US Army Corps of Engineers
Galveston District

# Value Engineering Study for EMERGENCY DREDGING WEST FORK SAN JACINTO RIVER, TEXAS

## U.S. Army Engineering District, Galveston

Study Dates: 1 – 4 May 2018

**VALUE ENGINEERING STUDY TEAM MEMBERS**


| | |
|---|---|
| William S. Easley, PE, CVS | VE Team Leader/Civil Engineer<br>CECO-O-RAO (Reemployed Annuitant Office, USACE) |
| Derek Anderson | Acting Resident Engineer, Houston Resident Office<br>Galveston District, USACE |
| José D. Castro-Rivera, PE | Civil Engineer, General Engineering Section<br>Galveston District, USACE |
| Al Meyer | Houston Resident Office<br>Galveston District, USAC |
| A. Rashid Ali | Cost Engineer<br>Galveston District, USACE |
| John A. Campbell | Regional Planning & Environmental Center<br>Fort Worth District, USACE |
| Jason E. Story | Regional Planning & Environmental Center<br>Fort Worth District, USACE |
| Tuan Nguyen | Civil Engineer, General Engineering Section<br>Galveston District, USACE |
| Mike Garske | Hydraulic Engineer, CESWG-EC-EH<br>Galveston District, USACE |
| Jake Walsdorf | Value Engineering Officer<br>Galveston District, USACE |

VALUE ENGINEERING TEAM STUDY

EXECUTIVE SUMMARY

| | |
|---|---|
| PROJECT TITLE: | West Fork San Jacinto River - Emergency Dredging<br>Greater Houston area, Texas |

A Value Engineering Study was conducted at the Galveston District Office of the US Army Corps of Engineers on 1 – 4 May 2018 to study the plans for Emergency Dredging of the West Fork of the San Jacinto River, Texas.This work had been requested by the Texas Division of Emergency Management in coordination with the Federal Emergency Management Agency (FEMA). Reference State of Texas Assistance Request (STAR) 16A-41062 (TX). USACE assistance with dredging operations was specifically requested in the West Fork of the San Jacinto River of approximately 8 miles (W. Lake Houston Parkway to Highway 59), because excessive debris from Hurricane Harvey was exacerbating and impeding the free flow of water down this portion of the West Fork of the San Jacinto River. Heavy rainfall received over this water shed as well as downstream flows into this portion of the river has created a situation that poses threats to life safety, critical infrastructure, as well as potential loss of life.

On 25 August 2017, Hurricane Harvey made landfall along the Texas Coast as a Category 4 storm. Hurricane Harvey created extensive flooding along the West Fork of the San Jacinto River creating a record high flood of 69.22 feet as recorded by the West Fork San Jacinto River gauge on August 29, 2017. This record flooding increased the amount of deposition of sand and silt within the West Fork of the San Jacinto River from areas further upstream.

This has now reduced the overall depth of the West Fork waterway and decreased the amount of water that can pass through and into Lake Houston. The epic flooding caused by Hurricane Harvey caused 4,139 structures along the West Fork to flood, including 1,621 homes with National Flood Insurance Program (NFIP) claims totaling over $407 million. In addition, during Hurricane Harvey a number of hospitals along the West Fork (e.g. Kingwood Medical Center, Memorial Hermann Northeast Hospital) were cut-off due to the West Fork flooding which prevented residents from obtaining emergency aid. Recent heavy rainfall along the West Fork has caused, and may again result in, downstream water levels that present a threat to persons and properties in the Kingwood-Humble-Lake Houston areas due to the inability of the West Fork to carry sufficient water volume. During the March 29, 2018 heavy rainfall event the West Fork swelled again to 51.62 feet (8 inches away from being in a Major Flood Stage). To put this into perspective, 33.04 inches of rain fell on the West Fork San Jacinto River gauge over the span of 5 days which contributed to the river swelling to its record high of 69.22 feet on August 29, 2017. Only 3.36 inches of rain fell on the West Fork San Jacinto River gauge over the span of 2 days which contributed to the river swelling to 51.62 feet on March 29, 2018. In the event of another heavy rainfall event there is a near certain likelihood that wide-spread flooding will occur impacting even more homes than before due to the rivers inability to pass heavy volumes of water. The average rainfall for May is 5.22" and June is 6.97" far above the recent 3.36" rain event.

The VE team was comprised of Galveston District employees, and facilitated by William Easley, a certified value engineering facilitator working for USACE-RAO.

Value Engineering (VE) is a process used to study the functions a project is to achieve. VE takes a critical look at how these functions are proposed to be met and it identifies alternative ways to achieve the equivalent function while increasing the value and the benefit ratio of the project. In the end, it is hoped that the project will realize a reduction in cost, but increased value is the focus of the process, rather than simply reducing cost. As noted in the agenda presented in Appendix A, the project was studied using the Corps of Engineers standard Value Engineering (VE) methodology, consisting of six phases:

Information Phase: The hydraulic engineer who'd been studying the channel and modeling its flow, Mike Garske, gave the Value Engineering Team an overview of the project, including concerns. Appendix B is an attendance list for the briefing and the study.

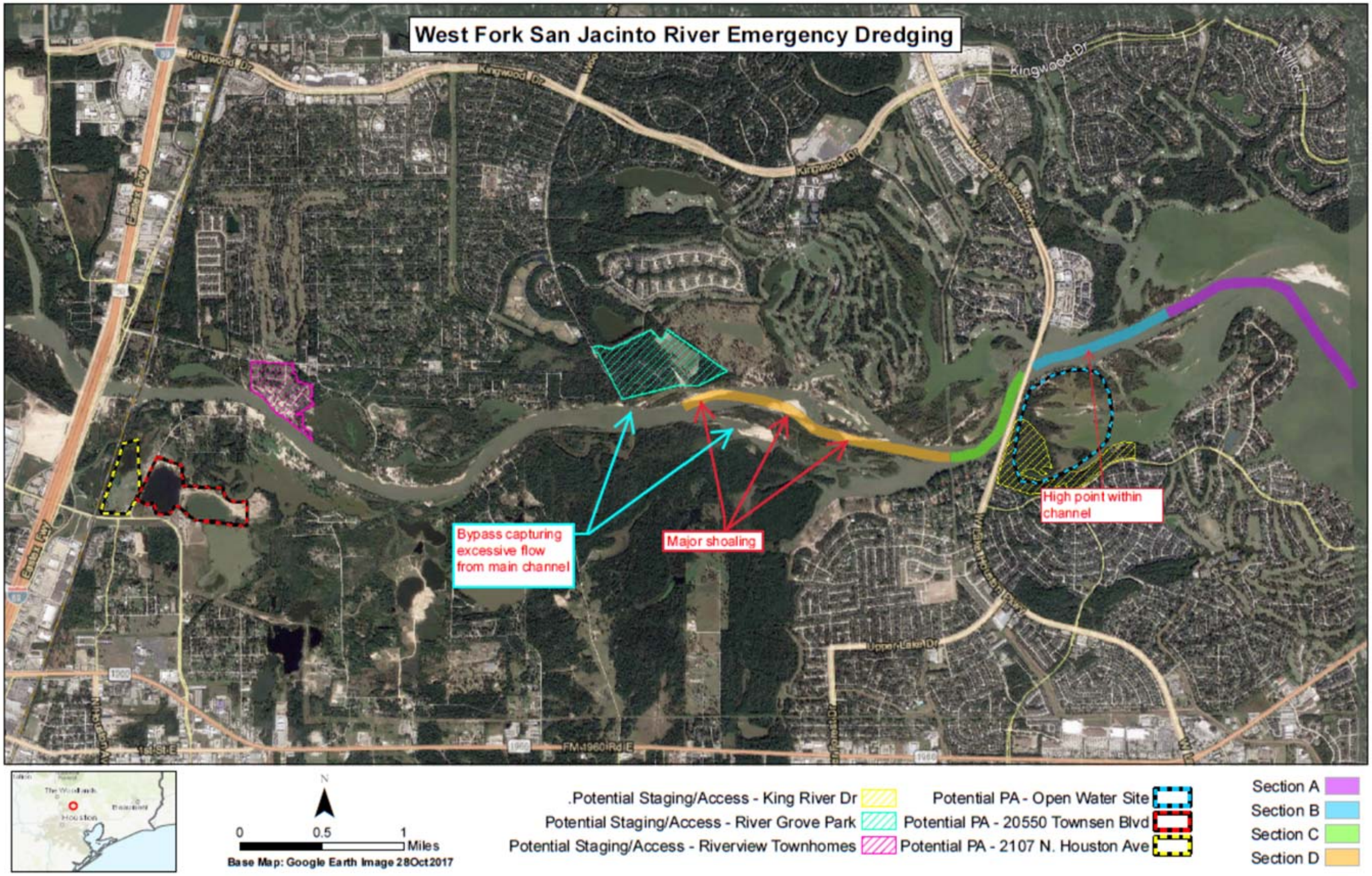
One concern noted was that the excessive flow from Hurricane Harvey had scoured out widened openings into at least two side channels, and the reduced flow in the main channel had allowed sediment to build up sand bars in three places within the main channel, as well as one short reach immediately downstream from the West Lake Houston Parkway bridge. The overall plan of the project on the next page shows the two side channels as well as the sand bars within the main channel.

Function Analysis: Value Engineering focuses on project functions rather than features. The team identified functions, which were organized into a Function Analysis System Technique showing the relationship between critical project functions and a FAST diagram was developed (see Appendix C).

Creativity Phase: The Team speculated by conducting a brainstorming session to generate ideas for alternative designs. All team members contributed ideas and critical analysis of the ideas was discouraged (see Appendix D).

Evaluation Phase: All ideas generated during speculation were thoroughly screened by the value engineering team to determine potential for savings and possibilities for risk, as well as whether they were feasible with respect to operations, constructability, or environmental concerns. Ideas that did not survive critical analysis were deleted. The Speculation List in Appendix D includes notation of the VE team decisions on whether ideas should be developed, and how fully they should be presented.

Development Phase: The most viable ideas surviving the Evaluation Phase were developed into written proposals by VE team members. Proposal descriptions, along



West Fork San Jacinto River Emergency Dredging
Kingwood Dr
Bypass capturing excessive flow from main channel
Major shoaling
High point within channel
Upper Lake Dr
FM 1960 Rd E
.Potential Staging/Access - King River Dr
Potential Staging/Access - River Grove Park
Potential Staging/Access - Riverview Townhomes
Potential PA - Open Water Site
Potential PA - 20550 Townsen Blvd
Potential PA - 2107 N. Houston Ave
Section A
Section B
Section C
Section D
N
0
0.5
1
Miles
Base Map: Google Earth Image 28Oct2017

with sketches, technical support documentation, and cost estimates were prepared to support implementation of ideas. Additional ideas are included as comments, or design suggestions, also presented in the report. This report also notes ideas which were not developed for technical or other reasons, as well as those which are already included as part of the design.

Out of the total number of 42 ideas brought up during the creativity phase, four were considered as potentially viable Proposals and 21 as Design Comments. Some of the remaining ideas were not developed because they are already being done, and others rejected for environmental, economic or operational reasons, or because they would delve into political discussions outside the scope of this study. The final count of proposals and comments varied as ideas are merged or deleted if they were found to be non-viable. It should also be noted that idea descriptions often change from the original speculation list to the developed idea.

Presentation Phase: The final phase of the Value Engineering Study included an outbrief and this VE Study Report, which will be distributed to all appropriate project supporters and decision-makers. Recommendations by these decision-makers will be incorporated when this report is finalized.

Potential cost avoidance for proposals included in the following table are based on life cycle cost analysis over a fifty-year period, based on the assumptions that (1) dredging the original channel without reducing flows to the side channels will not increase velocity to prevent sediment from dropping off and blocking the channel again, and that (2) failing to reinforce the toe as recommended in Comment C-5 will result in the banks caving in, since the trees are already leaning.

## SUMMARY OF RECOMMENDATIONS

| Comment No. | Description | Comments | Tentative Cost Avoidance (51 years) |
|---|---|---|---|
| P-1 | Create a weir to force flow thru main channel (Proposals are mutually exclusive.) | | |
| P-1A | Timber Piles | Creates natural hiding place for aquatic species. | Initial: ($641 K), LCC: $173M |
| P-1B | Fiberglass-Reinforced Polymer (FRP) sheetpile weir | Requires barge-mounted vibratory pile-driving equipment | Initial: ($858 K), LCC: $208M |
| P-1C | Piled Rock | Consistent with natural habitat | Initial: ($609 K), LCC: $208M |
| P-1D | Concrete Rubble | Reutilizes construction debris, but may be a water quality concern | Initial: ($615 K), LCC: $208M |
| P-1E | Tree Debris | Creates natural hiding place for aquatic species. Anchoring material could be a challenge. | Initial: ($577 K), LCC: $148M |
| C-1 | Be proactive with local businesses and residents to head off potential complaints | Critical for public relations success of project. | |
| C-2 | Explore beneficial use of dredged material, i.e., for public or private beaches on Lake Houston | C-2 and C-4 are non-Federal recommendations. | |
| C-3 | Install bumpers for debris on bridge piers | Non-Federal recommendation. | |
| C-4 | Explore incentives to encourage local entities to dredge Lake Houston | Combine with C-2. | |
| C-5 | Use stone toe to armor the base of the channel to prevent bank sloughing | Included in P-1 analyses. | |
| C-6 | Use barge with clamshell buckets for shoals | Contractor option. | |
| C-7 | Require noise monitoring within contract | Critical for public relations success of project. | |

| Comment No. | Description | Comments | Tentative Cost Avoidance (51 years) |
|---|---|---|---|
| C-8 | Use timber mats to extend access from existing boat ramps to edge of water | Contractor option. | |
| C-9 | Regulate sand mining operations | Outside scope of project. | |
| C-10 | Establish periodic maintenance dredging | Non-Federal concern; discussed in Proposal P-1. | |
| C-11 | Create an MOU with HCFCD, Harris County, and TxDOT for regular bridge debris removal | Related to Comment C-3. | |
| C-12 | Conduct a feasibility study for Flood Risk Management (FRM) and/or Ecosystem Restoration (ER) for the entire system | Outside scope of current project, but worth discussing at higher level. | |
| | | | |

VALUE ENGINEERING TEAM STUDY

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| | |
|---|---|
| **PROGRAM:** | West Fork San Jacinto River - Emergency Dredging |
| **LOCATION:** | Greater Houston area, Texas |
| **PROPOSAL #:** | P-1 |
| **DESCRIPTION:** | Create a weir to force flow thru main channel (Speculation List # 7, 8 & 27) |

**DESCRIPTION OF ORIGINAL CONCEPT:**
Leave the bypass channels open and allow a large percentage of water to flow thru them.

**DESCRIPTION OF ALTERNATIVE CONCEPT:**
The alternative consists of across the side channels where the river gets divided. The piles will block most of the flow using these secondary channels. The purpose is to concentrate the flow in the main channel.

Alternative ideas considered to reduce flow into the side channels include

P-1A. Timber piles driven close together
P-1B. Fiberglass-Reinforced Polymer (FRP) sheetpile
(https://www.wolfremediation.com/home/composite-sheet-pile/wr-532/)
P-1C. Piled rock
P-1D. Piled concrete rubble
P-1E. Downed trees which will be snagged and cleared from the channel

**ADVANTAGES OF ALTERNATIVE CONCEPT**

- Will help keep the main channel flushed or scoured, reducing the amount of sand drop in the area.
- Keeping the top of the weir or rock pile slightly below the normal water level allows the side channel to continue bypassing excessive flows.
- Restoring the majority of flow to the main channel will make the sediment flow more sustainable and reduce future dredging requirements.
- Reutilizing tree debris to the head of the bypasses provides a natural hiding place for some species

**DISADVANTAGES OF ALTERNATIVE CONCEPT**

- The government would be creating a new structure which might require maintenance
- The project may not authorize new features
- Using concrete rubble might adversely affect water quality

- Relocating tree debris from the main channel to the head of the bypass might take time to be secured to the side channel bottom and build up enough bulk to block flow

**DISCUSSION**

This alternative could be recommended to local authority in charge of preventing flooding as an inexpensive way to help to keep the channel open longer time. Not installing the weir will reduce time when the channel will have to be dredged again. The photo below shows a FRP sheet pile wall similar to the intended weir, although the proposed weir would be submerged.

<u>Quantity assumptions for proposals:</u>

Current design:
Mobilization/demobilization: $800,000
Initial dredging: 1.6 MCY
Repeat dredging main channel, 0.8 MCY, every three years (Not included in FEMA authorization, but it would be necessary for local floodplain maintenance. Same cost for mob/demob would occur even though less sediment is being dredged.

Proposed designs:
Increased initial costs for weirs and rock toes
Replace timber piles and repeat dredging 0.8 MCY every 15 years for P-1A
Replace tree debris piles and repeat dredging 0.8 MCY every 10 years for P-1E
No replacement or repetition of dredging required for P-1B, P-1C, or P-1D

**WEIR PICTURE**

**First tab of Cost Comparison for Proposal P-1A, constructing timber pile weirs, is based on initial construction costs only:**

| COST WORKSHEET | | | | | | | |
|---|---|---|---|---|---|---|---|
| PROJECT: | West Fork San Jacinto River - Emergency Dredging | | | | | PROPOSAL NO. | |
| PROPOSAL TITLE: | Use a Timber-Pile Weir to reduce flow to side channels | | | | | P-1A | |
| CONSTRUCTION ITEM | | CURRENT DESIGN | | | PROPOSED DESIGN | | |
| ITEM | UNITS | NO. OF UNITS | COST/ UNIT | TOTAL | NO. OF UNITS | COST/ UNIT | TOTAL |
| | | | | - | | | |
| near golf course (Sta 666+00), 42 - 30 LF x 12 IN DIA spaced @ 3 FT | VLF | | | - | 1,260 | 25.93 | 32,672 |
| Timber Piles at South Bypass, Sta 686+00, 60 - 30 LF x 12 IN DIA spaced @ 3 FT | VLF | | | - | 1,800 | 25.93 | 46,674 |
| Rock Toe at base of vulnerable | CY | | | - | 3,667 | 120.00 | 440,040 |
| Initial dredging | CY | 1,600,317 | 18.00 | 28,805,712 | 1,600,317 | 18.00 | 28,805,712 |
| Mobilization/Demobilization | LS | | | 800,000 | | | 800,000 |
| | | | | - | | | |
| | | | | - | | | |
| | | | | - | | | |
| | | | | - | | | |
| | | | | - | | | |
| | | | | - | | | |
| Subtotal | | | | 29,605,712 | | | 30,125,098 |
| Markup % | | 23.3% | | 6,911,873 | | | 7,033,131 |
| **TOTAL** | | | | 36,517,585 | | | 37,158,229 |
| | Net Cost Avoidance (or Cost Increase) | | | | | | **(640,644)** |

**Second tab of Cost Comparison for Proposal P-1A, constructing timber pile weirs, shows Life Cycle Comparison.**

It is assumed that only dredging the main channel will result in having to redredge at least 50% as much as the initial dredging every three years, and the proposal would include replacing timber piles every 15 years along with the minor dredging:

**LIFE CYCLE COST ESTIMATE WORKSHEET**
**West Fork San Jacinto River - Emergency Dredging**

| | | | |
|---|---|---|---|
| Proposal P-1A | Use a Timber-Pile Weir to reduce flow to side channels | | |
| ***System A - Service Life Years vs. System B - Service Life Years*** | | | |
| ANNUAL PERCENTAGE RATE: | **1.7000%** | ***Current Design*** | ***Proposed Change*** |
| | | ***Description*** | ***Description*** |
| INITIAL COST | | PRESENT WORTH | PRESENT WORTH |
| Timber Piles, North Bypass | | ***$0*** | ***$40,299*** |
| Timber Piles, SouthBypass | | ***$0*** | ***$57,571*** |
| Rock Toe | | ***$0*** | ***$542,774*** |
| Initial Dredging 1.6 MCY | | ***$35,530,814*** | ***$35,530,814*** |
| Mobilization/Demobilization | | ***$986,771*** | ***$986,771*** |
| | | | |
| | | | |
| SUBTOTAL | | ***$36,517,585*** | ***$37,158,229*** |

| (Given: i = 1.0 + 1.7"%) SINGLE EXPENDITURE | YEAR | PRESENT WORTH FACTOR | ESTIMATE | PRESENT WORTH | ESTIMATE | PRESENT WORTH |
|---|---|---|---|---|---|---|
| ***Mob/Demob & Dredge 0.8 MCY*** | ***3*** | ***0.95069*** | ***$18,752,178*** | ***$17,827,435*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***6*** | ***0.90380*** | ***$18,752,178*** | ***$16,948,295*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***9*** | ***0.85923*** | ***$18,752,178*** | ***$16,112,508*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***12*** | ***0.81686*** | ***$18,752,178*** | ***$15,317,937*** | ***$0*** | ***$0*** |
| ***Replace Timber Piles and Repeat dredging*** | ***15*** | ***0.77658*** | ***$18,752,178*** | ***$14,562,550*** | ***$18,850,048*** | ***$14,638,554*** |
| ***Repeat*** | ***18*** | ***0.73828*** | ***$18,752,178*** | ***$13,844,414*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***21*** | ***0.70188*** | ***$18,752,178*** | ***$13,161,692*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***24*** | ***0.66726*** | ***$18,752,178*** | ***$12,512,637*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***27*** | ***0.63436*** | ***$18,752,178*** | ***$11,895,590*** | ***$0*** | ***$0*** |
| ***Replace Timber Piles and Repeat dredging*** | ***30*** | ***0.60308*** | ***$18,752,178*** | ***$11,308,972*** | ***$18,850,048*** | ***$11,367,995*** |
| ***Repeat*** | ***33*** | ***0.57334*** | ***$18,752,178*** | ***$10,751,283*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***36*** | ***0.54506*** | ***$18,752,178*** | ***$10,221,095*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***39*** | ***0.51818*** | ***$18,752,178*** | ***$9,717,053*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***42*** | ***0.49263*** | ***$18,752,178*** | ***$9,237,867*** | ***$0*** | ***$0*** |
| ***Replace Timber Piles and Repeat dredging*** | ***45*** | ***0.46834*** | ***$18,752,178*** | ***$8,782,312*** | ***$18,850,048*** | ***$8,828,148*** |
| ***Repeat*** | ***48*** | ***0.44524*** | ***$18,752,178*** | ***$8,349,221*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***51*** | ***0.42328*** | ***$18,752,178*** | ***$7,937,489*** | ***$0*** | ***$0*** |
| SALVAGE VALUE | ***0*** | ***0*** | ***$0*** | ***$0*** | ***$0*** | ***$0*** |
| SUBTOTAL | | | | ***$208,488,349*** | | ***$34,834,697*** |

| *(Given: i = 1.0 + 1.7"%)*<br>ANNUAL<br>EXPENDITURE | YEAR | UNI PMT<br>PW<br>FACTOR | ESTIMATE | PRESENT<br>WORTH | ESTIMATE | PRESENT<br>WORTH |
|---|---|---|---|---|---|---|
| | 25 | 20.22887 | $0 | $0 | $0 | $0 |
| | 50 | 33.50121 | $0 | $0 | $0 | $0 |
| | 75 | 42.20932 | $0 | $0 | $0 | $0 |
| | 100 | 47.92279 | $0 | $0 | $0 | $0 |
| | | | | | | |
| SUBTOTAL | | | | $0 | | $0 |
| | | | | | | |
| TOTAL PRESENT WORTH | | | | $245,005,934 | | $71,992,926 |
| TOTAL LIFE CYCLE SAVINGS | | | | $173,013,008 | | |

## COST WORKSHEET

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| PROJECT: | West Fork San Jacinto River - Emergency Dredging | | | | | PROPOSAL NO. | |
| PROPOSAL TITLE: | Use Fiberglass-Reinforced Polymer (FRP) Weir to reduce flow to side channels | | | | | P-1B | |
| **CONSTRUCTION ITEM** | | **CURRENT DESIGN** | | | **PROPOSED DESIGN** | | |
| ITEM | UNITS | NO. OF UNITS | COST/ UNIT | TOTAL | NO. OF UNITS | COST/ UNIT | TOTAL |
| | | | | - | | | |
| FRP Sheetpile Weir at North Bypass, near golf course (Sta 666+00), 125 FT wide x 30 FT high | SF | | | - | 3,750 | 27.93 | 104,738 |
| FRP Sheetpile Weir at South Bypass, Sta 686+00, 180 FT wide x 30 FT high | SF | | | - | 5,400 | 27.93 | 150,822 |
| Rock Toe at base of vulnerable slopes, assuming 5 FT height x 5 FT depth x 0.75 MI length | CY | | | - | 3,667 | 120.00 | 440,040 |
| Initial dredging | CY | 1,600,317 | 18.00 | 28,805,712 | 1,600,317 | 18.00 | 28,805,712 |
| Mobilization/Demobilization | LS | | | 800,000 | | | 800,000 |
| | | | | - | | | |
| | | | | - | | | |
| | | | | - | | | |
| | | | | - | | | |
| | | | | - | | | |
| | | | | - | | | |
| Subtotal | | | | 29,605,712 | | | 30,301,311 |
| Markup % | | 23.3% | | 6,911,873 | | | 7,074,271 |
| **TOTAL** | | | | 36,517,585 | | | 37,375,582 |
| | Net Cost Avoidance (or Cost Increase) | | | | | | **(857,997)** |

## LIFE CYCLE COST ESTIMATE WORKSHEET
### West Fork San Jacinto River - Emergency Dredging

| | | | | | | |
|---|---|---|---|---|---|---|
| Proposal P-1B | Use Fiberglass-Reinforced Polymer (FRP) Weir to reduce flow to side channels | | | | | |
| ***System A - Service Life Years vs. System B - Service Life Years*** | | | | | | |
| ANNUAL PERCENTAGE RATE: | | **1.7000%** | ***Current Design*** | | ***Proposed Change*** | |
| | | | ***Description*** | | ***Description*** | |
| INITIAL COST | | | PRESENT WORTH | | PRESENT WORTH | |
| FRP Sheetpile Weir at North Bypass | | | | ***$0*** | | ***$129,190*** |
| FRP Sheetpile Weir at South Bypass | | | | ***$0*** | | ***$186,034*** |
| Rock Toe | | | | ***$0*** | | ***$542,774*** |
| Initial Dredging 1.6 MCY | | | | ***$35,530,814*** | | ***$35,530,814*** |
| Mobilization/Demobilization | | | | ***$986,771*** | | ***$986,771*** |
| | | | | | | |
| | | | | | | |
| SUBTOTAL | | | | ***$36,517,585*** | | ***$37,375,582*** |
| | | | | | | |
| *(Given: i = 1.0 + 1.7"%)* SINGLE EXPENDITURE | YEAR | PRESENT WORTH FACTOR | ESTIMATE | PRESENT WORTH | ESTIMATE | PRESENT WORTH |
| ***Mob/Demob & Dredge 0.8 MCY*** | ***3*** | ***0.95069*** | ***$18,752,178*** | ***$17,827,435*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***6*** | ***0.90380*** | ***$18,752,178*** | ***$16,948,295*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***9*** | ***0.85923*** | ***$18,752,178*** | ***$16,112,508*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***12*** | ***0.81686*** | ***$18,752,178*** | ***$15,317,937*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***15*** | ***0.77658*** | ***$18,752,178*** | ***$14,562,550*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***18*** | ***0.73828*** | ***$18,752,178*** | ***$13,844,414*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***21*** | ***0.70188*** | ***$18,752,178*** | ***$13,161,692*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***24*** | ***0.66726*** | ***$18,752,178*** | ***$12,512,637*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***27*** | ***0.63436*** | ***$18,752,178*** | ***$11,895,590*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***30*** | ***0.60308*** | ***$18,752,178*** | ***$11,308,972*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***33*** | ***0.57334*** | ***$18,752,178*** | ***$10,751,283*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***36*** | ***0.54506*** | ***$18,752,178*** | ***$10,221,095*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***39*** | ***0.51818*** | ***$18,752,178*** | ***$9,717,053*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***42*** | ***0.49263*** | ***$18,752,178*** | ***$9,237,867*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***45*** | ***0.46834*** | ***$18,752,178*** | ***$8,782,312*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***48*** | ***0.44524*** | ***$18,752,178*** | ***$8,349,221*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***51*** | ***0.42328*** | ***$18,752,178*** | ***$7,937,489*** | ***$0*** | ***$0*** |
| SALVAGE VALUE | ***0*** | ***0*** | ***$0*** | ***$0*** | ***$0*** | ***$0*** |
| SUBTOTAL | | | | ***$208,488,349*** | | ***$0*** |

| *(Given: i = 1.0 + 1.7"%)* ANNUAL EXPENDITURE | YEAR | UNI PMT PW FACTOR | ESTIMATE | PRESENT WORTH | ESTIMATE | PRESENT WORTH |
|---|---|---|---|---|---|---|
| | ***25*** | ***20.22887*** | ***$0*** | ***$0*** | ***$0*** | ***$0*** |
| | ***50*** | ***33.50121*** | ***$0*** | ***$0*** | ***$0*** | ***$0*** |
| | ***75*** | ***42.20932*** | ***$0*** | ***$0*** | ***$0*** | ***$0*** |
| | ***100*** | ***47.92279*** | ***$0*** | ***$0*** | ***$0*** | ***$0*** |
| | | | | | | |
| SUBTOTAL | | | | ***$0*** | | ***$0*** |
| | | | | | | |
| TOTAL PRESENT WORTH | | | | ***$245,005,934*** | | ***$37,375,582*** |
| TOTAL LIFE CYCLE SAVINGS | | | | **$207,630,352** | | |

# COST WORKSHEET

| | | | |
|---|---|---|---|
| PROJECT: | West Fork San Jacinto River - Emergency Dredging | PROPOSAL NO. | |
| PROPOSAL TITLE: | Use Rock Piles to reduce flow to side channels | P-1C | |

| **CONSTRUCTION ITEM** | | **CURRENT DESIGN** | | | **PROPOSED DESIGN** | | |
|---|---|---|---|---|---|---|---|
| ITEM | UNITS | NO. OF UNITS | COST/ UNIT | TOTAL | NO. OF UNITS | COST/ UNIT | TOTAL |
| | | | | - | | | |
| Rock pile at North Bypass, near golf course (Sta 666+00) | CY | | | - | 120 | 120.00 | 14,400 |
| Rock pile at South Bypass, Sta 686+00 | CY | | | - | 325 | 120.00 | 39,000 |
| Rock Toe at base of vulnerable slopes, assuming 5 FT height x 5 FT depth x 0.75 MI length | CY | | | - | 3,667 | 120.00 | 440,040 |
| Initial dredging | CY | 1,600,317 | 18.00 | 28,805,712 | 1,600,317 | 18.00 | 28,805,712 |
| Mobilization/Demobilization | LS | | | 800,000 | | | 800,000 |
| | | | | - | | | |
| | | | | - | | | |
| | | | | - | | | |
| | | | | - | | | |
| | | | | - | | | |
| | | | | - | | | |
| Subtotal | | | | 29,605,712 | | | 30,099,152 |
| Markup % | | 23.3% | | 6,911,873 | | | 7,027,074 |
| **TOTAL** | | | | 36,517,585 | | | 37,126,226 |
| | Net Cost Avoidance (or Cost Increase) | | | | | | **(608,641)** |

## LIFE CYCLE COST ESTIMATE WORKSHEET

### West Fork San Jacinto River - Emergency Dredging

| | | | | | | |
|---|---|---|---|---|---|---|
| Proposal P-1C | Use Rock Piles to reduce flow to side channels | | | | | |
| ***System A - Service Life Years vs. System B - Service Life Years*** | | | | | | |
| ANNUAL PERCENTAGE RATE: | | **1.7000%** | ***Current Design*** | | ***Proposed Change*** | |
| | | | ***Description*** | | ***Description*** | |
| INITIAL COST | | | PRESENT WORTH | | PRESENT WORTH | |
| Rock Pile at North Bypass | | | ***$0*** | | ***$17,762*** | |
| Rock PIle at South Bypass | | | ***$0*** | | ***$48,105*** | |
| Rock Toe | | | ***$0*** | | ***$542,774*** | |
| Initial Dredging 1.6 MCY | | | ***$35,530,814*** | | ***$35,530,814*** | |
| Mobilization/Demobilization | | | ***$986,771*** | | ***$986,771*** | |
| | | | | | | |
| | | | | | | |
| SUBTOTAL | | | ***$36,517,585*** | | ***$37,126,226*** | |
| | | | | | | |
| *(Given: i = 1.0 + 1.7"%)* SINGLE EXPENDITURE | YEAR | PRESENT WORTH FACTOR | ESTIMATE | PRESENT WORTH | ESTIMATE | PRESENT WORTH |
| ***Mob/Demob & Dredge 0.8 MCY*** | ***3*** | ***0.95069*** | ***$18,752,178*** | ***$17,827,435*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***6*** | ***0.90380*** | ***$18,752,178*** | ***$16,948,295*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***9*** | ***0.85923*** | ***$18,752,178*** | ***$16,112,508*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***12*** | ***0.81686*** | ***$18,752,178*** | ***$15,317,937*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***15*** | ***0.77658*** | ***$18,752,178*** | ***$14,562,550*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***18*** | ***0.73828*** | ***$18,752,178*** | ***$13,844,414*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***21*** | ***0.70188*** | ***$18,752,178*** | ***$13,161,692*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***24*** | ***0.66726*** | ***$18,752,178*** | ***$12,512,637*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***27*** | ***0.63436*** | ***$18,752,178*** | ***$11,895,590*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***30*** | ***0.60308*** | ***$18,752,178*** | ***$11,308,972*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***33*** | ***0.57334*** | ***$18,752,178*** | ***$10,751,283*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***36*** | ***0.54506*** | ***$18,752,178*** | ***$10,221,095*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***39*** | ***0.51818*** | ***$18,752,178*** | ***$9,717,053*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***42*** | ***0.49263*** | ***$18,752,178*** | ***$9,237,867*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***45*** | ***0.46834*** | ***$18,752,178*** | ***$8,782,312*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***48*** | ***0.44524*** | ***$18,752,178*** | ***$8,349,221*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***51*** | ***0.42328*** | ***$18,752,178*** | ***$7,937,489*** | ***$0*** | ***$0*** |
| SALVAGE VALUE | ***0*** | ***0*** | ***$0*** | ***$0*** | ***$0*** | ***$0*** |
| SUBTOTAL | | | | ***$208,488,349*** | | ***$0*** |

| (Given: i = 1.0 + 1.7"%) ANNUAL EXPENDITURE | YEAR | UNI PMT PW FACTOR | ESTIMATE | PRESENT WORTH | ESTIMATE | PRESENT WORTH |
|---|---|---|---|---|---|---|
| | 25 | 20.22887 | $0 | $0 | $0 | $0 |
| | 50 | 33.50121 | $0 | $0 | $0 | $0 |
| | 75 | 42.20932 | $0 | $0 | $0 | $0 |
| | 100 | 47.92279 | $0 | $0 | $0 | $0 |
| | | | | | | |
| SUBTOTAL | | | | $0 | | $0 |
| | | | | | | |
| TOTAL PRESENT WORTH | | | | $245,005,934 | | $37,126,226 |
| TOTAL LIFE CYCLE SAVINGS | | | | $207,879,708 | | |

# COST WORKSHEET

| PROJECT: | West Fork San Jacinto River - Emergency Dredging | PROPOSAL NO. |
|---|---|---|
| PROPOSAL TITLE: | Use Broken Concrete Rubble to reduce flow to side channels | P-1D |

| CONSTRUCTION ITEM | | CURRENT DESIGN | | | PROPOSED DESIGN | | |
|---|---|---|---|---|---|---|---|
| ITEM | UNITS | NO. OF UNITS | COST/ UNIT | TOTAL | NO. OF UNITS | COST/ UNIT | TOTAL |
| | | | | - | | | |
| Rubble pile at North Bypass, near golf course (Sta 666+00), 125 FT wide x 12 FT high, 3H:1V slopes | CY | | | - | 120 | 131.45 | 15,774 |
| Rubble pile at South Bypass, Sta 686+00, 180 FT wide x 12 FT high, 3H:1V slopes | CY | | | - | 325 | 131.45 | 42,721 |
| Rock Toe at base of vulnerable slopes, assuming 5 FT height x 5 FT depth x 0.75 MI length | CY | | | - | 3,667 | 120.00 | 440,040 |
| Initial dredging | CY | 1,600,317 | 18.00 | 28,805,712 | 1,600,317 | 18.00 | 28,805,712 |
| Mobilization/Demobilization | LS | | | 800,000 | | | 800,000 |
| | | | | - | | | |
| | | | | - | | | |
| | | | | - | | | |
| | | | | - | | | |
| | | | | - | | | |
| | | | | - | | | |
| Subtotal | | | | 29,605,712 | | | 30,104,247 |
| Markup % | | 23.3% | | 6,911,873 | | | 7,028,263 |
| **TOTAL** | | | | 36,517,585 | | | 37,132,511 |
| | Net Cost Avoidance (or Cost Increase) | | | | | | **(614,925)** |

**LIFE CYCLE COST ESTIMATE WORKSHEET**
**West Fork San Jacinto River - Emergency Dredging**

| | | | | | | |
|---|---|---|---|---|---|---|
| Proposal P-1D | Use Broken Concrete Rubble to reduce flow to side channels | | | | | |
| ***System A - Service Life Years vs. System B - Service Life Years*** | | | | | | |
| ANNUAL PERCENTAGE RATE: | | **1.7000%** | ***Current Design*** | | ***Proposed Change*** | |
| | | | ***Description*** | | ***Description*** | |
| INITIAL COST | | | PRESENT WORTH | | PRESENT WORTH | |
| Rock Pile at North Bypass | | | ***$0*** | | ***$19,457*** | |
| Rock PIle at South Bypass | | | ***$0*** | | ***$52,695*** | |
| Rock Toe | | | ***$0*** | | ***$542,774*** | |
| Initial Dredging 1.6 MCY | | | ***$35,530,814*** | | ***$35,530,814*** | |
| Mobilization/Demobilization | | | ***$986,771*** | | ***$986,771*** | |
| | | | | | | |
| | | | | | | |
| SUBTOTAL | | | ***$36,517,585*** | | ***$37,132,511*** | |
| | | | | | | |
| *(Given: i = 1.0 + 1.7"%)* SINGLE EXPENDITURE | YEAR | PRESENT WORTH FACTOR | ESTIMATE | PRESENT WORTH | ESTIMATE | PRESENT WORTH |
| ***Mob/Demob & Dredge 0.8 MCY*** | ***3*** | ***0.95069*** | ***$18,752,178*** | ***$17,827,435*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***6*** | ***0.90380*** | ***$18,752,178*** | ***$16,948,295*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***9*** | ***0.85923*** | ***$18,752,178*** | ***$16,112,508*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***12*** | ***0.81686*** | ***$18,752,178*** | ***$15,317,937*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***15*** | ***0.77658*** | ***$18,752,178*** | ***$14,562,550*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***18*** | ***0.73828*** | ***$18,752,178*** | ***$13,844,414*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***21*** | ***0.70188*** | ***$18,752,178*** | ***$13,161,692*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***24*** | ***0.66726*** | ***$18,752,178*** | ***$12,512,637*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***27*** | ***0.63436*** | ***$18,752,178*** | ***$11,895,590*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***30*** | ***0.60308*** | ***$18,752,178*** | ***$11,308,972*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***33*** | ***0.57334*** | ***$18,752,178*** | ***$10,751,283*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***36*** | ***0.54506*** | ***$18,752,178*** | ***$10,221,095*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***39*** | ***0.51818*** | ***$18,752,178*** | ***$9,717,053*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***42*** | ***0.49263*** | ***$18,752,178*** | ***$9,237,867*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***45*** | ***0.46834*** | ***$18,752,178*** | ***$8,782,312*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***48*** | ***0.44524*** | ***$18,752,178*** | ***$8,349,221*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***51*** | ***0.42328*** | ***$18,752,178*** | ***$7,937,489*** | ***$0*** | ***$0*** |
| SALVAGE VALUE | ***0*** | ***0*** | ***$0*** | ***$0*** | ***$0*** | ***$0*** |
| SUBTOTAL | | | | ***$208,488,349*** | | ***$0*** |

| *(Given: i = 1.0 + 1.7"%)* ANNUAL EXPENDITURE | YEAR | UNI PMT PW FACTOR | ESTIMATE | PRESENT WORTH | ESTIMATE | PRESENT WORTH |
|---|---|---|---|---|---|---|
| | 25 | 20.22887 | $0 | $0 | $0 | $0 |
| | 50 | 33.50121 | $0 | $0 | $0 | $0 |
| | 75 | 42.20932 | $0 | $0 | $0 | $0 |
| | 100 | 47.92279 | $0 | $0 | $0 | $0 |
| | | | | | | |
| SUBTOTAL | | | | $0 | | $0 |
| | | | | | | |
| TOTAL PRESENT WORTH | | | | $245,005,934 | | $37,132,511 |
| TOTAL LIFE CYCLE SAVINGS | | | | $207,873,423 | | |

# COST WORKSHEET

| | | |
|---|---|---|
| PROJECT: | West Fork San Jacinto River - Emergency Dredging | PROPOSAL NO. |
| PROPOSAL TITLE: | Relocate Tree Debris to reduce flow to side channels | P-1E |

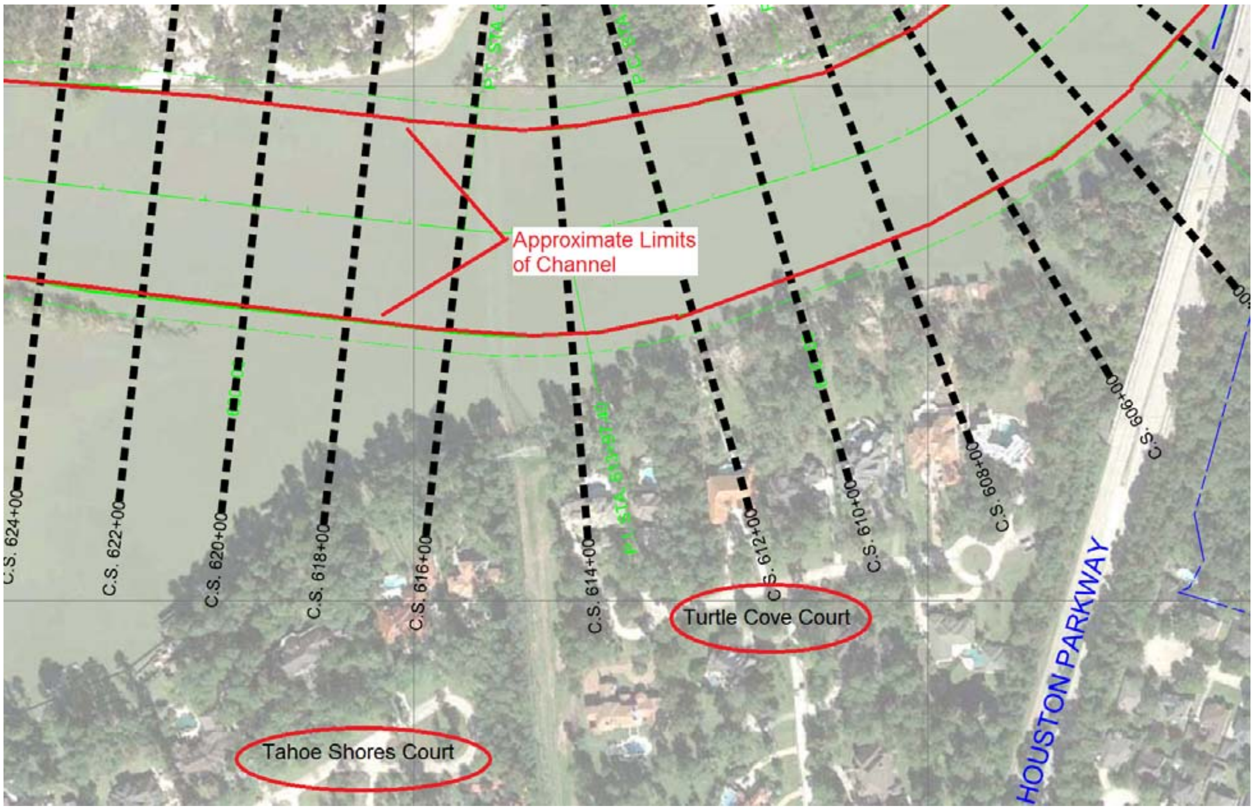
| CONSTRUCTION ITEM | | CURRENT DESIGN | | | PROPOSED DESIGN | | |
|---|---|---|---|---|---|---|---|
| ITEM | UNITS | NO. OF UNITS | COST/ UNIT | TOTAL | NO. OF UNITS | COST/ UNIT | TOTAL |
| | | | | - | | | |
| Relocate tree debris to North Bypass, near golf course (Sta 666+00) | CY | | | - | 120 | 63.00 | 7,560 |
| Relocate tree debris to South Bypass, Sta 686+00 | CY | | | - | 325 | 63.00 | 20,475 |
| Rock Toe at base of vulnerable slopes, assuming 5 FT height x 5 FT depth x 0.75 MI length | CY | | | - | 3,667 | 120.00 | 440,040 |
| Initial dredging | CY | 1,600,317 | 18.00 | 28,805,712 | 1,600,317 | 18.00 | 28,805,712 |
| Mobilization/Demobilization | LS | | | 800,000 | | | 800,000 |
| | | | | - | | | |
| | | | | - | | | |
| | | | | - | | | |
| | | | | - | | | |
| | | | | - | | | |
| | | | | - | | | |
| Subtotal | | | | 29,605,712 | | | 30,073,787 |
| Markup % | | 23.3% | | 6,911,873 | | | 7,021,152 |
| **TOTAL** | | | | 36,517,585 | | | 37,094,939 |
| | Net Cost Avoidance (or Cost Increase) | | | | | | **(577,354)** |

## LIFE CYCLE COST ESTIMATE WORKSHEET
### West Fork San Jacinto River - Emergency Dredging

| | | | | | | |
|---|---|---|---|---|---|---|
| Proposal P-1E | Relocate Tree Debris to reduce flow to side channels | | | | | |
| ***System A - Service Life Years vs. System B - Service Life Years*** | | | | | | |
| ANNUAL PERCENTAGE RATE: | | **1.7000%** | ***Current Design*** | | ***Proposed Change*** | |
| | | | ***Description*** | | ***Description*** | |
| INITIAL COST | | | PRESENT WORTH | | PRESENT WORTH | |
| Relocated tree debris at North Bypass | | | ***$0*** | | ***$9,325*** | |
| Relocated tree debris at South Bypass | | | ***$0*** | | ***$25,255*** | |
| Rock Toe | | | ***$0*** | | ***$542,774*** | |
| Initial Dredging 1.6 MCY | | | ***$35,530,814*** | | ***$35,530,814*** | |
| Mobilization/Demobilization | | | ***$986,771*** | | ***$986,771*** | |
| | | | | | | |
| | | | | | | |
| SUBTOTAL | | | ***$36,517,585*** | | ***$37,094,939*** | |
| | | | | | | |
| *(Given: i = 1.0 + 1.7"%)* SINGLE EXPENDITURE | YEAR | PRESENT WORTH FACTOR | ESTIMATE | PRESENT WORTH | ESTIMATE | PRESENT WORTH |
| ***Mob/Demob & Dredge 0.8 MCY*** | ***3*** | ***0.95069*** | ***$18,752,178*** | ***$17,827,435*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***6*** | ***0.90380*** | ***$18,752,178*** | ***$16,948,295*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***9*** | ***0.85923*** | ***$18,752,178*** | ***$16,112,508*** | ***$0*** | ***$0*** |
| ***Redredge & replace tree pile*** | ***10*** | ***0.84487*** | | ***$0*** | ***$19,320,207.01*** | ***$16,323,085*** |
| ***Repeat*** | ***12*** | ***0.81686*** | ***$18,752,178*** | ***$15,317,937*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***15*** | ***0.77658*** | ***$18,752,178*** | ***$14,562,550*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***18*** | ***0.73828*** | ***$18,752,178*** | ***$13,844,414*** | ***$0*** | ***$0*** |
| ***Redredge & replace tree pile*** | ***20*** | ***0.71381*** | | ***$0*** | ***$19,320,207.01*** | ***$13,790,903*** |
| ***Repeat*** | ***21*** | ***0.70188*** | ***$18,752,178*** | ***$13,161,692*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***24*** | ***0.66726*** | ***$18,752,178*** | ***$12,512,637*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***27*** | ***0.63436*** | ***$18,752,178*** | ***$11,895,590*** | ***$0*** | ***$0*** |
| ***Redredge & replace tree pile*** | ***30*** | ***0.60308*** | ***$18,752,178*** | ***$11,308,972*** | ***$19,320,207.01*** | ***$11,651,536*** |
| ***Repeat*** | ***33*** | ***0.57334*** | ***$18,752,178*** | ***$10,751,283*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***36*** | ***0.54506*** | ***$18,752,178*** | ***$10,221,095*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***39*** | ***0.51818*** | ***$18,752,178*** | ***$9,717,053*** | ***$0*** | ***$0*** |
| ***Redredge & replace tree pile*** | ***40*** | ***0.50952*** | | ***$0*** | ***$19,320,207.01*** | ***$9,844,047*** |
| ***Repeat*** | ***42*** | ***0.49263*** | ***$18,752,178*** | ***$9,237,867*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***45*** | ***0.46834*** | ***$18,752,178*** | ***$8,782,312*** | ***$0*** | ***$0*** |
| ***Repeat*** | ***48*** | ***0.44524*** | ***$18,752,178*** | ***$8,349,221*** | ***$0*** | ***$0*** |
| ***Redredge & replace tree pile*** | ***50*** | ***0.43048*** | | ***$0*** | ***$19,320,207.01*** | ***$8,316,951*** |
| ***Repeat*** | ***51*** | ***0.42328*** | ***$18,752,178*** | ***$7,937,489*** | ***$0*** | ***$0*** |
| SALVAGE VALUE | ***0*** | ***0*** | ***$0*** | ***$0*** | ***$0*** | ***$0*** |
| SUBTOTAL | | | | ***$208,488,349*** | | ***$59,926,522*** |

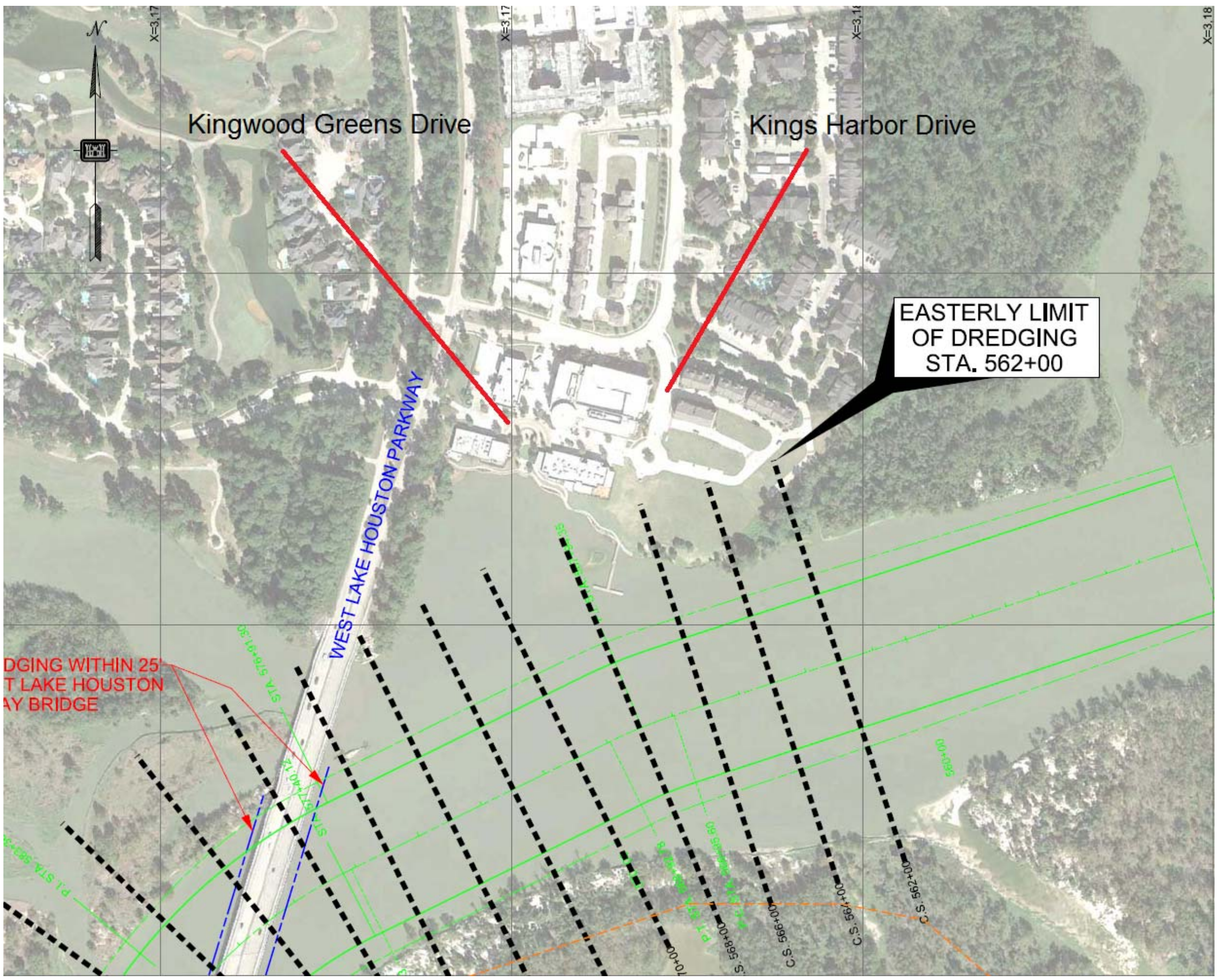
| *(Given: i = 1.0 + 1.7"%)* ANNUAL EXPENDITURE | YEAR | UNI PMT PW FACTOR | ESTIMATE | PRESENT WORTH | ESTIMATE | PRESENT WORTH |
|---|---|---|---|---|---|---|
| | ***25*** | ***20.22887*** | ***$0*** | ***$0*** | ***$0*** | ***$0*** |
| | ***50*** | ***33.50121*** | ***$0*** | ***$0*** | ***$0*** | ***$0*** |
| | ***75*** | ***42.20932*** | ***$0*** | ***$0*** | ***$0*** | ***$0*** |
| | ***100*** | ***47.92279*** | ***$0*** | ***$0*** | ***$0*** | ***$0*** |
| | | | | | | |
| SUBTOTAL | | | | ***$0*** | | ***$0*** |
| | | | | | | |
| TOTAL PRESENT WORTH | | | | ***$245,005,934*** | | ***$97,021,461*** |
| TOTAL LIFE CYCLE SAVINGS | | | | **$147,984,473** | | |

C-1. ***<u>Be proactive with local businesses and residents to head off potential complaints (Speculation List # 35, 36, 37 & 38):</u>*** It is suggested that residents and businesses which may be affected by the dredging operations be contacted for informational meetings regarding working hours and noise levels. In order to keep the contract cost-effective and achievable within the time goal, it is recommended that the contractor be allowed to work 24/7, except where the noise and lights would adversely affect nearby homes and businesses, as shown in the two reaches below:



The businesses and townhomes east of West Lake Houston Parkway bridge are currently unoccupied and being restored or renovated (Kingwood Greens Drive and Kings Harbor Drive). It is suggested that construction could possibly be phased to address this reach, Section B, first for the following reasons:

- Clearing the blockage which is furthest downstream enables natural scouring from future rain events
- If the work can be completed prior to reoccupation of the businesses and townhomes would allow the contractor to work 24/7, enabling more cost-effective completion



C-2. ***<u>Explore beneficial use of dredged material, i.e., for public or private beaches on Lake Houston (Speculation List # 18 & 23):</u>*** There are no known public beaches on Lake Houston. If there is interest, it might be useful to have a site to place sand dredged from the West Fork of the San Jacinto River or from Lake Houston. If the material is being reutilized at the same general site, the local sponsor might make a case against the entity being taxed for mining the sand.

C-3. ***<u>Install bumpers for debris on bridge piers (Speculation List # 25):</u>*** As shown in the following photos, the West Lake Houston Parkway Bridge has been acting as a trash rake for debris floating on the West Fork of the San Jacinto River. Since the bridge runs parallel with the stream for approximately 2600 feet, the number of piers blocking debris is multiplied. During Hurricane Harvey, the parkway had been submerged so debris had been trapped by beams as well as columns. It is suggested that bumpers be attached to the columns to reduce the physical impact of debris hitting the bridge.

C-4. ***<u>Explore incentives to encourage local entities to dredge Lake Houston (Speculation List # 32 & 33):</u>*** One major reason that stormwater and sediment back up from Lake Houston is the low water pool in the lake due to the build-up of sediment. The lake drains downstream using a weir and/or pumping. Sediment is not passed downstream. It was noted that the local community would be highly interested in dredging the lake, but the sand which would be removed is considered a saleable commodity and thus subject to mining fees from the State of Texas. It is suggested that the state waive the fees, even on a one-time basis, and allow the city to have the lake dredged down to the clay layer. This will help the sediment flow from both the West Fork and East Fork of the San Jacinto River.

C-5. ***<u>Use stone toe to armor the base of the channel to prevent bank sloughing (Speculation List # 6):</u>*** While the channel dredging will help move sediment down the West Fork to Lake Houston in the short run, it was noted during site visits that there are several trees along the banks leaning toward the channel. Cutting the side slope of the channel will further weaken the support for the trees. Building a stone toe along the base of the side slopes will provide some anchoring against slop failure or sloughing.

C-6. ***<u>Use barge with clamshell buckets for shoals (Speculation List # 17):</u>*** It is envisioned that the majority of the shoal material will be removed by a small cutterhead dredge. However, there are some areas to be dredged where the shoals have formed emergent sand bars that may be more easily excavated with mechanical equipment rather than a cutterhead. Placement areas are limited and their capacity is unknown, with the potential result that some of the material may have to be hauled off site by truck. In this case, excavation by clamshell would be more advantageous as it results in a lower water content than if excavated by a cutterhead. Finally, due to the anticipated short construction period, a combination of different types of dredges could be advantageous. In the end, the specifications should be written to allow the contractor the flexibility to choose which type of equipment to use, rather than prescribe one type over another.

C-7. ***<u>Require noise monitoring within contract (Spec List # 34):</u>*** A dredging contract in 2006 at Bayport Ship Channel resulted in complaints from nearby residents from the noise produced by the dredge and associated equipment. The noise issue was addressed the next time Bayport Channel was dredged in the vicinity of the residents by specifying noise requirements of the contractor. Prior to dredging near a residential area, the contractor will hire an Acoustical Consultant to develop and implement a noise control plan. Noise monitoring stations are established along the residential areas and sound measurements taken 7 days prior to dredging to establish a daytime and nighttime noise level baseline. The contractor is required to monitor the stations throughout the contract duration, and physically record the results twice a day. A weekly summary report should be provided to the government verifying noise compliance. The community of Kingwood is within the jurisdiction of the City of Houston (COH). The COH Noise Ordnance provides that for residential properties, the noise level should not exceed 65dB(A) during daytime (0800-2200hrs) and 58 dB(A) during nighttime.

C-8. ***Use timber mats to extend access from existing boat ramps to edge of water (Spec List # 40):*** There is no commercial traffic on this portion of the river, and the existing boat ramps are designed and intended for small recreational craft. Heavy construction equipment will be used to perform the work on this contract, and will most likely be brought in by trucks on low-boy trailers. Timber mats are often used to support heavy equipment working in soft or unstable soils and may be required to minimize damage to the existing boat ramps. The specifications should not necessarily prescribe the use of timber mats, but should contain cautionary language that advises the contractor that the boat ramps were designed for recreational use and any damage to the ramps must be repaired by the contractor.

C-9. ***Regulate sand mining operations (Speculation List # 11):*** This comment refers to sand mining operations upstream of the US 59 highway bridge that are within the floodplain. During flood events where the boundaries of the sand pits are overrun, the river carries sediment from these pits downstream. This is potentially a 404 issue/violation and it may be possible to get the mine operators to incorporate some abatement features to minimize the amount of sediment from their operations they discharge into the river.

C-10. ***Establish periodic maintenance dredging (Speculation List # 15):*** Regardless of how much we dredge out of the river during this initial action, the river is going to keep on returning sediment to this stretch of the river. One way to maintain the pre-Harvey FEMA baseline is regular maintenance dredging. This would also require regular surveys and permanent river access for dredging equipment. The 2000 Regional Flood Protection Study may have recommendations for this as well.

C-11. ***Create an MOU with HCFCD, Harris County, and TxDOT for regular bridge debris removal (Speculation List # 26):*** One of the main problems with shoaling in the river is the West Lake Houston Parkway Bridge and part of that is the large rafts of trees and debris that snag on the bridge piers. The debris snagging is a result of bridge piers being relatively close together and the fact that the bridge roughly parallels the river. So, debris moves north in between the piers rather than moving perpendicular to the bridge and going between the spans. There are multiple stakeholders within this portion of the river and therefore responsibility for this debris removal is uncertain, but the interest in removing the debris would be a shared interest, if not legal responsibility. To facilitate and expedite the removal, the USACE could suggest these stakeholders draft a Memorandum of Understanding (MOU) to regularly manage the removal of debris along the bridge.

C-12. ***Conduct a feasibility study for Flood Risk Management (FRM) and/or Ecosystem Restoration (ER) for the entire system (Speculation List # 39):*** The problem with dredging only during this initial action is that the river is going to eventually revert to its current state. This is a combination of factors related to the velocity of the water in the river channel. First, the river slows down at the West Lake Houston Parkway Bridge as it turns north. As water slows at the bridge, it dumps its suspended sediments on the east side of the bridge. The water then slows as it reaches the upper end of Lake Houston dumping its suspended sediments into a delta. The accretion of this delta creates a dam like feature which then increasingly slows water and accretes the delta, compounding the problem. Additionally, Lake Houston has a spillway dam, which does not allow the majority of sediments to leave the lake and move downstream, out of the system. Essentially, the system is all sediment in and no sediment out. To create a sustainable hydrologic system that would alleviate flood risk along the West Fork San Jacinto River and also maintain water capacity within the lake, the USACE could look at a broader FRM project that incorporates beneficial use features as mitigation, or an ER project that uses ER to improve the health of the river.

**VALUE ENGINEERING STUDY AGENDA**
**WEST FORK SAN JACINTO RIVER EMERGENCY DREDGING**
**GALVESTON DISTRICT, US ARMY CORPS OF ENGINEERS**

All meetings will be held in Galveston District Library. All times will be flexible, related to team processes, work schedules, breaks and lunchtimes. For instance, if the information phase takes less time than expected, the team may start other phases earlier.

**TUESDAY, 1 MAY 2018**

| | |
|---|---|
| 8:30 AM – 12:00 PM | Introductions and Agenda<br>Brief introduction to Value Engineering process<br>INFORMATION PHASE<br>In-briefing by Project Manager:<br>Overview of project history and status<br>Recommendations and constraints based on charrette<br>Alternatives considered and Lessons Learned |
| 12:00 PM – 1:00 PM | Lunch |
| 1:00 PM – 5:00 PM | FUNCTION ANALYSIS PHASE<br>What are we doing? Why? How?<br>Create FAST diagram to show relationship of functions<br>Introduction to CREATIVITY PHASE |

Homework assignment for evening:
Keep a notepad and pen on your night table in case you come up with questions or ideas in the middle of the night.

**WEDNESDAY, 2 MAY 2018**

| | |
|---|---|
| 8:30 AM – 12:00 PM | Complete CREATIVITY PHASE<br>Freeform brainstorming<br>EVALUATION PHASE<br>Screen ideas suggested during Speculation for Proposals or Comments to be developed, ideas already being done, or non-viable ideas<br>Assign Proposals and Comments<br>Go over formats and procedures for writing up ideas |
| 1:00 PM – 4:30 PM | Begin DEVELOPMENT PHASE<br>Write up ideas<br>Pass write-ups on to facilitator when completed |

**THURSDAY, 3 MAY 2018**

| | |
|---|---|
| 8:00 AM – 2:30 PM | Complete DEVELOPMENT PHASE<br>Write up ideas<br>Pass write-ups on to facilitator when completed |
| 2:30 PM – 4:30 PM | Team goes over each other's write-ups, compile remaining taskers, prepare for outbrief |

**FRIDAY, 4 MAY 2018**

| | |
|---|---|
| 8:30 AM – 12:00 PM | PRESENTATION PHASE<br>Present findings to Project Development Team and note responses<br>Discuss any remaining to-do items, i.e., uncompleted write-ups, responses from PDT during outbrief requiring follow-up revisions<br>Adjourn |

## APPENDIX B: ATTENDANCE LIST

| NAME / EMAIL | ROLE / ORGANIZATION | TELEPHONE |
|---|---|---|
| William S. Easley, PE, CVS * <br> billeasley@easleyvm.com | VE Team Co-Leader/Civil Engineer <br> CECO-O-RAO (Reemployed Annuitant Office, USACE) | 843-813-9599 |
| Jacob.C.Walsdorf <br> Jacob.C.Walsdorf@usace.army.mil | Value Engineering Officer/A-E Contract Coordinator <br> Professional Services Section, Galveston District | 409-766-3817 |
| Derek Anderson <br> derek.r.anderson@usace.army.mil | Acting Resident Engineer, Houston Resident Office <br> Galveston District, USACE | 409-766-3116 |
| Al Meyer <br> alton.h.meyer@usace.army.mil | Houston Resident Office <br> Galveston District, USACE | 409-766-3145 |
| José D. Castro-Rivera, PE * <br> Jose.D.Castro-Rivera@usace.army.mil | Civil Engineer, General Engineering Section <br> Galveston District, USACE | 409-766-6334 |
| Tuan Nguyen <br> tuan.q.nguyen@usace.army.mil | Civil Engineer, General Engineering Section <br> Galveston District, USACE | 409-766-3017 |
| Jason Story <br> jason.e.story@usace.army.mil | Regional Planning and Environmental Center <br> Fort Worth District, USACE | 817-886-1852 |
| John A. Campbell <br> john.a.campbell@usace.army.mil | Regional Planning and Environmental Center <br> Galveston District, USACE | 409-766-3878 |
| A. Rashid Ali <br> Abdurashid.y.sheikh-ali@usace.army.mil | Cost Engineer <br> Galveston District, USACE | 409-766-3096 |
| Michael Garske <br> Michael.L.Garske@usace.army.mil | Hydraulic Engineer, EC-EH <br> Galveston District, USACE | 409-766-3152 |

* Value Engineering Team Member

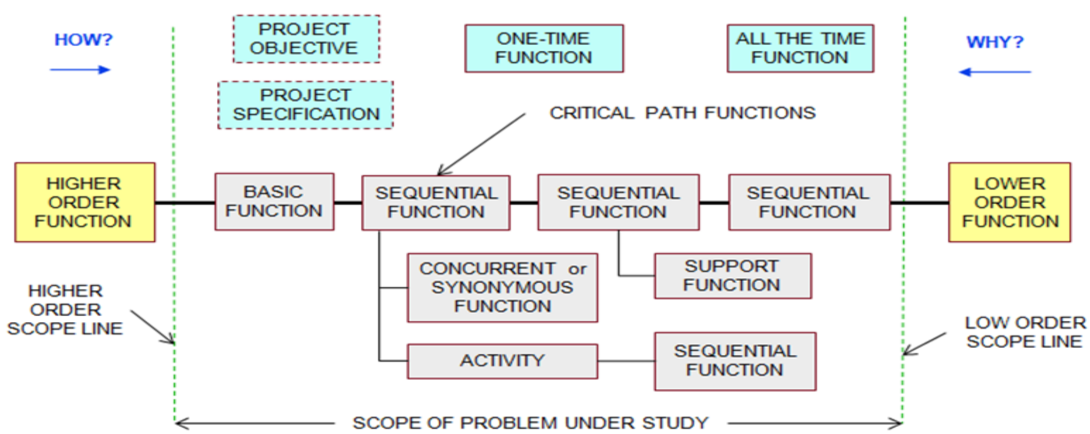
The key to Value Engineering is studying Functions rather than Features. Functions are expressed as two-word phrases with an active verb and a measureable noun. In the early 1960's, Charles W. Bytheway, a Mechanical Engineer with Sperry Rand, developed Function Analysis System Technique (FAST) Diagrams as a method to show specific relationships of important functions with respect to each other, deepen the understanding of the problem to be solved, promote discussion and flow from the Information Phase into the Creativity Phase.

FAST diagrams are Function-oriented, not time- or feature-oriented. There are several variations, but Classical and Technical are used most often in USACE studies.

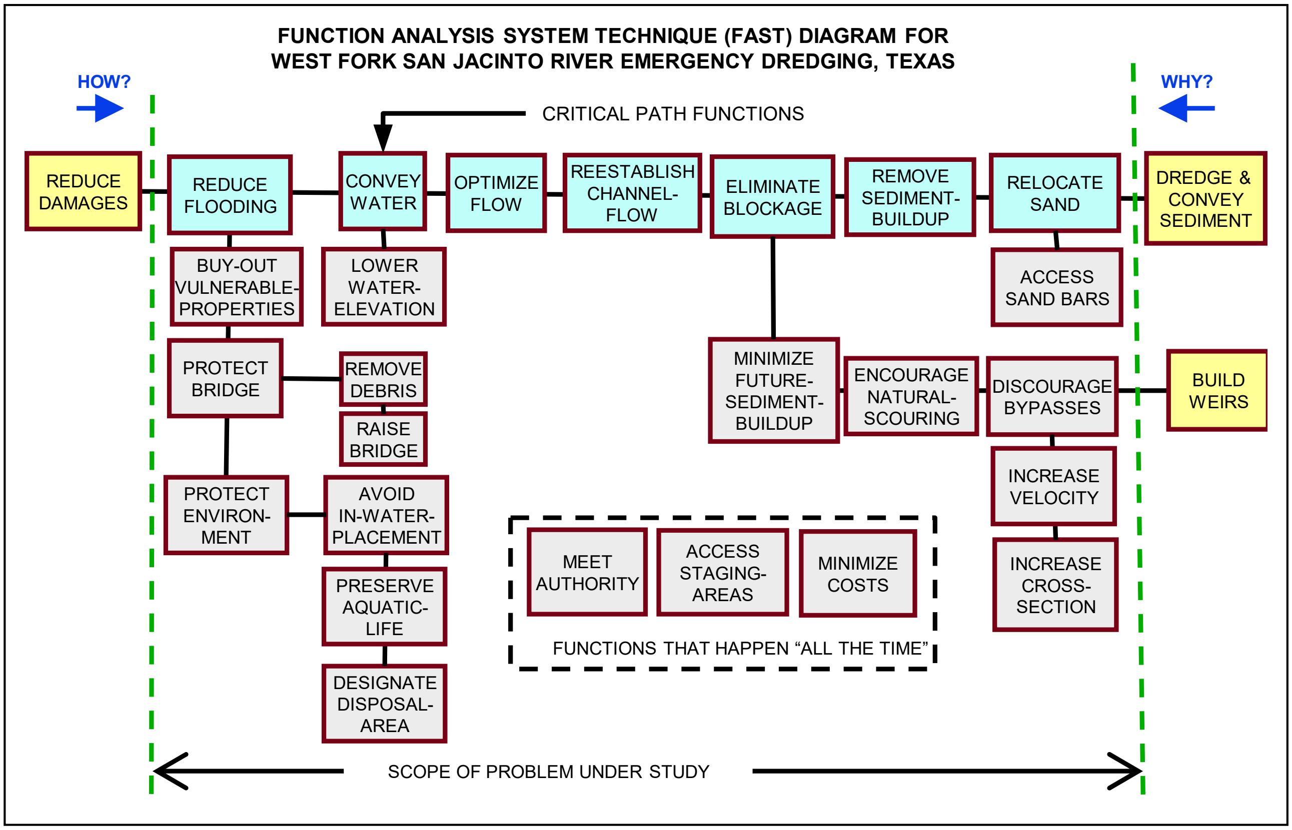
Classical FAST Model:
A diagram displaying the interrelationship of functions to each other in a "how-why" logic. This was first demonstrated by Charles Bytheway and further developed by Wayne "Doc" Ruggles in 1968.

Technical FAST Model:
A variation to the Classical FAST that adds "all-the-time" functions, "one -time" functions and "same-time " or "caused by" functions. This was developed by Richard Park and Frank Wojciechowski and is probably the most commonly used FAST type in construction-oriented projects.

Template for a Technical FAST Diagram:



The following FAST diagram was developed by the Value Engineering Team on 2 May 2018, after getting familiar with the project during the Information Phase:



## APPENDIX D: VALUE ENGINEERING SPECULATION LIST

Key:

P Proposal, develop idea in detail (Note that this may have been combined with other ideas

C Comment or design suggestion

X Rejected for technical, economic or environmental reasons

BD Being Done, or already expected to be part of design

Numbers following P- or C- indicate multiple brainstorming ideas which will be combined into a common write-up. Note that proposal and comment numbers will be consolidated in the report.

| # | Description | Evaluation Decision |
|---|---|---|
| 1 | Straighten channel | X |
| 2 | Buy out properties | X |
| 3 | Remove bridge | X |
| 4 | Raise bridge | X |
| 5 | Lower water elevation of Lake Houston Dam | X |
| 6 | Conduct water shed area study | X |
| 7 | Use FRP or other sheet-pile weirs to redirect flow from bypasses back to original channel | P-7,24,27 |
| 8 | Use downed trees for weirs | P |
| 9 | Get rid of upstream sandpits | X |
| 10 | Place dredged material in upstream sandpits with geosynthetic cover | X |
| 11 | Regulate sand mining operations | C |
| 12 | Construct new public boat ramps | X |
| 13 | Construct dredged material disposal island in middle of Lake Houston | X |
| 14 | Construct sand traps | X |
| 15 | Establish periodic maintenance dredging | C |
| 16 | Use suction dredge instead of cutterhead | X |
| 17 | Use barge with clamshell buckets for shoals | C |
| 18 | Explore beneficial use of dredged material, i.e., for public or private beaches on Lake Houston | C-18/23 |
| 19 | Execute hydraulic analysis of entire West Fork San Jacinto River basin | X |
| 20 | Perform subsurface profile to determine clay layer | X |

| # | Description | Evaluation Decision |
|---|---|---|
| 21 | Check soil logs from upstream (US 59/I-69) and downstream (West Lake Houston Parkway) bridge construction | C |
| 22 | Determine access routes to staging areas | C |
| 23 | Use sand to build a public beach along Lake Houston | C-18/23 |
| 24 | Use stone piles to increase roughness on undesired bypasses | P-7,24,27 |
| 25 | Install bumpers for debris on bridge piers | C |
| 26 | Create a Memorandum Of Understanding with HCFCD, Harris County and TxDOT over handling of debris under bridge | C |
| 27 | Use timber piles to reduce flow to bypasses | P-7,24,27 |
| 28 | Place culvert from Sta 600+00 at 45-degree angle under bridge and across island to Lake Houston | X |
| 29 | Separate contract for removing debris (clearing and snagging), both above and below water level, and for dredging | X |
| 30 | Raise railroad east of US-59 | X |
| 31 | Use railroad bridge to load equipment onto river | X |
| 32 | Explore waiving mining fees from state on city for dredging Lake Houston and selling material | C-32,33 |
| 33 | Consider incentives in addition to waiving mining fees to dredge Lake Houston on one-time basis | C-32,33 |
| 34 | Require noise monitoring within contract | C |
| 35 | Address 24/7 contracting with public meetings | C-35,36,37,38 |
| 36 | Limit working hours in reaches close to homes | C-35,36,37,38 |
| 37 | Discuss working hours and noise specifically with homeowners on Turtle Cove Court and Tahoe Shores Court | C-35,36,37,38 |
| 38 | Dredge Section B before businesses and townhomes east of West Lake Houston Parkway bridge reoccupy (Kingwood Greens Drive and Kings Harbor Drive) | C-35,36,37,38 |
| 39 | Combine small flood-risk management studies like this one into future civil works projects (Flood Risk Management/Environmental Restoration, FRM/ER) | C |
| 40 | Use timber mats to extend access from existing boat ramps to edge of water | C |
| 41 | Use helicopter to deliver dredge equipment | C |
| 42 | Use stone toe to armor the base of the channel to prevent bank sloughing | C |

# APPENDIX E: CERTIFICATION

This report was commissioned by:
US Army Corps of Engineers, Galveston District

This report was compiled in accordance with SAVE International Value Methodology by:

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## END OF REPORT