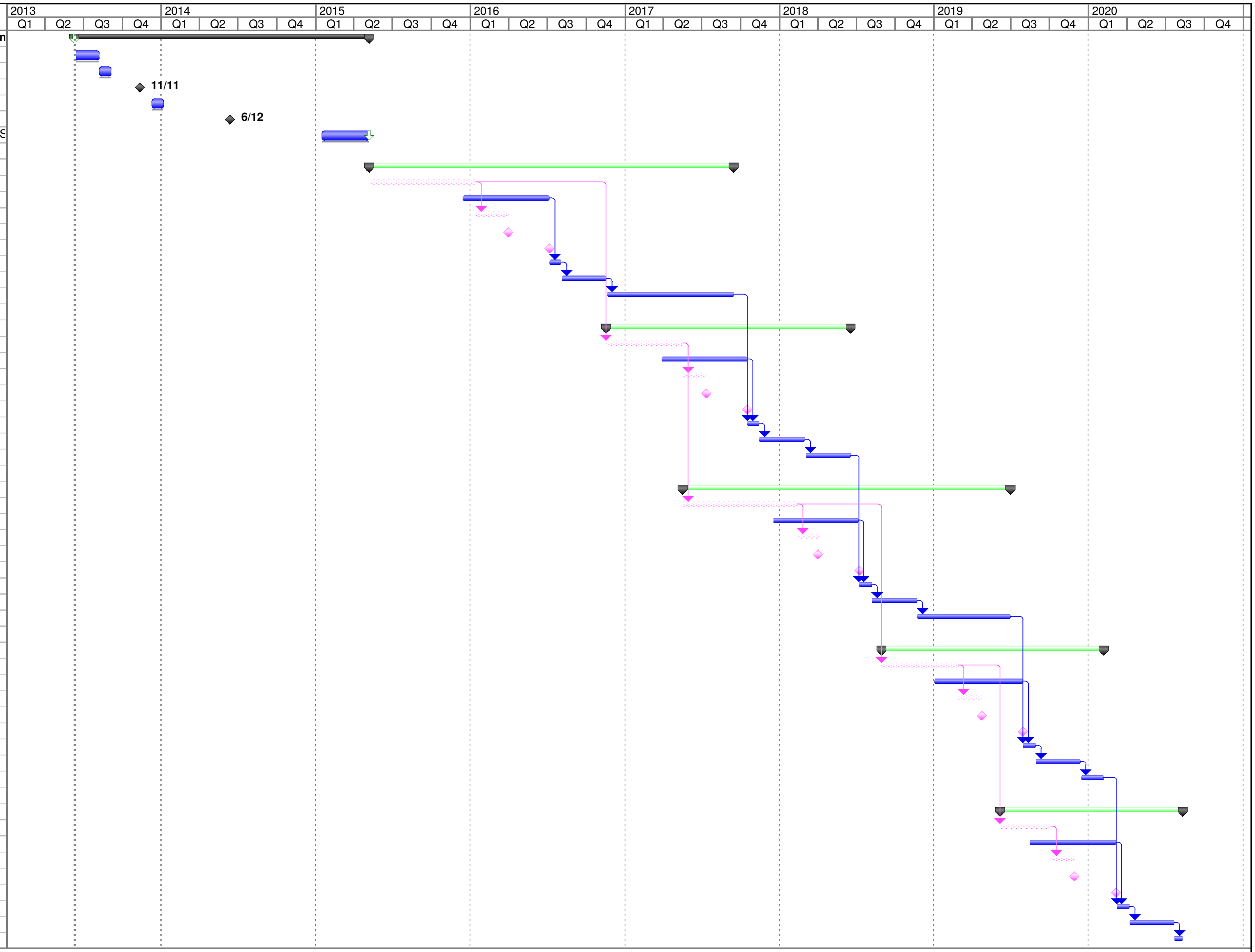
Available Upon Request

ATTACHMENT A4-6
TSP Cost and Schedule Risk Analysis

Available Upon Request

ATTACHMENT A4-7
Schedule

ID	Task Name
1	**Hunting Bayou Federal Flood Study (Remain**
2	Alternative Formulation Breifing
3	Final Project Guidance Memorandum
4	ATR Certification (FINAL)
5	Headquarters Study Review
6	ATR Certification (HQ)
7	ASA Civil Works Review and Approval of S
8	
9	**Contract A**
10	Develop Plans & Specifications
11	Lands Acquisitions
12	Advertise Project / Evluate Bid Packages
13	Award Constructoin Project
14	Issue NTP for Construction
15	Contract Mobilization
16	Relocations
17	Detention Pond Construction
18	
19	**Contract B**
20	Develop Plans & Specifications
21	Lands Acquisitions
22	Advertise Project / Evluate Bid Packages
23	Award Constructoin Project
24	Issue NTP for Construction
25	Contract Mobilization
26	Relocations
27	Channel Excavation and Construction
28	
29	**Contract C**
30	Develop Plans & Specifications
31	Lands Acquisitions
32	Advertise Project / Evluate Bid Packages
33	Award Constructoin Project
34	Issue NTP for Construction
35	Contract Mobilization
36	Relocations
37	Channel Excavation and Construction
38	
39	**Contract D**
40	Develop Plans & Specifications
41	Lands Acquisitions
42	Advertise Project / Evluate Bid Packages
43	Award Constructoin Project
44	Issue NTP for Construction
45	Contract Mobilization
46	Relocations
47	Channel Excavation and Construction
48	
49	**Contract E**
50	Develop Plans & Specifications
51	Lands Acquisitions
52	Advertise Project / Evluate Bid Packages
53	Award Constructoin Project
54	Issue NTP for Construction
55	Contract Mobilization
56	Relocations
57	Channel Excavation and Construction



Project: Hunting Revised Construction
Date: Sun 6/9/13

Task		Progress		Summary		External Tasks		Deadline	
Split		Milestone		Project Summary		External Milestone			