



U.S. Army Corps  
of Engineers  
Galveston District

**Galveston Harbor Channel Extension  
Feasibility Study  
Houston-Galveston Navigation Channels, Texas**

**APPENDIX B  
ENGINEERING APPENDIX**

**U.S. Army Corps of Engineers  
Southwestern Division  
Galveston District  
2016**

**Engineering Appendix**  
**Galveston Harbor Channel Extension**  
**Feasibility Study**  
**Houston-Galveston Navigation Channels, Texas**

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## **REFERENCES**

- 1 Houston-Galveston Navigation Channels, Texas Limited Reevaluation Report and Final Supplemental Environmental Impact Statement, November 1995 (1995 LRR)
- 2 Houston-Galveston Navigation Channels, Texas Galveston Channel Project Final Limited Reevaluation Report, May 31,2007 (2007 LRR)
- 3 Draft MLT to MLLW Vertical Datum Conversion: Galveston Harbor, Texas City Ship Channel, Houston Ship Channel, Engineering Documentation Report, June 2015 (2015 MLT to MLLW EDR)

## 1.0 GENERAL

Engineering studies for the Galveston Harbor Channel (GHC) Extension Section 216 Feasibility Study Report (GHCE Feasibility Report) included: preliminary geotechnical investigations (sampling and laboratory analysis); preparation of a preliminary dredged material management plan (DMMP); beneficial use concept studies; in-house hydrographic surveys of the channel; and land surveys. Other engineering and design features considered include surveying and mapping, environmental quality features, civil design, geotechnical design, structural design, access roads, operations and maintenance (O&M), cost estimates, data management and schedules for design and construction. Preliminary alternative designs and screening level cost estimates were developed in sufficient detail to substantiate the recommended plan and baseline cost estimate.

The Design Team assisted the Planning and Environmental Leads during the Plan Formulation process. Refer to the GHCE Feasibility Report for detailed discussion/analyses not covered here. This includes Planning Objectives, Preliminary Plan Formulation, including the No-Action Alternative and Structural Alternatives consisting of navigation channel improvements.

Plan Formulation Phase – Channel bottom elevations at -43, -44, -45, and -46 feet Mean Lower Low Water (MLLW) were evaluated during plan formulation. The width considered for each depth alternative was kept constant at 1,075 feet and matches the existing 46-foot (45-foot MLT) GHC at Station 20+000.

During the course of this study, the tidal datum used to describe channel depths changed from Mean Low Tide (MLT) to MLLW. Throughout the remainder of this appendix, channel bottom elevations will be referred to as channel depths (positive number) with the value shown as MLLW. Depths shown in parenthesis (if any) are referenced to MLT. See Section 3.3.2 *Vertical Datums* for more information on the datum change.

Plan Formulation Phase – Alternatives Advanced for Further Screening:

- 1) No-Action Alternative;
- 2) 43-foot and 46-foot channel depth alternatives;
- 3) Alternatives for the Management of Dredged Material

The following types of placement areas were evaluated:

- Marsh creation
- Existing Pelican Island Upland confined placement area (PA)
- Proposed 81.76-acre Pelican Island Upland confined PA.

The considered plan alternatives are discussed in detail in this Appendix and the GHCE Feasibility Report.

### *1.1 Project Description*

The study produced a National Economic Development (NED) Plan consisting of deepening the western most portion of the currently authorized 41-foot deep GHC, resulting in a 2,571 foot extension of the existing 46-foot channel. The plan includes keeping the width of the channel extension equal to the existing 46-foot channel at 1,075 feet. The NED Plan includes using the existing Pelican Island upland confined PA for containment of the resulting dredged new work materials from the channel deepening and the future dredged maintenance material for the 50-year period of analysis.

## 2.0 CIVIL ENGINEERING

The plan of improvement described in this document pertains to the Galveston Harbor Channel, Texas. A study area map and pertinent channel design information are shown on Drawing Nos. C-0 through C-05 attached to this appendix.

### 2.1 Galveston Channels

The Galveston portion of the Houston-Galveston Navigation Channels, Texas Project (HGNC) consists of a series of channels as shown in Table 1.

**TABLE 1 - CURRENTLY AUTHORIZED GALVESTON CHANNELS**

Reach	Station	to	Station	Nominal Bottom Width (feet)	Authorized Project Depth (feet- MLLW)	Channel Depth (feet- MLLW)	Allowable Overdepth (feet)	Advanced Maintenance (included in Channel Depth)
Galveston Entrance Channel (aka Offshore Reach)								
Extended Entrance Channel	55+840		76+000	800	-48*	-50	2	2
Entrance Channel	30+515		55+840	800	-48*	-50	3	2
Outer Bar Channel	21+753		30+515	800	-48*	-50	2	2
Inner Bar Channel	4+490		21+753	800	-46	-48	1	2
Bolivar Roads Channel	0+000		4+490	800	-46	-48	1	2
Galveston Channel								
Galveston Harbor Channel	0+000		20+000	Varies	-46	-49	2	3
Galveston Harbor Channel	20+000		22+571	1,085	-41	-44	2	3

\*Note: Depths are increased 2 feet to allow for wave motion (pitch) in the entrance channel reaches.

### 2.2 Galveston Harbor Channel

The GHC is subdivided into two reaches: Station 0+000 to Station 20+000 and Station 20+000 to Station 22+571. The existing 46-foot deep GHC reach, part of the HGNC, intersects the Inner Bar Channel at Station 0+000, and extends to about Pier 38 at Station

20+000. The existing 41-foot GHC reach extends from Station 20+000 to about 43<sup>rd</sup> Street at Station 22+571. The Extended Entrance, Entrance, Outer and Inner Bar Channels were deepened to their existing depths during the recent Houston-Galveston 46-foot Widening and Deepening Project for the Houston Ship Channel (HSC). Refer to Drawing C-01 for a plan view of the GHC.

The recently completed 46-foot GHC has a bottom width that varies from about 650 feet to 1,133 feet between Station 1+400 and Station 20+000. A widened transition begins at Station 1+400 and ends with the connection to the HGNC Bolivar Roads Channel. The 46-foot GHC footprint does not include the entire originally-authorized 41-foot GHC footprint. Those portions of the 41-foot channel footprint that lie outside the 46-foot channel will continue to be maintained as per the HGNC authorization. Within the proposed GHC Extension reach (Station 20+00 to Station 22+571) the proposed 46-foot channel footprint replaces the 41-foot footprint, and thus the 41-foot channel will not be maintained after construction of the 46-ft channel. Drawing C-05 shows the existing authorized 41-foot channel footprint, the existing 46-foot channel, and the proposed 46-foot extension footprint. The proposed 46-foot extension would have a design width of 1,075 feet, thus matching the width of the existing 46-foot GHC at Station 20+000.

### *2.3 Site Selection and Project Development*

The feasibility study was conducted in three phases: Preliminary Plan Formulation, Plan Formulation, and Detail phases.

#### **2.3.1 Preliminary Plan Formulation Phase**

Preliminary Plan Formulation Phase considered channel depths of 42, 43, 44, 45, and 46-feet. All alternative plans considered a 1,075-foot wide channel, thus matching the existing 46-foot GHC width. Refer to the GHCE Feasibility Report for complete descriptions of the alternative plans studied. Several dredged material disposal options were considered including the existing upland confined Pelican Island PA, a new upland confined PA on Pelican Island, and a new beneficial use site (marsh) located off the west end of Pelican Island.

#### **2.3.2 Plan Formulation Phase**

The Plan Formulation phase re-focused on the 43-foot through 46-foot depths while maintaining a proposed channel bottom width of 1,075-ft channel. This bottom width will

be 10 feet less than the existing 41-foot GHC width. Placement alternatives considered in this phase included the existing Pelican Island PA and the marsh described above.

### 2.3.3 Detail Phase

The Detail Phase of this study produced the selected plan. The selected plan was identified as the 46-foot deep channel extending 2,571 feet from the end of the currently authorized 46-foot channel to the existing 41-foot channel limits to the west (Station 20+000 to Station 22+571). The dredged new work material would be placed in the existing Pelican Island PA. Refer to the Geotechnical Design section of this appendix for details.

#### 2.3.3.1 Proposed Extension Channel

The proposed channel centerline alignment extends westward from Station 20+000 to the end of the existing 41-foot channel at Station 22+571. The channel would have side slopes of 1V:3H and a bottom width of 1,075 feet. See Table 2 for a summary of the proposed channel dimensions and Drawing No. C-03 for the proposed channel cross section.

**TABLE 2 - PROPOSED GALVESTON HARBOR CHANNEL**

Reach	Station	to	Station	Nominal Bottom Width (feet)	Authorized Project Depth (feet-MLT)	Channel Depth (feet-MLT)	Allowable Overdepth (feet)	Advanced Maintenance (included in Channel Depth)
Existing Galveston Harbor Channel	0+000		20+000	Varies	-46	-49	2	3
Proposed Galveston Harbor Channel Extension	20+000		22+571	1075	-46	-49	2	3

### 2.4 Real Estate

No additional land will be required for the selected plan.

### 2.5 Relocations and Removals

Relocations and removals associated with the project and considered for this analysis included aids to navigation, structures, pipelines and utilities.

## 2.5.1 Relocations and Removals

During the Detail Phase, the latest pipeline crossing information was incorporated and re-analyzed for the selected depth. One pipeline was identified in the project area as shown in Table 3. This identified pipeline requires neither relocation nor removal for this project.

**TABLE 3 - GALVESTON HARBOR CHANNEL EXTENSION PIPELINE LIST**

Approximate Station	Description	Owner	Permit No.	Relocate	Remove
21+400	24" Water Main, -72' MLT	City of Galveston	14114(05)809	No	No

## 2.5.2 Aids to Navigation

The GHC Extension, beyond the channel improvements, will not require changes to the navigation aids.

## 2.5.3 Structures

### 2.5.3.1 Berthing Dock Areas

Docks and berthing areas which will utilize the new project depth had dredging volumes calculated. Port facility information was obtained through facility owners, and the local sponsor.

### 2.5.3.2 Structure Stability Analyses

Information was received from Texas International Terminals facility, located on the south side and at the west end of the proposed GHC Extension indicating that this bulk materials handling facility would take advantage of the proposed deeper draft channel. Texas International Terminals plans to dredge their berthing area and will retrofit their existing bulkhead facility to accommodate the deeper draft. This retrofit is a third-party portside facilities associated project cost and has been accounted for in the economics portion of this study. Design drawings were received for the existing Sulphur Terminal dock facility located on the south side of the GHC Extension at approximately Station 22+000. This facility lies about 170 feet south of the proposed channel bottom alignment and consists of a concrete dock supported on square precast concrete piles driven to an elevation of about -101.66 feet MLLW. Upon review of the provided structural drawings, it was determined that the structure will not be impacted by the channel deepening.

The Edison-Chouest bulkhead lies approximately 100 feet north of the proposed channel bottom alignment at approximately Station 21+300 and handles predominantly light draft vessel traffic. A stability analysis of the existing Edison-Chouest bulkhead was performed using the CWALSHT computer program developed by the U.S. Army Corps of Engineers (USACE) Waterways Experiment Station (WES) Information Technology Laboratory currently known as the Engineer Research and Development Center (ERDC). A global slope stability of the channel side slope in the vicinity of the Edison-Chouest bulkhead using the SLOPE/W computer program. SLOPE/W is one component of a suite of geotechnical analysis tools called Geostudio which is distributed by GEO-SLOPE International, Ltd. SLOPE/W analyzes slope stability models using the limit equilibrium method. The Morgenstern-Price method of analysis was used which satisfies both moment and force equilibrium equations are satisfied. The CWALSHT and SLOPE/W stability analyses indicated the existing bulkhead will not be affected by the channel deepening. Results of the two analyses are attached to this appendix. It was determined that other water-front structures along this project will not be affected because of their distance from the channel template.

#### *2.6 Maintenance Dredging Frequency and Shoaling Rate*

The dredging cycle of the existing channel was determined by the average number of years between the O&M dredging operations for a historical period. Each channel or reach may or may not have its own dredging frequency. The Galveston District's Dredging History Database, a Microsoft Access-based computer database, was utilized to establish the existing shoaling rate and dredging frequency for the existing 46-foot GHC for the 2007 Galveston Channel Limited Reevaluation Report (2007 LRR), Engineering Appendix. For that report, an analysis of 24 years of dredging history identified six maintenance dredging cycles with an estimated shoaling rate of 1,425,500 cubic yards per year for the complete 22,571-foot long GHC channel. The 46-foot deep channel shoaling rate will be assumed to remain the same as the existing channel, with 1,425,500 cubic yards per year, and a dredging frequency of four years. Shoaling will be assumed to be evenly distributed along the length and width of the channel; therefore, a linear interpolation of the channel dredging data produces a shoaling rate of approximately 162,000 cubic yards per year for the proposed GHC Extension reach. The dredging frequency will remain the same (four years) as the existing 46-foot channel.

#### *2.7 Design Considerations*

Several design assumptions were made in conjunction with this study. Hydrographic survey data provided by the area office were utilized in defining new work volumes. Maintenance materials identified in the surveys were discounted and new work volumes were calculated as material below the existing template, including advance maintenance and allowable overdepth. The proposed 46-foot channel bottom width would be 10 feet narrower than the existing 41-foot channel.

### ***2.8 New Work Dredging***

The term “new work” refers to the material below the existing channel template which will be removed to increase the channel depth to the new project depth. The new work material quantities were calculated using a 3-dimensional surface (\*.dtm) generated by the InRoads software program. The surface is a 3-D representation of the existing channel geometry. The channel has existing and proposed templates which are trapezoidal shapes, defined by bottom width and side slopes. Those templates were used to model the channel and calculate new work volumes. The existing template included the current advance maintenance and allowable overdepth values of three feet and two feet, respectively. The proposed new channel template also included an advance maintenance depth of three feet and a constant two feet of allowable overdepth for calculation of new work volumes. New work material volumes are shown in Table 4.

**TABLE 4 - NEW WORK DREDGING VOLUMES FOR 46-FOOT PLAN**

<b>Reach</b>	<b>Station Nos.</b>	<b>Federal Channel Estimated New Work CY</b>	<b>Third-Party Facilities* Estimated New Work CY</b>	<b>Total Estimated New Work CY</b>
Galveston Harbor Channel Extension	20+000 to 22+571	513,800	95,700	609,500

\* non-Federal portside facilities

### **2.8.1 Non-Pay Dredging**

Non-pay dredging would be defined as dredging outside the paid allowable overdepth that may occur due to such factors as unanticipated variations in substrate, incidental removal of submerged obstructions, or unusual wind and wave conditions. An estimated volume of 102,400 cubic yards of non-pay dredging is assumed for new work in the federal channel. This estimate is based on non-pay depth of 1 foot below the bottom of the allowable overdepth and within the channel toe width of 1,075 feet. Non-pay dredging is not assumed on the side slopes because it is anticipated that no new work will be performed on the side slopes based on the geometry of the new versus old channel templates. Non-pay dredging within the private facility is estimated at 15,000 cubic yards. Non-pay volumes are included in the maintenance dredging volumes presented in Section 2.6 *Maintenance Dredging Frequency and Shoaling Rate*.

### **2.8.2 Third-Party Portside Facilities Dredging**

Third-party (non-Federal) portside facilities new work dredging volume is calculated using the square footage of the third-party facilities and multiplying by the depth of new work dredging. The third-party maintenance volume would be based on the GHC shoaling rate and dredging frequency determined as described in Section 2.6. Using the GHC shoaling rate and the area of third-party maintenance dredging, a shoaling rate of 85,700 cubic yards per four-year dredging cycle would be assumed. The third-party maintenance dredging volume described above is not an incremental increase over and above the third-party maintenance volume for the existing project. The third-party new work and maintenance material would be placed within the Pelican Island PA. An existing tipping fee charged to third-party users for use of the Pelican Island PA covers the cost of lost capacity as a result of third-party dredging volumes placed in the PA. This work is considered an associated cost used in the benefit-cost ratio calculation and PA capacity analysis.

### **2.8.3 Allowable Overdepth**

Additional depth outside the required channel template would be permitted to allow for inaccuracies in the dredging process. Per Engineering Regulation (ER) 1130-2-520, *Navigation and Dredging Operations and Maintenance Policies*, “District Commanders may dredge a maximum of two feet of allowable overdepth in coastal regions . . . , and inland navigation channels.” This additional dredging allowance would be referred to as a dredging tolerance, or allowable overdepth. The existing channel has a two-foot allowable overdepth. It is anticipated that large pipeline dredges, similar in size used for maintenance dredging of the existing channel, will be utilized to construct the proposed 45-foot channel

extension. District policy recommends a two-foot allowable overdepth in reaches where these large dredges operate.

#### **2.8.4 Advance Maintenance**

Advance maintenance consists of dredging deeper than the authorized channel template to provide for the accumulation and storage of sediment. In critical and fast-shoaling areas advance maintenance would be required to avoid frequent re-dredging and to ensure the most reliability for navigation within the channel and the least overall cost for operating and maintaining the project authorized dimensions. ER 1130-2-520 authorizes Major Subordinate Command (MSC) Commanders to approve advance maintenance. The existing 46-foot (Station 0+000 to Station 20+000) and 41-foot (Station 20+000 to Station 22+571) channels have an authorized three-foot advance maintenance depth. Advance maintenance for the proposed 46-foot GHCE would be three feet. This would allow the GHCE to be maintained at the same frequency (4-year cycle) as the existing adjacent 46-foot channel, thus operations and maintenance cost over the 50-year project life would be optimized because of the reduction in the number of required maintenance dredging contracts (and mobilization costs).

#### *2.9 Beneficial Use of Dredged Material*

Conceptual designs for beneficial use of dredged material were performed during the Plan Formulation Phase. Four beneficial use alternatives were evaluated for this project. General assumptions were used. The least cost methods were generally used in developing designs. It was assumed that no relocations would be necessary, and that right-of-ways (ROWs) and right-of-entries (ROEs) would be available. Specific field and design data was provided by the Environmental Section. During the Detail Phase, the selected marsh creation features were individually evaluated and updated. The evaluated marsh creation site adjoins Pelican Island near the southwest corner with most of the site currently under water. The following design and construction assumptions were developed based on the proposed site existing conditions and on typical sections proven successful in the Galveston Bay area for similar projects. Swamp accessible machinery would be required during marsh construction. Hydraulic dikes would be built with the new work dredged material and the dredge pipeline routes are assumed to be the shortest distance to the middle of the site. Dike side slopes were designed to have slope protection such as rip-rap and concrete cellular mats. Marsh fill would occur with selective placement of dredged material within the marsh site boundary. Marsh fill could be new work or maintenance material, depending on the requirements of the marsh design. Where plantings would occur, it was assumed that abundant local species are available. Marsh creation was not selected as part of the

NED Plan. The evaluated Marsh site location and conceptual plan are shown on Drawing No. B-02.

## **3.0 SURVEYING, MAPPING, AND OTHER GEOSPATIAL DATA REQUIREMENTS**

### *3.1 Surveys*

Extensive land surveys were not performed for this study. The district utilized color orthodigital aerial maps taken in 2004 to identify existing topographical features such as shoreline, docks, creeks, open or wooded areas, etc. Hydrographic surveys provided by the Galveston Area Office provided after-dredged surveys at 200-foot intervals for the channel, and represent ground surface ranging from elevation -30 feet to the bottom of the channel. Additional land elevations were implied from the ortho maps. Interpolation between hydrographic surveys and land surveys were performed using the InRoads software program. An overall 3-D surface (\*.dtm) was generated, providing a representation of the existing conditions along the channel.

#### **3.1.1 Additional Surveys**

During the preconstruction, engineering and design (PED) phase of this project, a complete land survey of the PA site will be required. Hydrographic condition surveys of the channel will be performed by the area office and will be utilized and coordinated during PED to the extent practical.

### *3.2 Mapping*

For this study, existing maps of the project area available at Galveston District (SWG) were used during the initial and plan formulation phases. Updated mapping was developed for the Detail phase, to include current conditions.

#### **3.2.1 Additional Mapping**

It will be assumed the existing maps of the project area will require only minor updating as time progresses. It is not anticipated that major changes will occur related to the mapping presented in the Engineering Appendix.

### 3.3 Datums

#### 3.3.1 Horizontal Datum

Horizontal Datum referenced in this appendix is the Texas State Plane Coordinate System, South Central Zone, North American Datum (NAD) of 1983.

#### 3.3.2 Vertical Datums

The Galveston District has recently converted the local Mean Low Tide (MLT) datum to the Mean Lower Low Water (MLLW) datum. Reference the *Draft MLT to MLLW Vertical Datum Conversion: Galveston Harbor, Texas City Ship Channel, Houston Ship Channel, Engineering Documentation Report, June 2015* (2015 MLT to MLLW EDR). The calculated MLLW datum for the Galveston Harbor Channel Project is 1.18 feet above zero MLT at the Texas Coastal Ocean Observation Network (TCOON) Gage 1450 (Galveston Pier 21). The calculated conversion was rounded to the nearest foot for application to authorized channel depths. The elevations in this appendix and Feasibility report have been converted to MLLW except as noted as MLT. Engineering analysis done prior to the datum conversion have remained in MLT. The Vertical Tidal Datum Table below provides the depth conversion relationship between MLT to MLLW for the existing GHC.

**TABLE 5 - VERTICAL TIDAL DATUM CONVERSION**

<b>Project Name</b>	<b>Station Nos.</b>	<b>Project Depths MLT, ft</b>	<b>Project Depths MLLW, ft</b>	<b>Conversion from MLT to MLLW, ft</b>
GHC	0+000 to 20+000	-45	-46	-1
GHC	20+000 to 22+571	-40	-41	-1

Existing after-dredging hydrographic surveys performed using the MLT datum were used in calculating new work volumes.

Existing land survey data for the Pelican Island PA used North American Vertical Datum of 1988 (NAVD 88).

## **4.0 PROJECT SITE ACCESS**

The Pelican Island PA has existing access roads available. No public roads require improvement for access to the project site.

## **5.0 ENVIRONMENTAL ENGINEERING**

### *5.1 Environmental Objectives and Requirements*

Environmental objectives and requirements described herein will be fulfilled by compliance with plans for the management of dredged material in the Pelican Island upland confined PA and by adopting and enforcing prudent and reasonable measures to avoid impacts and by the completion of measures described in the Environmental Assessment (EA) performed for this study.

### *5.2 Environmental Considerations*

#### **5.2.1 Energy Savings Features of the Design**

Energy saving features of the design includes minimizing pumping distances between dredge vessels and the PA thereby reducing the load on the pump and minimizing the amount of diesel fuel and other commodities required to execute the planned project goals.

#### **5.2.2 Environmental Effects of the Project**

- a. Emissions from the dredging vessel and other heavy equipment will locally degrade air quality during channel dredging and dredged material pumping operations.
- b. Water clarity and quality at the dredging sites and the PAs will be temporarily affected by the dredging process. Some soil particles are temporarily lost in the water column during the dredging process. With time, the sediments are winnowed out, and settle back down on the channel and bay bottom thus re-establishing water clarity and quality as it existed prior to the dredging.
- c. On a microorganism level, the dredged channel bottom will temporarily be affected while the area adjusts to the new environment the project created.

### **5.2.3 Integration of Environmental Sensitivity into All Aspects of the Project**

Water and sediment quality of new work and maintenance dredging will be monitored to manage any impacts from dredging in the channel and dredged material pumping, placement, and decanting operations in the Pelican Island upland PA.

### **5.2.4 Lessons Learned During Past Project**

The Environmental Review Guide for Operations (ERGO) was reviewed to identify environmental lessons learned on past projects. The identified lessons learned were applied to the design concepts considered for this project.

For some time now, the SWG geotechnical section has been refining the science of PA design and utilization. Included in the design concepts for this project is the use of improved drop-outlet structures that provide more effective sediment control to minimize turbidity of the effluent in the surrounding water column. Innovative dike construction techniques have been incorporated into the conceptual design. These techniques include placing selected soil types desirable for building dikes directly into berms alongside the interior of existing dikes during dredging operations to provide dike building materials for more efficient access during dike raising construction. Desirable dredged material may also be placed directly within proposed marsh dike templates to minimize later manipulation and therefore less turbidity in the surrounding water column.

### **5.2.5 Incorporation of Environmental Compliance Measures into the Project Design**

There are numerous environmental drivers which govern protection of the public and environment during the construction phase of a project that were incorporated into the feasibility design for this project. Local, State and Federal environmental compliance measures incorporated into the project include:

- The Texas Pollutant Discharge Elimination System (TPDES) administered by the Texas Commission on Environmental Quality (TCEQ)
- Protection of Environmental Resources
- Preservation and Recovery of Historical, and Cultural Resources
- Protection of Water Resources
- Protection of Fish and Wildlife Resources
- Protection of Air Resources
- Protection from Sound Intrusions

- Pollution Prevention

### *5.3 Hazardous Toxic Radioactive Waste (HTRW)*

Historic dredging events within the channel have not encountered HTRW. Therefore, based upon the HTRW assessment performed as described in the EA and additional in-house research, it has been determined that there would be a low probability of encountering contaminated sites or toxic substances during project construction.

## **6.0 GEOTECHNICAL ENGINEERING**

### *6.1 Terminology*

A variety of special terms used in this document shall be defined as follows:

Hydraulic placement referred to in this document shall be defined as discharging a slurry of water and soil from a dredge pipe.

Mechanical construction referred to in this document shall be defined as construction operations performed on land with conventional construction equipment (bulldozers, draglines, tractors, etc.).

Shaping referred to in this document shall be defined as the construction operations in connection with forming and constructing materials to a specified dike template.

New Work referred to in this document would be defined as new and currently undisturbed soils obtained from the deepening portion of the GHC.

Ponding shall be defined as the accumulation of water and or dredge fluid to some elevation behind dikes within a PA.

Pure New Work refers to new work materials which are dredged separately from maintenance materials.

Mixed New Work refers to new work materials which are dredged with maintenance material mixed in with the new work material. For clarification however, whenever quantities of mixed new work are referred to in the design or cost estimates, these mixed quantities only represent the quantity of the new work material, and exclude the quantity of maintenance material allowed to mix with the new work material.

### *6.2 Existing Soils Data - Channel*

Soil borings drilled within and near the channel extension in 1965 and 1980 were reviewed to identify the existing channel bottom soil conditions. Additional soil borings were not performed for this study. A boring layout and plotted boring logs are shown on Drawing Nos. B-08 and B-09. As shown by the boring logs the new work materials that will be dredged to deepen the channel will consist primarily of stiff to hard high-plasticity clays classified as CH soils. According to the Houston-Galveston Navigation Channels, Texas Limited Reevaluation Report and Final Supplemental Environmental Impact Statement,

November 1995 (1995 LRR), previous estimates made near or prior to 1995 indicate that the make-up of dredged maintenance material from the channel has consisted in the past of approximately 80 percent fine grained materials and approximately 20 percent coarse grained or sandy materials.

### *6.3 Placement Areas*

#### **6.3.1 Pelican Island PA**

##### 6.3.1.1 Background

A boring location layout along with the plotted boring logs, for borings drilled at the site in 1972, 1977, 1979, and 1993 can be found in the 2007 LRR Engineering Appendix. A brief description of the soils conditions within the Pelican Island PA is also included in the referenced 2007 LRR Engineering Appendix. Since the preparation of the 2007 LRR, new work and maintenance materials have been dredged from the GHC from Station 0+000 to Station 20+000 and pumped to the Pelican Island PA during the time period from late-2009 through mid-2010. Maintenance materials have been dredged from the GHC from Station 20+000 to Station 22+571 and placed in the Pelican Island PA during the same time period. New work materials were placed in interior berms and on dikes within Cells A, B, and C. In addition, perimeter dikes at Cell C that had been damaged during Hurricane Ike were repaired and incrementally raised. Graded stone riprap shoreline protection was constructed along two sections of the Cell C perimeter dike at the northeast end of the PA. A new weir was constructed to replace the existing weir at the northwest end of Cell B to control dredge ponding levels and flow into Cell C. The new weir is 40-feet wide and is constructed using structural steel members, timber bulkheads, and has a cast-in-place concrete base. The design elevation of top of the concrete base is +18.0 feet (NAVD88). The weir is capable of restricting flow using stop log timbers up to elevation +30.0 feet; therefore, this flow control elevation adjustment is available from elevation +18.0 to +30.0 feet (NAVD88). An existing weir at the northeast end of Cell A was removed. A new five-bay drop-outlet structure was constructed near the southeast corner of Cell C, replacing the old structure, providing the only discharge of effluent into the bay from the PA. The effluent is discharged through two 48-inch diameter steel pipes to the south. Flow of effluent is controlled using stop-log timbers at elevations ranging from about +12.0 feet to +30.0 feet (NAVD88). The drop-outlet structure will be periodically raised and moved laterally in the future as required to accommodate dike raisings and/or realignments.

### 6.3.1.2 Dredged Material Placement Capacity

Dredging needs for the proposed deepened channel section (Station 20+000 to Station 22+571) include requirements for the new work during initial construction and for 50 years of maintenance dredging following construction. From Section 2.6 *Maintenance Dredging Frequency and Shoaling Rate*, the estimated annual shoaling rate for the GHCE is 162,000 cubic yards, resulting in a forecast of about 7.8 MCY of maintenance material for placement in the PA over the 50-year period. The estimated 50-yr non-Federal maintenance dredging volume is about 1.0 MCY. The total new work volume anticipated for placement in the PA from construction of this channel extension is 726,900 cubic yards (581,520 cubic yards after shrinkage), including 513,800 CY of new work from construction of the extension, 95,700 CY of new work from third-party facilities, plus 102,400 CY and 15,000 CY of non-pay dredging for the extension and third-party facilities, respectively. The PA must have capacity for storage of maintenance dredging volumes from the entire GHC (Station 0+000 to Station 22+571) which totals about 69.4 MCY over the 50-year period of analysis. This total includes the forecast 7.8 MCY of maintenance material from the GHCE and 1.0 MCY from non-Federal sources. Therefore, the total forecast dredging volume planned for placement in Pelican Island PA over the 50-year period is about 70.1 MCY including maintenance and new work.

Per the 50-Year Disposal Plan presented in the 1995 LRR, in order to have enough capacity for maintenance material over the 50-year period of analysis, the final projected elevation of the PA, after a series of dike lifts in the O&M phase, would be approximately +50 feet MLT. The current estimated remaining neat line volume in the Pelican Island PA is about 46.1 MCY based on an ultimate dike elevation of +50 feet and required freeboard of 3 feet, as discussed in the 1995 LRR. This neat line volume is approximately equivalent to an in situ volume (in channel dredging volume) of about 70.9 MCY (using a shrinkage factor of 0.65 for long term storage, as discussed in the section of the 2007 LRR Engineering Appendix entitled CONSTRUCTION PROCEDURE). Therefore, the remaining capacity of Pelican Island PA after construction of the GHCE and the 50 years of maintenance would be about 0.8 MCY. See Table 6 presented below for a summary of the estimated new work and maintenance dredging quantities and PA capacity.

**TABLE 6 – DREDGING VOLUMES AND PLACEMENT AREA CAPACITY**

<b>Channel</b>	<b>Reach Station Nos.</b>	<b>New Work Volume, MCY</b>	<b>Federal &amp; non-Federal 50-YR Maintenance Volume, MCY</b>	<b>Total Dredging Volume, MCY</b>	<b>Pelican Is. PA Remaining Capacity</b>
Existing 46-ft GHC	0+500 to 20+000	NA	60.6	60.6	70.9
GHCE	20+000 to 22+571	0.7	8.8	9.5	10.3
Totals	0+500 to 22+571	0.7	69.4	70.1	0.8

No incremental increase in shoaling within the Federal channel or private facilities is anticipated as result of this project. Therefore, Pelican Island PA has sufficient remaining capacity to accommodate the new work and maintenance volume generated by this channel extension.

Based on the above analysis of the Pelican Island PA capacity, there is no requirement for additional placement areas to contain the new work or maintenance dredge materials over the 50-year period of analysis.

### **6.3.2 Proposed Upland PA on Pelican Island**

At the request of the Port of Galveston, an 81.76-acre tract located on the north edge of the GHC and between the Halliburton Energy Services Galveston Terminal Slip and the Pennzoil/Oxy USA Slip was explored for consideration as a new dredged material upland confined PA. A total of eight soil borings were performed within the proposed PA to characterize the soil conditions. As described in the 1995 LRR, the soils at emergent areas of Pelican Island are the result of dredged material discharges over the past 70 or so years. The soil borings taken within this tract of land on Pelican Island indicate the soils in this area are a mixture of fill materials, consisting of medium to high plasticity clays, sands, silty sands, and clayey sands. A review of the soil types encountered indicate that approximately 70 percent (or-that the majority) of the encountered soils consist of sands, silty sands, and clayey sands with the remainder being fine-grained sandy clays to clays. The encountered soil types are typical of the fill soils encountered on Pelican Island in historic borings. Consideration of this tract for upland disposal for inclusion in the NED Plan was abandoned during the Detail Phase of this study because of the high cost to develop the site compared to the relatively small placement capacity of the completed PA. A conceptual PA plan, soil boring layout, and boring logs are shown on Drawing Nos. B-03 through B-07.

#### *6.4 Beneficial Use Site Alternatives*

A beneficial use site (hereinafter referred to as the Marsh Site) was considered during the Preliminary Plan Formulation and Plan Formulation Phases of this study. The Marsh Site considered would be located just off and west of the southwest corner of Pelican Island. The studied Marsh Site ranged in area from about 48 acres to 103 acres to accommodate the volume of new work material for the various proposed channel depth alternatives studied. Preliminary dike construction design and dike erosion and wave protection systems were developed and construction quantities were estimated for preliminary construction cost determinations. The conceptual dike and wave protection designs are based on designs used successfully in the Galveston Bay area having similar fetch lengths. The Marsh Site alternatives were not selected for inclusion in the NED plan because of the high cost to construct and develop compared to placement of the dredged materials into the existing Pelican Island PA and the lack of a cost share partner to offset those costs. A conceptual beneficial use site plan and dike cross section are shown on Drawing No. B-02 attached to this appendix.

#### *6.5 Dike Work*

##### **6.5.1 Initial Mechanical Dike Work**

The proposed plan involves mechanically raising the dikes at Pelican Island PA, prior to deepening the channel, to sufficient height to: 1) allow for the containment of the new work material; and 2) account for any initial maintenance material that may be encountered above the new work material during the channel deepening. Neither the existing weir structure located at the northwest corner of Cell B, nor the existing drop-outlet structure located in Cell C, would be required to be raised as a result of the proposed dike raising.

##### **6.5.2 Hydraulically Placed Dike Foundation**

Using the proposed channel extension configuration (46-foot channel), the most current estimate of new work material from the channel deepening (not including maintenance material) would be around 726,900 cubic yards including Federal and non-Federal, and non-pay volumes. It would be proposed that the new work materials from the channel be stacked hydraulically along the perimeter dikes, to the inside of the PA in Cell B, serving the dual purpose of providing usable dike building material following the channel deepening, and providing added foundational strength by displacing and consolidating some of the softer materials from beneath the hydraulically placed new work materials.

During hydraulic placement of the new work material along the dike perimeter, it would be expected that up to half of the new work material pumped in from the channel may displace softer soils within the PA. By replacing some of the softer soils with stronger new work materials through displacement, the goal will be to create a stronger counteractive shear surface within the dike embankment to help prevent or reduce the chance of deep dike failures as the dikes are raised in the future. The discharge point of the dredge pipe will be moved along the dike as the hydraulic fill is placed; therefore, incurring additional cost to the dredging contract. The additional cost for moving the dredge discharge has been considered in the economic analysis.

After hydraulic placement, but prior to the next dredge cycle, it is proposed that the remaining available mounded new work then be shaped to a selected slope, crown width, and dike elevation as directed by USACE. In addition, during the shaping process of the new hydraulically placed foundation, it is proposed that the new shaped dike be slightly offset inward from the current dike configuration which will increase the overall length of the counteractive shear surface in the dike embankment, allowing for an increased counteracting force against the driving weight of the dike embankment. The hydraulically placed new work dike foundation will serve as the base for all future dike lifts, and be shaped to a uniform elevation. A conceptual typical cross section for Pelican Island dike construction is shown on Drawing No. B-01.

During future O&M dike construction on top of the hydraulically placed new work foundation, it is recommended that periodic checks of the foundation and embankment be made. Additional core borings, soils sampling, soils testing, and follow up stability analyses, should be performed periodically as conditions require. The additional soils data will be used to verify to what extent consolidation and foundation strength gain has occurred over time, and determine if additional stability measures should be taken (such as offsetting the dikes further into the PA if necessary or other measures). Per the 50-Year Disposal Plan presented in the 1995 LRR, in order to have enough capacity for maintenance material over the 50 year period of analysis, the final projected elevation of the PA, after a series of dike lifts in the O&M phase, would be approximately +50 feet MLT.

The assumption that dikes may be built to at least elevation +50 feet is based on “a report submitted to the Port of Houston Authority by a private consultant, *Geotechnical Memorandum Disposal Area Management Plan, Spilman Island, Alexander Island, Lost Lake, Houston Ship Channel, Harris County, Texas (1994)*...which shows that a dike could be built to +60.0 feet at Alexander Island, without failure.” The 1995 LRR goes on to state that, “The District believes that Alexander Island has the weakest foundation conditions.” Note the 1995 LRR disposal plan included Pelican Island. The District will perform

additional geotechnical exploration and stability analysis over the course of the project life during the PED phase of future dike-raising projects to confirm dike configuration, stability and allowable ultimate height.

#### *6.6 Proposed Order of Work*

The proposed order of work includes first mechanically raising the Pelican Island PA, Cell B west dike and mechanically constructing retention dikes within the interior of the Cell. Dredging of the GHC Extension will follow with placement of maintenance and new work materials hydraulically within Cell B. The new work material will be placed in berms along the interior of the Cell B west perimeter dike. The dredge pipe shall have a “Y” valve installed such that when maintenance or “mixed new work” materials are encountered that contain materials unsuitable for dike construction, the discharge can be directed toward the interior of Cell B and not in the proposed interior berms (see paragraph above entitled Terminology).

#### *6.7 Dike and Channel Templates*

Typical dike slope templates proposed for the Pelican Island upland PA were developed for the 1995 Engineering Supplement to LRR and the 2007 LRR Engineering Appendix referenced herein. Drawing No. B-01 of this report presents a conceptual hydraulic fill and dike template for this project. The proposed channel slopes for the channel deepening construction are 1V on 3H. The channel slopes will be maintained at a 1V on 2H slope during O&M as per existing practices for the GHC.

#### *6.8 Proposed Additional Soils Investigations*

As discussed in Section **6.4.2 Hydraulically Placed Dike Foundation**, it would be recommended that future periodic checks of the dike foundation and embankment be made by performing additional exploratory soil borings, sampling, and testing. The data obtained from the additional investigations would be used to verify consolidation and foundation strength gain over time and stability of the dike embankments. The resulting analyses would be used during future O&M dike raising design and construction. Additional geotechnical data will be obtained for the PED phase of this project by drilling soil borings within the proposed channel extension template in accordance with the guidance outlined in Engineer Manual (EM) 1110-1-1804, *Geotechnical Investigations*. Samples of the channel foundation soils will be obtained for classification and strength measurement. The data will be analyzed to develop estimated quantities of acceptable materials available for dike building and to verify channel side slopes will be stable after the deepening project.

## 7.0 OPERATION AND MAINTENANCE

The O&M phase of the project will be accomplished using the existing procedure for all the navigation channels in the Galveston District. The procedure would be composed of the following steps:

- 1) Historical records are kept for shoaling rates in various reaches of the navigation channel. The data in the historical records are continually updated based on actual dredging volumes for the various reaches.
- 2) Condition Surveys are conducted twice a year to determine the actual cross-sections at several stations along the navigation channel. The cross-sections are used to compute the actual shoaling rate in the various reaches. The actual shoaling rates are compared with the expected rates obtained from the historical data.
- 3) Dredging contracts are prepared to restore the channel to its design template as required for the various reaches of the channel.
- 4) The Corps of Engineers performs all the activities indicated above. The Local Sponsors provide the land for dredged materials placement and the containment dikes required.
- 5) The structural components in this project are limited to the interior weir and drop-outlet structure used to drain the excess water from the Pelican Island PA. The structures are composed of structural steel members and access/working platforms. Water drainage would be controlled by the use of timber planks. These structures will be periodically painted as needed, and the timber planks replaced. As the dike heights are raised to accommodate future dredged material, the drop-outlet structure will also be raised and repositioned laterally as required depending on the new dike configuration.
- 6) Other structures impacted by the project may be industrial wharfs and docks. The maintenance of these structures would be the responsibility of their owners.
- 7) The anticipated dredged maintenance material quantities for future O&M are not anticipated to change from those previously calculated for the existing 41-foot project. The existing shoaling rate has been determined to be approximately 162,000 cubic yards per year for the proposed 46-foot channel extension. The required maintenance dredging frequency is once every four years. The cost estimates for maintenance dredging over the 50-year period of analysis can be found in Section **9.0 COST ENGINEERING** of this Appendix.

## 8.0 HYDROLOGY AND HYDRAULICS

Studies performed for the Galveston Bay Area Navigation Study (GBANS), Feasibility Report and Environmental Impact Statement (EIS) for improving the Houston and Galveston channel (GBANS 1987) and subsequent studies to support the 1995 and 2007 LRR's are viable for this GHCE Feasibility Report. Below is a summary of hydraulic and hydrology studies that have been completed and their applications.

### *8.1 Hydrodynamic and Salinity Model Study*

A number of hydrodynamic and salinity models have been developed as part of the GBANS study. These models assist in refining estimates of project induced changes to the circulation patterns and salinity regime of Galveston Bay. Studies of freshwater inflows were conducted for the GBANS, 1987. For the 1995 LRR the Texas Water Development Board (TWDB)-Soil Conservation Service Model was applied to obtain existing condition runoff for gaged and ungaged basins. The future hydrology described in the GBANS report was updated and revised to incorporate new data.

As part of the GBANS, 1987 report, a two dimensional model utilized by the State of Texas was used to evaluate the hydrodynamics of all the bay systems along the Gulf Coast. The model; however, did not fully capture all the pertinent physical processes in the Bay. Therefore, a detailed RMA-10-WES three dimensional model was developed as part of the 1995 LRR. Two new data collection efforts were used to acquire the boundary conditions, initial conditions, and verification data for the model: an intensive 25-hour survey for vertical current and salinity data and a long-term (180 days) monitoring program to obtain water level, salinity, and currents. The results from the hydro-salinity study were coordinated with an oyster model study directed by Dr. Eric Powell of Texas A&M University used to assess project-induced impacts on oysters for the EIS in the 1995 LLR. The currents produced by the hydro-salinity model were also used as a key input parameter for the ship simulation study. A discussion and analysis of model results is found in "*Houston-Galveston Navigation Channels, Texas Project, Report 4, Three-Dimensional Numerical Modeling of Hydrodynamics and Salinity, TR HL-92-7.*" Figures and a summary from this report can be found in the 1995 LRR. A brief discussion of modeled parameters is described below.

The model was run for existing condition (40 feet MLT), 46 feet MLT and 51 feet MLT for low, medium, and high freshwater inflows for tidal, meteorological, and hydrologic conditions. The resulting time series, isohaline charts, and cross sections plots can be viewed in the WES Technical Report TR-HL-92-7. The isohaline charts can also be

viewed in the Appendices of the 1995 LRR. According to the WES report, “The typical Galveston Bay trend is for low salinity values through early summer. The large drop in freshwater inflow beginning in July along with the higher Gulf salinity causes a rise in salinity, usually, reaching a maximum around October. The simulated Gulf salinity drops quickly in September and the Bay salinities follow later. The overall increase in salinity of the 45’ deepening in comparison to the existing conditions was regionally most noticeable in the upper bay; and time-wise in the fall (for all regions). During freshwater flow periods this region and Trinity Bay were practically fresh for both existing and 45’ deepening. Generally, the maximum increase in salinity was greater during the high flow scenario than in the low.”

In summary, for this GHCE LRR study, the conclusions from the 1995 LRR RMA report are applicable – channel deepening resulted in a larger salinity gradient from the channel to the bay. The salinity increase in the lower bay was much less significant than in other areas, typically about 1 part per thousand (ppt). Salinity values are lower in the summer months and highest in October.

### *8.2 Ship-Handling Simulation Model Study*

This study was conducted as part of the 1995 LRR. Results are applicable to the channel extension. The study tested both the proposed 45-foot and 50-foot channels for safe two-way navigation, efficient design, and recommended design changes where needed. The ship simulation provided a template design for the GHC that provided for safe ship maneuverability for a design vessel 990 feet long, 160 feet wide, and a draft of 44 feet. The simulation resulted in a recommendation for a minimum 4,500-foot long turning area extending past Pier 36 or approximately Station 19+300. The 1995 LRR adopted a turning area of 4,700 feet long by 1,075 feet wide which ends at Station 20+000 or the end of the existing 45-foot channel. The GHC Extension further extends the turning area to the end of the proposed Extension, resulting in a 1,075-foot wide by 7,271-foot long turning area. The extended turning area would allow pilots additional leeway in selecting appropriate vessel turning locations within the channel to account for variable factors such as current and location of docked vessels. Refer to the 1995 LRR, Section 4.3 “Ship Simulation Study” for a detailed analysis of the ship simulation study.

### *8.3 Shoaling Rate Investigation*

During the re-evaluation study, annual maintenance rates for the existing 45-foot GHC were derived by observing the results for detailed investigations of the bayou and bay reaches for the HSC and taking into account the quadratic equation in WES Technical

Report TR H-78-5, “*Methods of Estuarine Shoaling Analysis*”, Trawle, 1981. The predictions were verified in analysis of the historical shoaling rates. Based on observations, predicted rates for the proposed project were the same as the existing channel. The results from this investigation combined with additional analysis of shoaling rates in the District’s Dredging History Database were used to develop the shoaling estimates for the GHC Extension. Estimated shoaling is 162,000 cubic yards per year.

#### *8.4 Dredging Frequency Study*

The proposed maintenance cycle of four years for the existing GHC will be used for the extension. This value was derived during the shoaling rate investigation. Historically the channel had been dredged every four years during the prior 24 years for a total of six cycles. Because the shoaling rates were not predicted to increase the same dredging frequency is applicable.

#### *8.5 Advance Maintenance Study*

This was conducted to ascertain the effectiveness of the advance maintenance depths. Existing O&M practices since the year the channel was initially dredged to the 41-foot project have yielded an advance maintenance depth of three feet as being adequate in maintaining the project depth between dredging contracts. This existing depth of three feet will be used for the channel extension in this GHCE Feasibility Report. The allowable overdepth will be two feet.

#### *8.6 Relative Sea Level Change*

Current USACE guidance was used to assess relative sea level change (RSLC) for this GHCE Feasibility Report. USACE guidance (ER 1100-2-8162, December 2014 and Engineer Technical Letter (ETL) 1100-2-1, June 2014) specify the procedures for evaluating and incorporating climate change and relative sea level change into USACE planning studies and engineering design projects.

USACE guidance recommend that projects be evaluated using three different projections of future sea level change, i.e., “low, intermediate, and high,” as follows:

- Low – Use the historic rate of local mean sea level change as the “low” rate. The guidance further states that historic rates of sea level change are best determined by local tide records (preferably with at least a 40 year data record).

- Intermediate – Estimate the “intermediate” rate of local mean sea level change using the modified NRC Curve I. The modified curve corrects for the local rate of vertical land movement.
- High – Estimate the “high” rate of local mean sea level change using the modified NRC Curve III. The modified curve corrects for the local rate of vertical land movement.

Additionally, USACE guidance also recommend that RSLC be evaluated at planning horizons other than the one used in the economic analysis, recommending at a minimum, RSLC analysis at 20, 50 and 100 years post-construction.

The recent historic rate of local sea level change can be obtained from local tide records. The tide gage nearest the GCHE is located at Pier 21 in Galveston, Texas (NOAA gage 8771450). The NOAA mean sea level trend at this site (from 1908 to 2013) is equal to 6.35 millimeters (mm)/year with a 95 percent confidence interval of  $\pm 0.25$  mm/year. This equates to a rise of 0.42 feet in 20 years. If the estimated historic eustatic (global) rate equals that given for the Modified NRC curves (1.7 mm/year), this results in an observed subsidence rate of  $6.35 - 1.7 = 4.65$  mm/year.

Utilizing the online sea level calculator referenced in ER 1100-2-8162, estimates of future RSLC were determined. The computed future rates of RSLC in the table below give the predicted low, intermediate, and high estimates of sea level change at the 20-, 50- and 100-year planning horizons.

**TABLE 7 – ANTICIPATED FUTURE RELATIVE SEA LEVEL CHANGE\***

<b>Year</b>	<b>Low (feet)</b>	<b>Intermediate (feet)</b>	<b>High (feet)</b>
2036 (20 years)	0.42	0.54	0.92
2066 (50 years)	1.05	1.48	2.86
2116 (100 years)	2.10	3.41	7.58

*\*Based on nearest NOAA tidal gage at Pier 21, Galveston, Texas.*

Relative sea level change is not expected to have a significant impact on dredging frequency, shoaling or ship handling.

## 9.0 COST ENGINEERING

A Limited Reevaluation Report (LRR) and Environmental Impact Statement (EIS), dated November 1995 for the Houston-Galveston Navigation Channels (HGNC) Study was prepared by the Galveston District Corps of Engineers. The plan presented in the LRR consisted of deepening and widening the Houston Ship Channel and the Galveston Harbor Channel. The Galveston Channel was subdivided into two reaches designated as the Offshore Reach and the Galveston Channel Reach. The Galveston Channel Reach, referred to as the GHC in this document, is authorized to -46 feet (-45-foot MLT) deep from Station 0+000 to Station 20+000. From Station 20+000 to Station 22+571 the channel was only authorized to a depth of -40-feet MLT. As such, the local sponsor and facilities at the far end of the Galveston Ship Channel (last 0.5 mile) are not able to receive deeper draft vessels at their facilities without practices such as light-loading.

A Post Authorization Change Report (PACR) and integrated Environmental Assessment was developed in 2010 to evaluate deepening the remaining segment up to 45 feet in order to update the results of the 1995 LRR. The PACR was never finalized due to the Houston-Galveston Navigation Channel (HGNC) 902 limit exceedance.

On February 29, 2016 a new Federal Cost Share Agreement (FCSA) was signed, which removed the GHCE from the HGNC study in order to resume the GHCE study under Section 216 of the Flood Control Act (FCA) of 1970, Public Law (P.L.) 91-611, authorizes the Secretary of the Army to review existing Corps of Engineers (USACE) constructed projects due to changes in physical and economic conditions and report to Congress recommendations on the advisability of modifying the structures or their operation, and for improving the quality of the environment in the overall public interest, and the Galveston Harbor Channel is a constructed separable element of the authorized Houston-Galveston Navigation Channels, Texas project.

This current Feasibility report would involve extending the -46 foot (-45-foot MLT) deep Galveston Harbor Channel the remaining 2,571 feet to reach the end of the limits of the authorized and currently maintained -41-foot (-40-foot MLT) deep channel. The Mii estimate was prepared for this report. The NED proposes deepening it from -41-foot (-40-foot MLT) to -46-foot (-45-foot MLT) deep. This would be accomplished by pipeline dredging the channel and placing the material into the existing Pelican Island placement area (PA). Pelican Island PA is located north of the Galveston Channel.

The placement area would be conventional earthen dikes with the material excavated from the site. Quantities and design features were developed by the Galveston District (SWG) Engineering Branch.

This estimate was prepared using the latest Unit Price Books and labor rates for fiscal year 2017 (October 2016). The estimate was set-up as one contract, being subdivided into Non-Federal and Federal Costs. The costs were further organized in accordance with the work breakdown structure. The midpoint date of each account code was provided by the project manager for developing the fully funded costs. The estimate was prepared in accordance with ER 1110-2-1302, dated 15 September 2008. The costs were escalated in accordance with the above Engineering Regulation and EM 1110-2-1304, dated 31 March 2012, amend #8, Tables Revised as of 31 March 2016. All this data was input into the Total Project Cost Summary Sheet (TPCS). The baseline estimate provides for all pertinent elements for a complete project ready for operations.

Since the project is under 40 million dollars, a formal cost risk analysis using Crystal Ball software was not needed. Instead an Informal Risk Analysis developed by Walla Walla District was used to come-up with the project contingencies. The results of the Mii and contingencies are presented in the total project cost summary.

The Operation and Maintenance estimate was prepared in May 2016.

**ACCOUNT CODE 12 -- NAVIGATION PORTS AND HARBORS:** Dredge quantities were developed by the design engineer. The channel was assumed to be dredged using traditional dredging methods for the area, a 30" pipeline, with the material going into existing Pelican Island PA located back from the waterway. The dredging cost was developed using CEDEP. The dredge production rates were reduced to account for the stiffer "new work" material to be encountered. The cost for mobilization and demobilization was developed using CEDEP, and assuming the pipeline dredge was based in New Orleans. The Dredging estimates were based on standard operating practices for the Galveston. No overtime would be required to perform the work.

The cost for creating Cell B was included under this code of accounts. Part of the cost for creating the Cell B included clearing, grubbing, and stripping the area; as well as turfing the outside of the new levee. Labor rates and overhead costs were adjusted to reflect Region 6. Soil characteristics were provided by SWG, Engineering Division, Geotechnical and Structures Section.

**ACCOUNT CODE 30 -- ENGINEERING AND DESIGN:** The cost for this account was developed using the guidelines provided in the TPCS, with the agreement of the cost engineer and the project manager.

**ACCOUNT CODE 31 -- CONSTRUCTION MANAGEMENT:** The cost for this account was developed using the guidelines provided in the TPCS, with the agreement of the cost engineer and the project manager.

## **10.0 CHANNEL CONSTRUCTION**

### *10.1 General*

The project will be dredged in one contract. All material will be excavated with a hydraulic pipeline dredge, and placed into the confined upland Pelican Island PA.

### *10.2 Construction Method*

The construction will utilize traditional dredging techniques, such as the hydraulic pipeline dredge. Placement of the material for the GHC Extension will also be traditional, in that the material will be contained in a confined upland site. The Pelican Island PA will be decanted during and following dredging to reduce hydraulic material volume and with the intent to minimize dispersal of sediments into the bay through the effluent. The PA construction is such that flow will be directed from Cell B through the weir into Cell C, then around training dikes in Cell C toward the drop-outlet box and finally discharging into the bay. This labyrinth of weir and training dikes maximizes the distance that the dredge pipe discharge water and sediment must travel. Elevations of the weir and drop-outlet box would be controlled using adjustable stop-log timbers to control flow volume and velocities within the PA, thus allowing the maximum amount of sediment to settle prior to discharge into the bay.

## **11.0 PROJECT SECURITY**

Security measures for protecting the project against attacks, such as terrorism attacks, are not considered necessary because of the nature of the project. The only likely attack would be attempts to sink a vessel in order to block navigation. The sunken vessel can usually be removed within a few days to allow navigation to resume. The only vertical structures in this project are the existing drop-outlet and weir structures in the Pelican Island PA, but they are not considered likely attack targets because of the unimportant consequences of failure, and because they can be repaired fairly quickly to restore their function.

## **12.0 DATA MANAGEMENT**

The electronic version of the Engineering Appendix, related civil and geotechnical design, and cost information is located on the Districts “W” drive. Location of the folder is at the following address: W:\Cadd\Projects\Galv\Galveston Har Ext 2016.

### **13.0 USE OF METRIC SYSTEM MEASUREMENTS**

The existing GHC, Texas is established in English units. The navigation industry exclusively uses English units. In the District, water depths are typically expressed in feet and accuracy standards are expressed in feet. Distances are measured in feet, or miles. Engineering project coordinates are normally in English units (feet). Construction measurement quantities are normally measured in linear feet, square feet, or cubic yards. The Districts' Dredging History Database uses English units.

## **14.0 ENVIRONMENTAL OPERATING PRINCIPLES (EOP)**

The purpose of this section is to provide examples of how the Engineering Appendix integrates EOPs as applicable to engineering and design as required for sustainability, preservation, stewardship, and restoration of the project area's natural resources.

Throughout the study process USACE Environmental Operating Principles (EOP) are considered. The EOP's are outlined in Appendix A of ER 200-1-5 "*Environmental Quality - Policy for Implementation and Integrated Application of the U.S. Army Corps of Engineers (USACE) Environmental Operating Principles (EOP) and Doctrine,*" dated 30 October 2003. The re-energized EOP principles (announced in 2012) are considered at the same level as economic issues and are listed below.

- 1) Foster a culture of sustainability throughout the organization;
- 2) Proactively consider environmental consequences of all USACE activities and act accordingly;
- 3) Create mutually supporting economic and environmental solutions;
- 4) Continue to meet our corporate responsibility and accountability under the law for activities undertaken by the USACE which may impact human and natural environments;
- 5) Consider the environment in employing a risk management and systems approach throughout life cycles of projects and programs;
- 6) Leverage scientific, economic, and social knowledge to understand the environmental context and effects of USACE actions in a collaborative manner; and
- 7) Employ an open, transparent process that respects views of individuals and groups interested in USACE activities.

Various project planning and design processes were carried out to achieve practical balance between environmental and economic considerations. The following paragraphs discuss various planning and design considerations that incorporate ways and means to minimize the environmental impact of the project.

### *14.1 Dredging*

In order to minimize water quality degradation, the most efficient dredging techniques and equipment would be utilized for new work and maintenance dredging. Sediment sampling and soil core borings would be performed during the PED phase of the project to classify

the new work and maintenance material proposed to be dredged and to identify existing contaminants for appropriate disposal during dredging operations.

#### *14.2 Dredged Material Disposal*

Selection of the existing Pelican Island PA site and placement of dredged material within the PA was optimized for proximity to the project. Thus, the need for construction of additional upland disposal sites was eliminated and the distance required to pump the dredged material was minimized. This will result in saving energy and reducing equipment exhaust emissions.

#### *14.3 Design*

The project is designed to provide increased navigational safety and efficiency along the channel.

#### *14.4 Effluent Water and Sediment Quality*

The effluent water and sediment quality will be monitored during dredging operations to insure it meets state and national quality requirements.

#### *14.5 Geotechnical Engineering*

In an effort to “proactively consider environmental consequences of Corp programs” as part of the EOP’s, PA containment dike design practices have been focused on providing a dike layout design with sufficient freeboard, to provide the needed settling time for soil particles within the effluent discharge material, to promote lower levels of turbidity in the drop-outlet structure effluent. Other factors may influence settling time including the discharge flow rate implemented by the dredging contractor. Specification language is added at the time plans and specifications are produced. This language provides additional restrictions on contractor dredging operations such that effluent concentrations at drop-outlet structure are within legal and allowable limits.

#### *14.6 Environmental Engineering*

Section 5.0 ENVIRONMENTAL ENGINEERING of this document discusses the application of EOP’s.

## **15.0 RISK AND UNCERTAINTY**

This section provides detail as applicable for addressing USACE policy concerning risk and uncertainty with regard to estimated construction quantities. Typical changes in channel shoaling rates are attributed to several major factors including: increase in bottom width; decreased flow velocity due to enlarged cross-section; modified salinity regime; increased vessel traffic; channel bank failure; and, sediment brought down by rivers, etc.

The only change in the channel dimensions for this project is an increase in depth and a slight decrease in bottom width. Based on the hydrodynamic and salinity model study performed for the 1995 LRR, the salinity in the Lower Bay area will remain the same or change very little with channel deepening. The channel bank in the area has a proven history of stability and there is no river to increase sediment load. The cross section is enlarged because of the increased depth thereby providing a possible decrease in current velocities.

Navigable vessels and docks are predicted to experience insignificant impacts of higher water elevation resulting from RSLC.

Because of the uncertainty involved in the assumptions and calculations of velocity data and channel side slope stability, the estimated shoaling quantities for the proposed project may not match the actual shoaling rates and are therefore subject to a certain degree of uncertainty.

Since the project is under 40 million dollars, a formal cost risk analysis using the Crystal Ball software was not required. Therefore, cost contingencies were developed using the Informal Risk Analysis method developed by the Walla Walla District. Refer to Section 9.0 COST ENGINEERING of this appendix.

## **ATTACHMENTS**

ATTACHMENT 1  
Page 1 of 10

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS  
BY CLASSICAL METHODS

DATE: 13-SEPTEMBER-2016

TIME: 8:35:26

\*\*\*\*\*  
\* INPUT DATA \*  
\*\*\*\*\*

I.--HEADING  
'EDISON-CHOUEST BULKHEAD

II.--CONTROL  
ANCHORED WALL DESIGN  
FACTOR OF SAFETY FOR ACTIVE PRESSURES = 1.00  
FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.50

III.--WALL DATA  
ELEVATION AT TOP OF WALL = 10.00 FT.  
ELEVATION AT ANCHOR = -2.00 FT.

IV.--SURFACE POINT DATA

IV.A.--RIGHTSIDE  
DIST. FROM WALL (FT) ELEVATION (FT)  
0.00 10.00

IV.B.--LEFTSIDE  
DIST. FROM WALL (FT) ELEVATION (FT)  
0.00 -26.00  
40.00 -26.00  
70.00 -36.00  
100.00 -46.00  
100.50 -51.00

V.--SOIL LAYER DATA

V.A.--RIGHTSIDE  
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE = 1.00  
LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = 1.50

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT. PASS.	
110.00	110.00	30.00	0.00	20.00	0.00	-2.00	0.00	1.00	1.50
120.00	120.00	26.00	0.00	20.00	0.00	-30.00	0.00	1.00	1.50
120.00	120.00	20.00	150.00	17.00	50.00	-46.00	0.00	1.00	1.50
120.00	120.00	20.00	120.00	17.00	50.00	-65.00	0.00	1.00	1.50
120.00	120.00	20.00	200.00	17.00	50.00			1.00	1.50

V.B.--LEFTSIDE  
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE = 1.00

# ATTACHMENT 1

## Page 2 of 10

LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = 1.50

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH- ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH- ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT. PASS.
120.00	120.00	20.00	150.00	17.00	50.00	-46.00	0.00	1.00 1.50
120.00	120.00	20.00	120.00	17.00	50.00	-65.00	0.00	1.00 1.50
120.00	120.00	20.00	200.00	17.00	50.00			1.00 1.50

### VI.--WATER DATA

UNIT WEIGHT = 64.30 (PCF)  
RIGHTSIDE ELEVATION = 0.00 (FT)  
LEFTSIDE ELEVATION = 0.00 (FT)  
NO SEEPAGE

### VII.--VERTICAL SURCHARGE LOADS

#### VII.A.--VERTICAL LINE LOADS

NONE

#### VII.B.--VERTICAL UNIFORM LOADS

LEFTSIDE (PSF)	RIGHTSIDE (PSF)
0.00	250.00

#### VII.C.--VERTICAL STRIP LOADS

NONE

#### VII.D.--VERTICAL RAMP LOADS

NONE

#### VII.E.--VERTICAL TRIANGULAR LOADS

NONE

#### VII.F.--VERTICAL VARIABLE LOADS

NONE

### VIII.--HORIZONTAL LOADS

NONE

ATTACHMENT 1  
Page 3 of 10

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS  
BY CLASSICAL METHODS

DATE: 13-SEPTEMBER-2016

TIME: 8:35:31

\*\*\*\*\*  
\* SUMMARY OF RESULTS FOR \*  
\* ANCHORED WALL DESIGN \*  
\*\*\*\*\*

I.--HEADING

'EDISON-CHOUEST BULKHEAD

II.--SUMMARY

RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

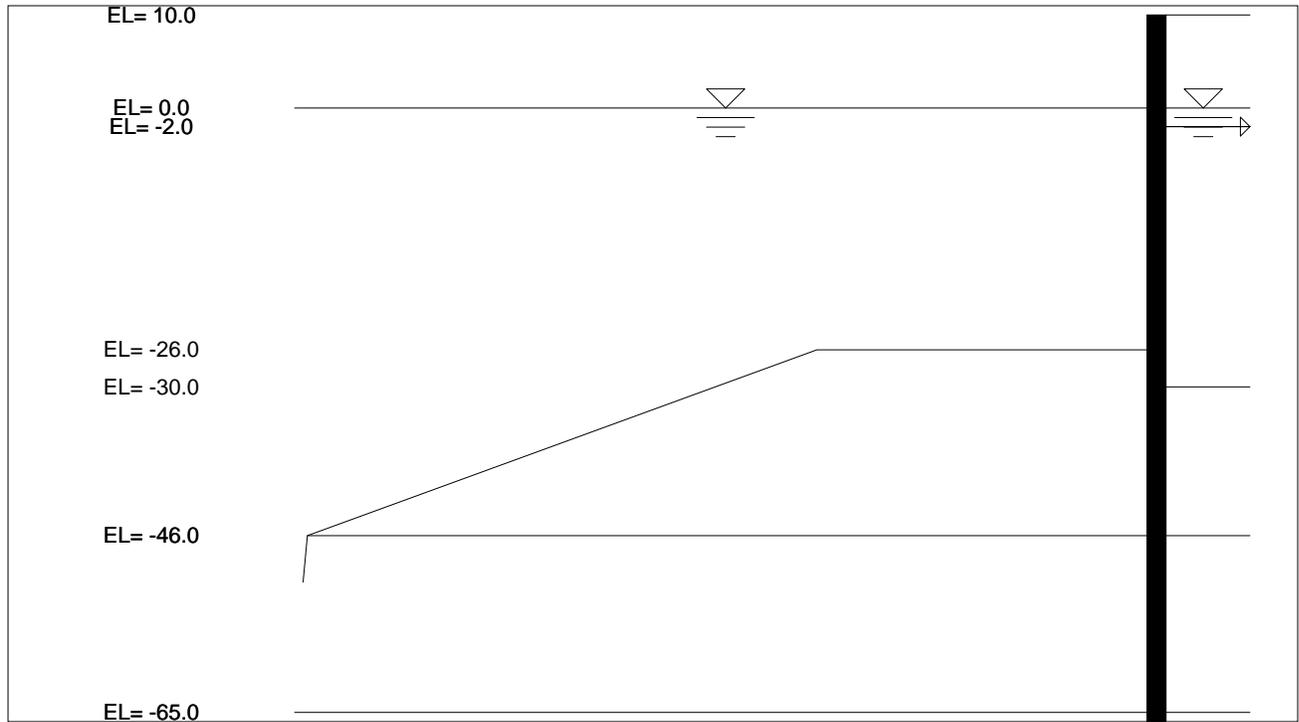
\*\*\*\*\*WARNING: STANDARD WEDGE SOLUTION DOES NOT EXIST  
AT ALL ELEVATIONS. SEE COMPLETE OUTPUT.

METHOD	:	FREE EARTH	FIXED EARTH
WALL BOTTOM ELEVATION (FT)	:	-43.26	-58.23
PENETRATION (FT)	:	17.26	32.23
MAXIMUM BENDING MOMENT (LB-FT)	:	-9.4769E+04	-7.9088E+04
AT ELEVATION (FT)	:	-19.87	-18.70
MAXIMUM SCALED DEFLECTION (LB-IN <sup>3</sup> )	:	2.5537E+10	2.0652E+10
AT ELEVATION (FT)	:	-21.00	-21.00
ANCHOR FORCE (LB)	:	1.4132E+04	1.3224E+04

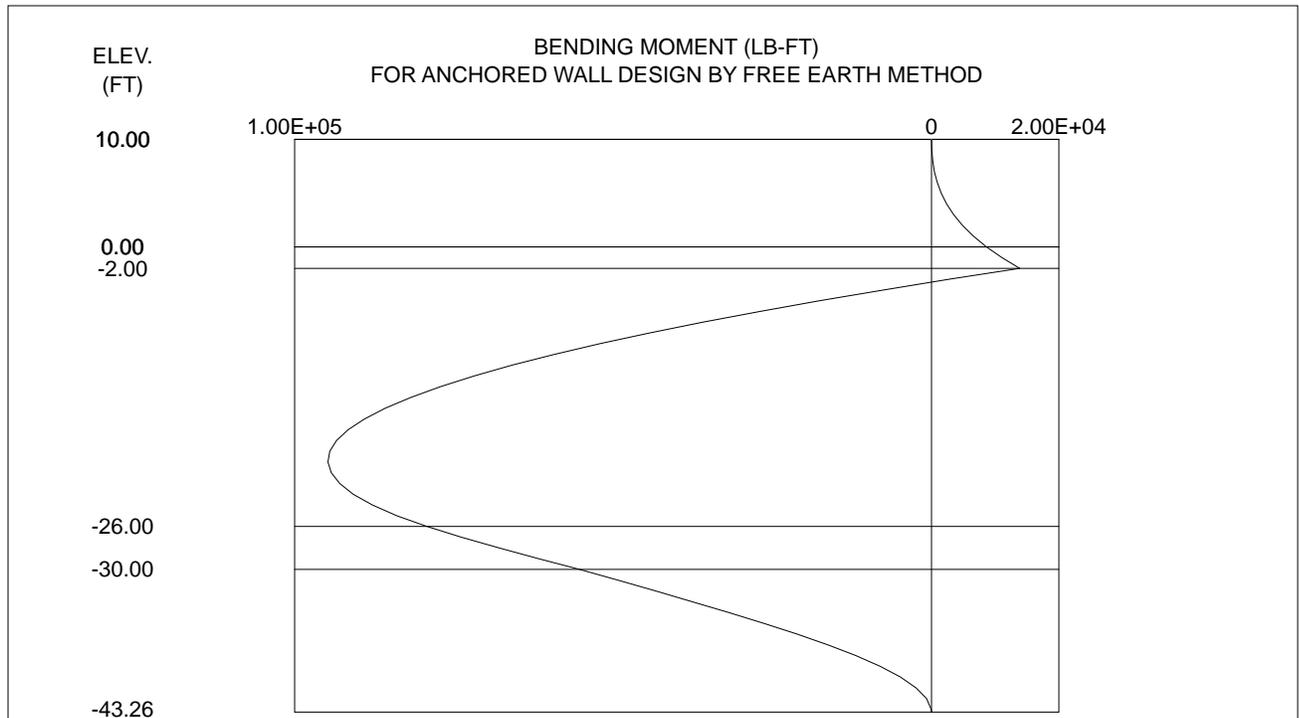
NOTE: DIVIDE SCALED DEFLECTION MODULUS OF  
ELLASTICITY IN PSI TIMES PILE MOMENT  
OF INERTIA IN IN<sup>4</sup> TO OBTAIN DEFLECTION  
IN INCHES.

ATTACHMENT 1  
Page 4 of 10

EDISON-CHOUEST BULKHEAD

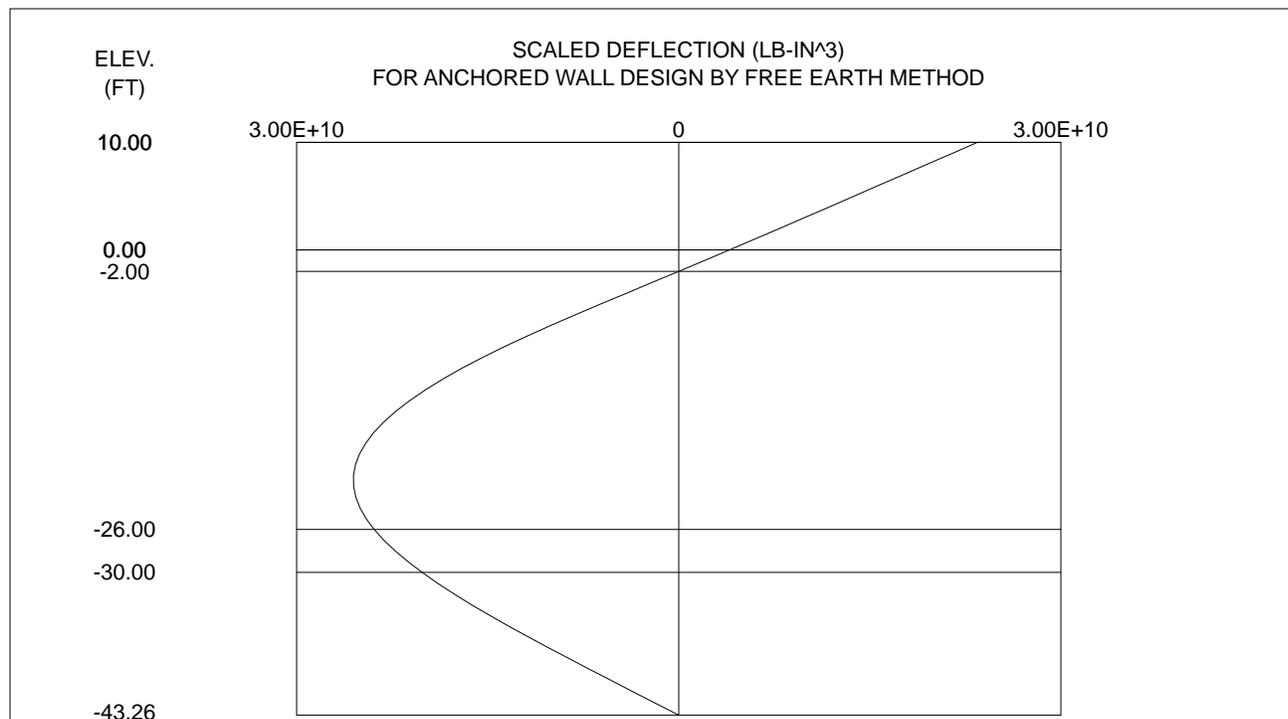


EDISON-CHOUEST BULKHEAD

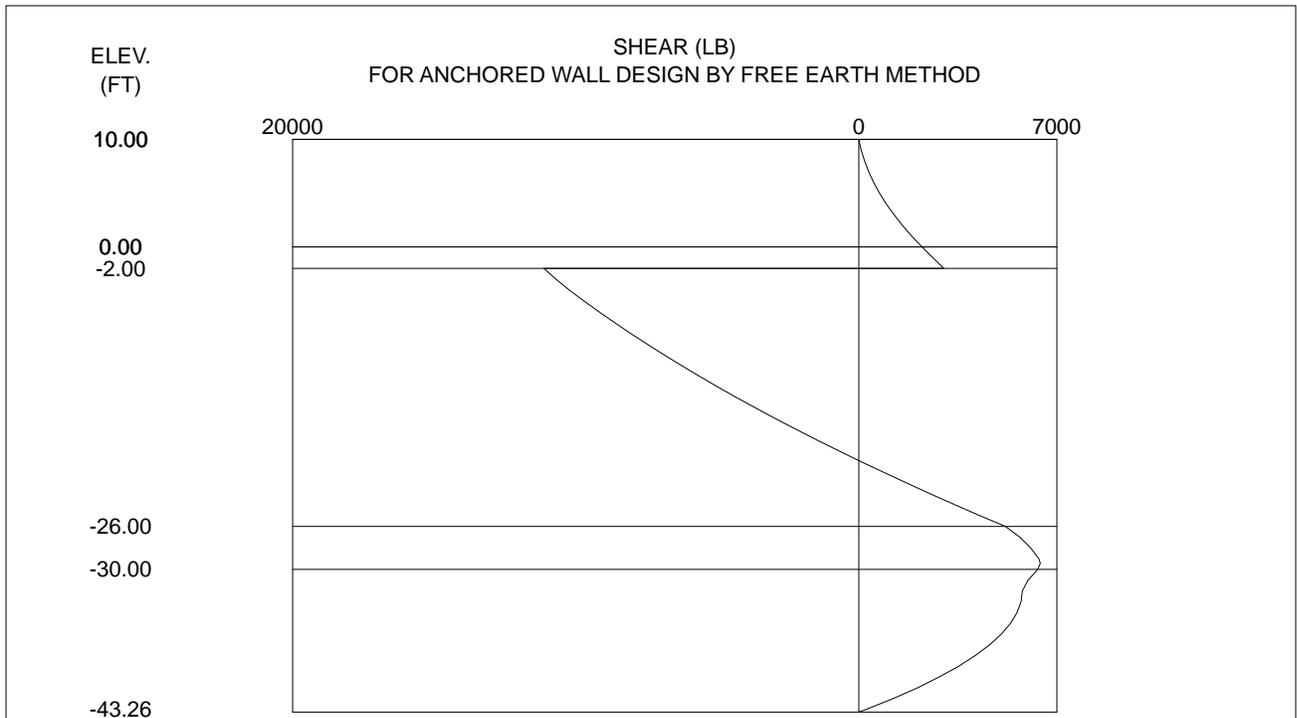


ATTACHMENT 1  
Page 6 of 10

EDISON-CHOUEST BULKHEAD

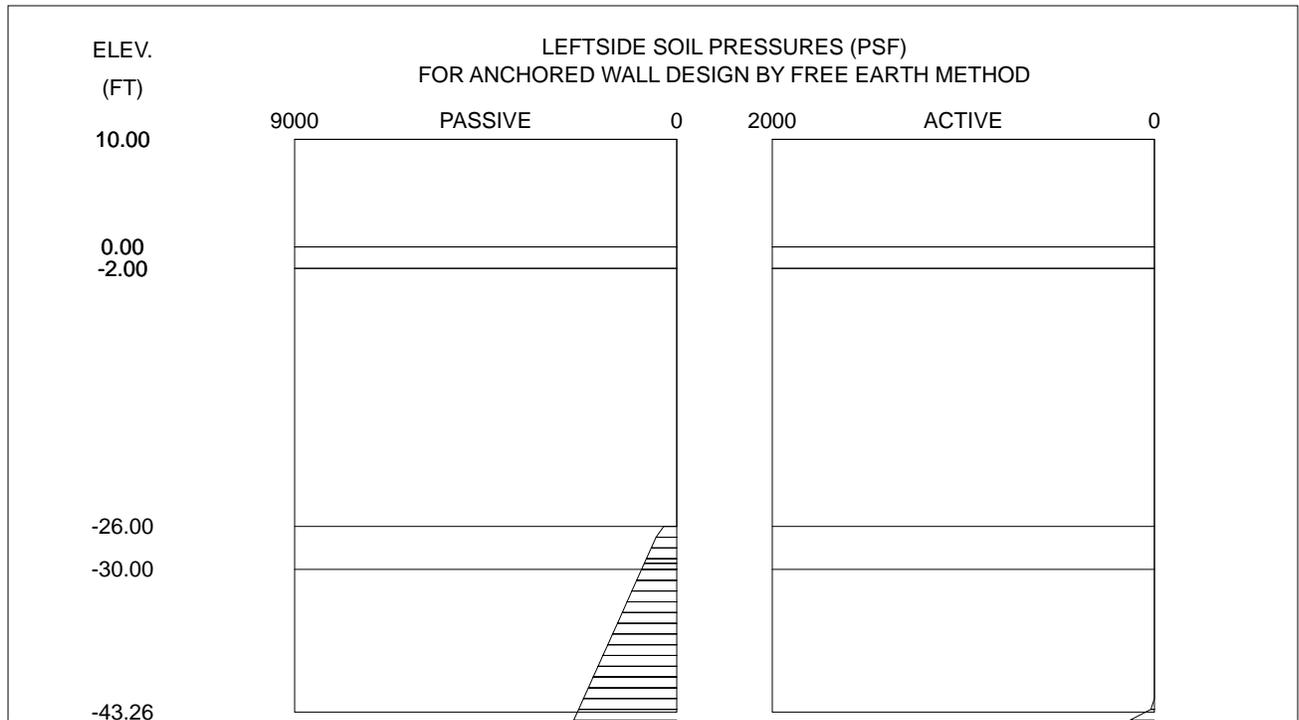


EDISON-CHOUEST BULKHEAD



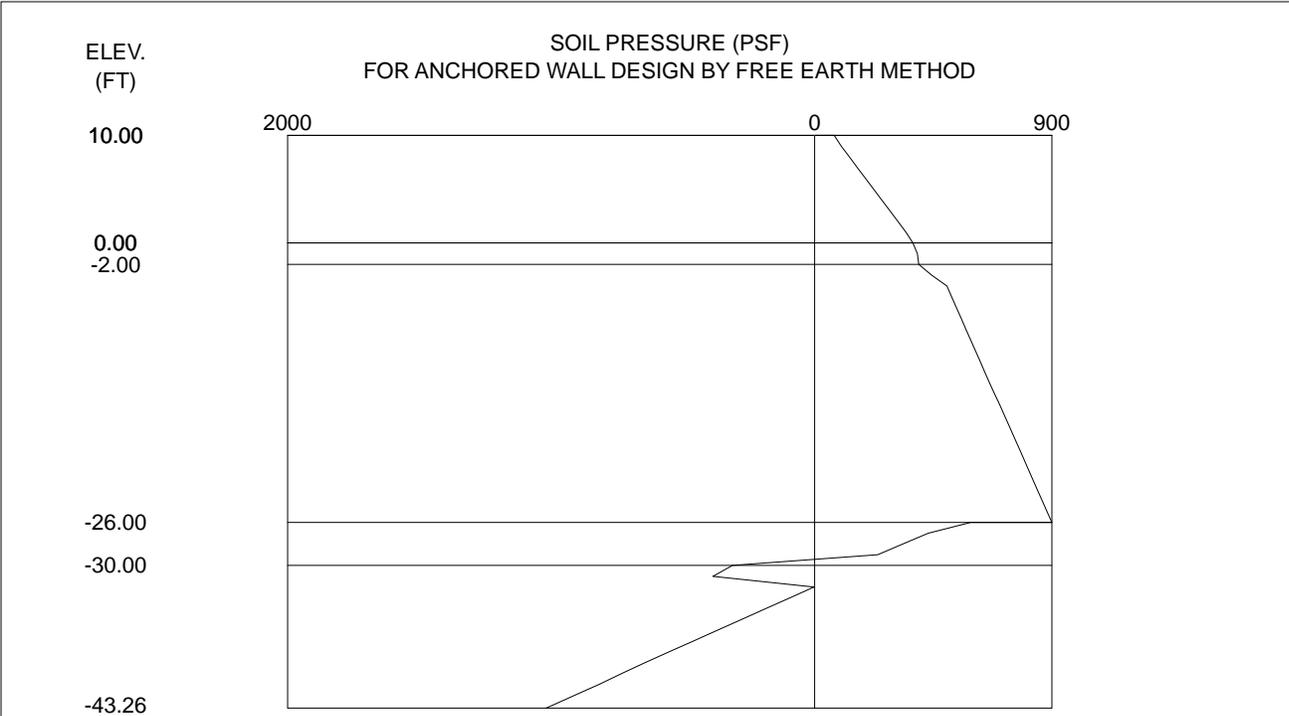
ATTACHMENT 1  
Page 8 of 10

EDISON-CHOUEST BULKHEAD

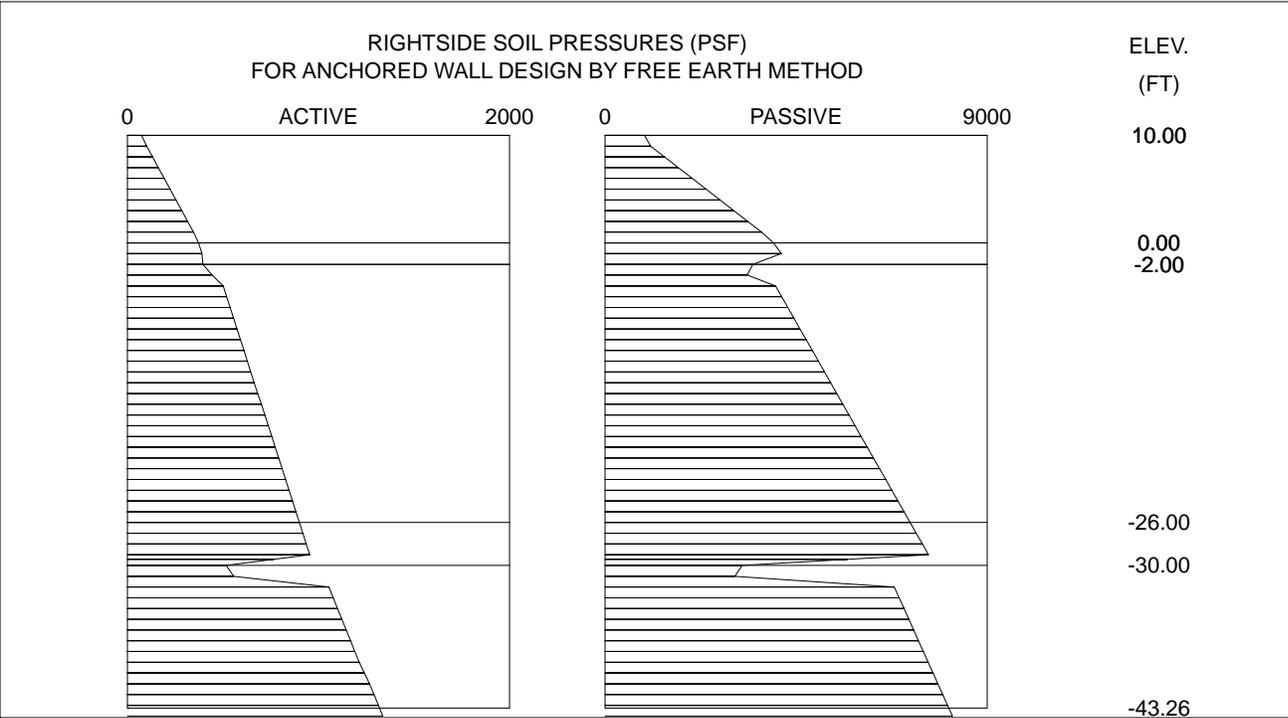


ATTACHMENT 1  
Page 9 of 10

EDISON-CHOUEST BULKHEAD



EDISON-CHOUEST BULKHEAD



# ATTACHMENT 2

## Page 1 of 2

Galveston Harbor Channel Extension Feasibility Study  
 Edison-Chouest Bulkhead  
 Channel Slope - Short Term Condition  
 Name: EdisonChouestBulkhead-60.250psf.ST1

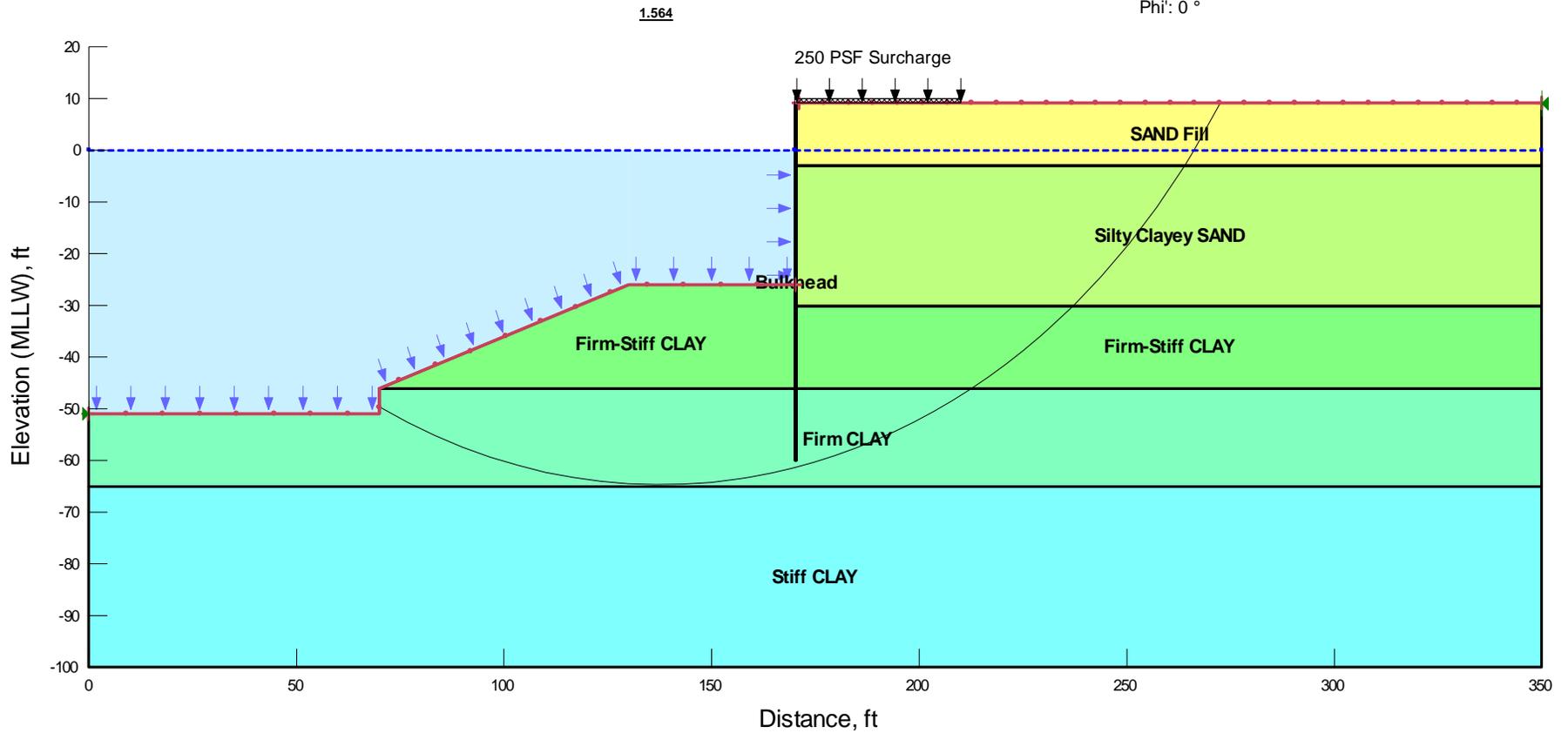
Name: Stiff CLAY  
 Unit Weight: 120 pcf  
 Cohesion: 1,500 psf  
 Phi: 0 °

Name: Silty Clayey SAND  
 Unit Weight: 120 pcf  
 Cohesion: 0 psf  
 Phi: 26 °

Name: Firm CLAY  
 Unit Weight: 120 pcf  
 Cohesion: 1,000 psf  
 Phi: 0 °

Name: SAND Fill  
 Unit Weight: 110 pcf  
 Cohesion: 0 psf  
 Phi: 30 °

Name: Firm-Stiff CLAY  
 Unit Weight: 120 pcf  
 Cohesion: 1,250 psf  
 Phi: 0 °



# ATTACHMENT 2

## Page 2 of 2

Galveston Harbor Channel Extension Feasibility Study  
 Edison-Chouest Bulkhead  
 Channel Slope - Long Term Condition  
 Name: EdisonChouestBulkhead-60.250psf.LT1

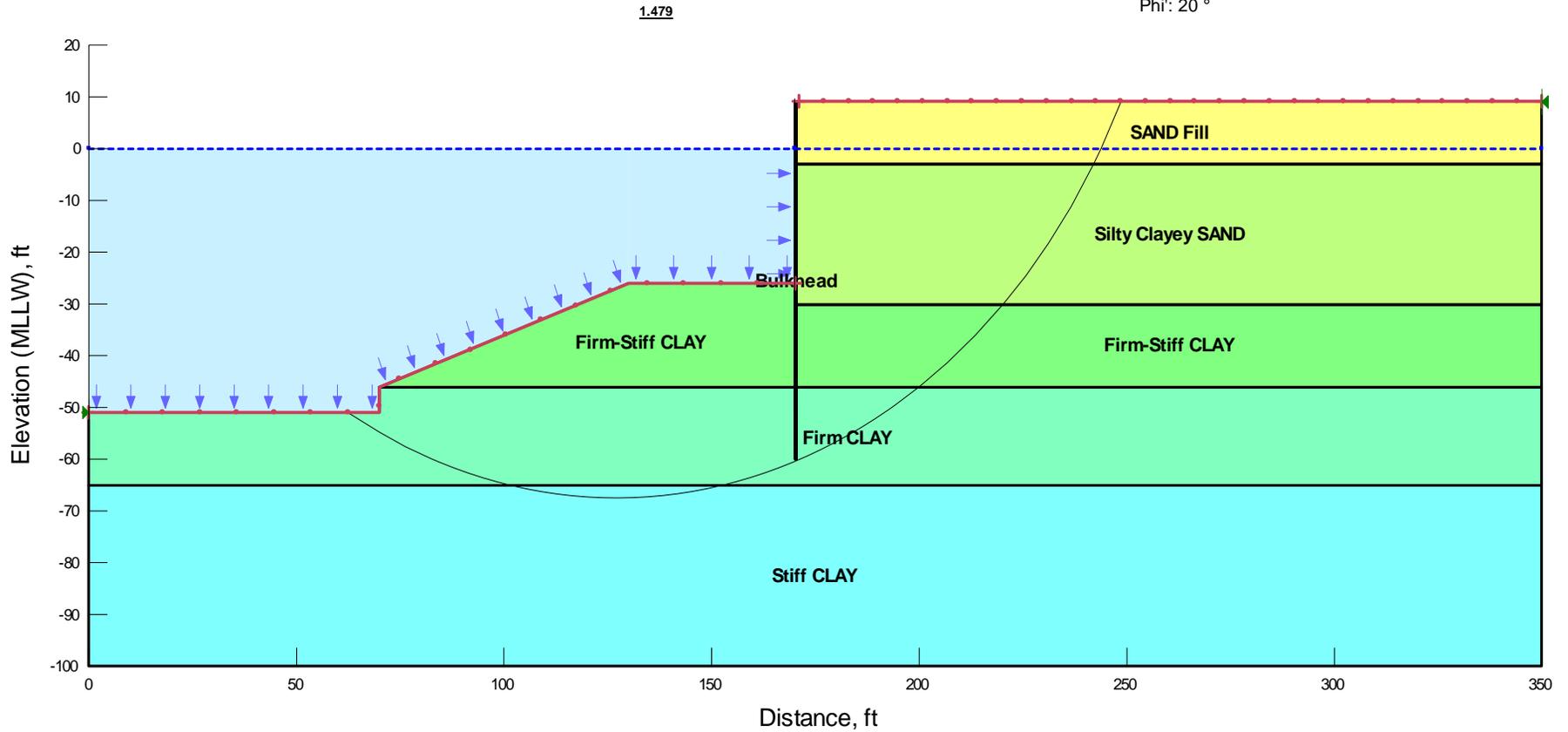
Name: Stiff CLAY  
 Unit Weight: 120 pcf  
 Cohesion: 200 psf  
 Phi: 20 °

Name: Silty Clayey SAND  
 Unit Weight: 120 pcf  
 Cohesion: 0 psf  
 Phi: 26 °

Name: Firm CLAY  
 Unit Weight: 120 pcf  
 Cohesion: 120 psf  
 Phi: 20 °

Name: SAND Fill  
 Unit Weight: 110 pcf  
 Cohesion: 0 psf  
 Phi: 30 °

Name: Firm-Stiff CLAY  
 Unit Weight: 120 pcf  
 Cohesion: 150 psf  
 Phi: 20 °



## **DRAWINGS AND PLATES**































Galveston Ch Ext V4.3 Feb 2017  
Galveston Harbor Channel Extension Feasibility

Estimated by J. Lockhart  
Designed by CESWG-EC  
Prepared by Jackie Lockhart

Preparation Date 2/7/2017  
Effective Date of Pricing 2/7/2017  
Estimated Construction Time 120 Days

This report is not copyrighted, but the information contained herein is For Official Use Only.

<u>Description</u>	<u>Quantity</u>	<u>UOM</u>	<u>DirectCost</u>	<u>ContractCost</u>	<u>ProjectCost</u>
<b>Project Cost Summary Report</b>			<b>8,489,399</b>	<b>8,804,360</b>	<b>8,804,360</b>
<b>02 Contract 1 - 45' - NED, Ch to Peican Island Cell B</b>	<b>1.00</b>	<b>LS</b>	<b>8,489,399</b>	<b>8,804,360</b>	<b>8,804,360</b>
<b>0202 Federal Costs</b>	<b>1.00</b>	<b>LS</b>	<b>8,489,399</b>	<b>8,804,360</b>	<b>8,804,360</b>
<b>020212 Navigation Ports and Harbors</b>	<b>1.00</b>	<b>LS</b>	<b>8,489,399</b>	<b>8,804,360</b>	<b>8,804,360</b>

<b>Description</b>	<b>Page</b>
<b>Project Cost Summary Report</b>	<b>1</b>
02 Contract 1 - 45' - NED, Ch to Peican Island Cell B	1
0202 Federal Costs	1
020212 Navigation Ports and Harbors	1

**WALLA WALLA COST ENGINEERING  
MANDATORY CENTER OF EXPERTISE**

**COST AGENCY TECHNICAL REVIEW**

**CERTIFICATION STATEMENT**

For P2 401250

SWG Houston-Galveston Ship Channel Extension  
45' Depth

The Houston Galveston Ship Channel Extension as presented by Galveston District has undergone a successful Cost Agency Technical Review (Cost ATR), performed by the Walla Walla District Cost Engineering Mandatory Center of Expertise (Cost MCX) team. The Cost ATR included study of the project scope, report, cost estimates, schedules, escalation, and risk-based contingencies. This certification signifies the products meet the quality standards as prescribed in ER 1110-2-1150 Engineering and Design for Civil Works Projects and ER 1110-2-1302 Civil Works Cost Engineering.

As of February 14, 2017, the Cost MCX certifies the estimated total project cost of:

FY 17 Project First Cost: \$15,333,000  
Fully Funded Amount: \$16,305,000

It remains the responsibility of the District to correctly reflect these cost values within the Final Report and to implement effective project management controls and implementation procedures including risk management through the period of Federal interest.

**CALLAN.KIM.**

**C.123155822**

**1**

Digitally signed by CALLAN.KIM.C.1231558221  
DN: c=US, o=U.S. Government, ou=DoD, ou=PKI,  
ou=USA, cn=CALLAN.KIM.C.1231558221  
Date: 2017.02.14 07:32:42 -08'00'



**US Army Corps  
of Engineers®**

**Kim C. Callan, PE, CCE, PM  
Chief, Cost Engineering MCX  
Walla Walla District**

**PLATE NO. 2  
Page 1 of 3**

\*\*\*\* TOTAL PROJECT COST SUMMARY \*\*\*\*

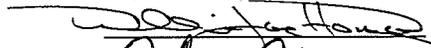
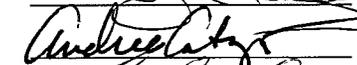
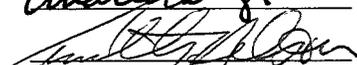
PROJECT: Houston-Galveston Navigation Channels, Texas  
PROJECT NO: P2 401250  
LOCATION: Galveston, Texas

DISTRICT: Galveston District  
POC: CHIEF, COST ENGINEERING, Willie Joe Honza, P.E.

PREPARED: 2/13/2017

This Estimate reflects the scope and schedule in report; Galveston Harbor Channel Extension Project Post Authorization Change Report and Environmental Assessment Draft

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)					TOTAL PROJECT COST (FULLY FUNDED)				
WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	COST (\$K) C	CNTG (\$K) D	CNTG (%) E	TOTAL (\$K) F	ESC (%) G	COST (\$K) H	CNTG (\$K) I	TOTAL (\$K) J	Spent Thru: 1-Oct-15 (\$K) K	TOTAL FIRST COST (\$K) K	INFLATED (%) L	COST (\$K) M	CNTG (\$K) N	FULL (\$K) O
02	RELOCATIONS	\$0	\$0	-	\$0	-	\$0	\$0	\$0	\$0	\$0	-	\$0	\$0	\$0
12	NAVIGATION PORTS & HARBORS														
12	Federal Costs	\$8,804	\$2,113	24.0%	\$10,917	5.2%	\$9,266	\$2,224	\$11,490	0	\$11,490	5.9%	\$9,811	\$2,355	\$12,166
12	Non-Fed Costs - Berthing Area	\$1,485	\$356	24.0%	\$1,841	5.2%	\$1,563	\$375	\$1,938	0	\$1,938	5.9%	\$1,655	\$397	\$2,052
<b>CONSTRUCTION ESTIMATE TOTALS:</b>		\$10,289	\$2,469		\$12,758	5.2%	\$10,829	\$2,599	\$13,428	\$0	\$13,428	5.9%	\$11,466	\$2,752	\$14,218
01	LANDS AND DAMAGES	\$0	\$0	-	\$0	-	\$0	\$0	\$0	\$0	\$0	-	\$0	\$0	\$0
30	PLANNING, ENGINEERING & DESIGN	\$1,181	\$283	24.0%	\$1,464	2.7%	\$1,213	\$291	\$1,504	\$0	\$1,504	8.9%	\$1,321	\$317	\$1,638
31	CONSTRUCTION MANAGEMENT	\$315	\$76	24.0%	\$391	2.7%	\$324	\$78	\$401	\$0	\$401	11.8%	\$362	\$87	\$449
<b>PROJECT COST TOTALS:</b>		\$11,785	\$2,828	24.0%	\$14,613		\$12,365	\$2,968	\$15,333	\$0	\$15,333	6.3%	\$13,149	\$3,156	\$16,305

 CHIEF, COST ENGINEERING, Willie Joe Honza, P.E.  
 PROJECT MANAGER, Andrea Catanzaro  
 CHIEF, REAL ESTATE, Timothy Nelson  
\_\_\_\_\_  
CHIEF, PLANNING, Eric Verwers  
\_\_\_\_\_  
CHIEF, ENGINEERING, Joe King, R.A., LEED Green Assoc.  
\_\_\_\_\_  
CHIEF, OPERATIONS, Joseph Hrametz, P.E.  
\_\_\_\_\_  
CHIEF, CONSTRUCTION, Donald W. Carelock, P.E.  
\_\_\_\_\_  
CHIEF, CONTRACTING, Kathrine Freeman  
\_\_\_\_\_  
CHIEF, PM-G, Valerie Miller  
\_\_\_\_\_  
CHIEF, DPM, Edmond J. Russo Jr., PhD, P.E., D.CE, D.NE

ESTIMATED TOTAL PROJECT COST: **\$16,305**

\*\*\*\* TOTAL PROJECT COST SUMMARY \*\*\*\*

\*\*\*\* CONTRACT COST SUMMARY \*\*\*\*

PROJECT: Houston-Galveston Navigation Channels, Texas  
LOCATION: Galveston, Texas

DISTRICT: Galveston District  
POC: CHIEF, COST ENGINEERING, Willie Joe Honza, P.E.

PREPARED: 2/13/2017

This Estimate reflects the scope and schedule in report: Galveston Harbor Channel Extension Project Post Authorization Change Report and Environmental Assessment Draft

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	Estimate Prepared: Effective Price Level:			TOTAL (\$K) F	Program Year (Budget EC): Effective Price Level Date:			Mid-Point Date P	INFLATED (%) L	COST (\$K) M	CNTG (\$K) N	FULL (\$K) O	
		COST (\$K) C	CNTG (\$K) D	CNTG (%) E		ESC (%) G	COST (\$K) H	CNTG (\$K) I						TOTAL (\$K) J
	<b>CONTRACT 1</b>													
<b>12</b>	<b>NAVIGATION PORTS &amp; HARBORS</b>													
<b>12</b>	Channel Dredging	\$8,804	\$2,113	24.0%	\$10,917	5.2%	\$9,266	\$2,224	\$11,490	2020Q1	5.9%	\$9,811	\$2,355	\$12,166
<b>12</b>	(Depth 41' to 45')	\$7,043	\$1,690	24.0%	\$8,733	5.2%	\$7,412	\$1,779	\$9,191	2020Q1	5.9%	\$7,849	\$1,884	\$9,732
<b>12</b>	(Depth 45' to 46')	\$1,761	\$423	24.0%	\$2,184	5.2%	\$1,853	\$445	\$2,298	2020Q1	5.9%	\$1,962	\$471	\$2,433
<b>12</b>	Non-Fed Costs - Berthing Area	\$1,485	\$356	24.0%	\$1,841	5.2%	\$1,563	\$375	\$1,938	2020Q1	5.9%	\$1,655	\$397	\$2,052
	<b>CONSTRUCTION ESTIMATE TOTALS:</b>	\$10,289	\$2,469	24.0%	\$12,758		\$10,829	\$2,599	\$13,428			\$11,466	\$2,752	\$14,218
<b>01</b>	<b>LANDS AND DAMAGES</b>	\$0	\$0	0.0%	\$0	0.0%	\$0	\$0	\$0	0	0.0%	\$0	\$0	\$0
<b>30</b>	<b>PLANNING, ENGINEERING &amp; DESIGN</b>													
0.6%	Project Management	\$57	\$14	24.0%	\$71	2.7%	\$59	\$14	\$73	2019Q2	8.7%	\$64	\$15	\$79
0.7%	Planning & Environmental Compliance	\$68	\$16	24.0%	\$84	2.7%	\$70	\$17	\$87	2019Q2	8.7%	\$76	\$18	\$94
7.0%	Engineering & Design	\$720	\$173	24.0%	\$893	2.7%	\$739	\$177	\$917	2019Q2	8.7%	\$804	\$193	\$996
1.0%	Reviews, ATRs, IEPRs, VE	\$103	\$25	24.0%	\$128	2.7%	\$106	\$25	\$131	2019Q2	8.7%	\$115	\$28	\$143
0.5%	Life Cycle Updates (cost, schedule, risks)	\$51	\$12	24.0%	\$63	2.7%	\$52	\$13	\$65	2019Q2	8.7%	\$57	\$14	\$71
0.3%	Contracting & Reprographics	\$34	\$8	24.0%	\$42	2.7%	\$35	\$8	\$43	2019Q2	8.7%	\$38	\$9	\$47
1.0%	Engineering During Construction	\$103	\$25	24.0%	\$128	2.7%	\$106	\$25	\$131	2020Q1	11.8%	\$118	\$28	\$147
0.0%	Planning During Construction	\$0	\$0	24.0%	\$0	0.0%	\$0	\$0	\$0	0	0.0%	\$0	\$0	\$0
0.4%	Project Operations	\$45	\$11	24.0%	\$56	2.7%	\$46	\$11	\$57	2019Q2	8.7%	\$50	\$12	\$62
<b>31</b>	<b>CONSTRUCTION MANAGEMENT</b>													
2.2%	Construction Management	\$225	\$54	24.0%	\$279	2.7%	\$231	\$55	\$287	2020Q1	11.8%	\$258	\$62	\$320
0.4%	Project Operation:	\$45	\$11	24.0%	\$56	2.7%	\$46	\$11	\$57	2020Q1	11.8%	\$52	\$12	\$64
0.4%	Project Management	\$45	\$11	24.0%	\$56	2.7%	\$46	\$11	\$57	2020Q1	11.8%	\$52	\$12	\$64
	<b>CONTRACT COST TOTALS:</b>	\$11,785	\$2,828		\$14,613		\$12,365	\$2,968	\$15,333			\$13,149	\$3,156	\$16,305

**Abbreviated Risk Analysis**  
**Project Example**  
**Feasibility (Recommended Plan)**

Meeting Date: 6-Jan-12

**PDT Members**

Note: PDT involvement is commensurate with project size and involvement.

Represents	Name
Project Management:	<u>Byron Williams</u>
Study Manager:	<u>Cheryl Jaynes</u>
Real Estate:	<u>Kenny Pablo</u>
Relocations:	<u>Nancy Young</u>
Engineering & Design:	<u>Nancy Young/David Boothby</u>
Cost Engineering:	<u>Jackie Lockhart</u>

**Abbreviated Risk Analysis**

Project (less than \$40M): **Project Example**  
 Project Development Stage/Alternative: **Feasibility (Recommended Plan)**  
 Risk Category: **Low Risk: Typical Construction, Simple**

Alternative: **N/A**

Meeting Date: **1/6/2012**

Total Estimated Construction Contract Cost = \$ **8,804,360**

	CWWBS	Feature of Work	Estimated Cost	% Contingency	\$ Contingency	Total
	01 LANDS AND DAMAGES	Real Estate	\$ -	0%	\$ -	\$ -
1	12 NAVIGATION, PORTS AND HARBORS	Mob/Demob	\$ 1,100,000	19%	\$ 214,459	\$ 1,314,459
2	12 NAVIGATION, PORTS AND HARBORS	Dredging	\$ 6,453,328	24%	\$ 1,540,394	\$ 7,993,722
3	12 NAVIGATION, PORTS AND HARBORS	Placement Area (PA)	\$ 1,251,032	26%	\$ 326,969	\$ 1,578,001
4				0%	\$ -	\$ -
5				0%	\$ -	\$ -
6				0%	\$ -	\$ -
7				0%	\$ -	\$ -
8			\$ -	0%	\$ -	\$ -
9			\$ -	0%	\$ -	\$ -
10			\$ -	0%	\$ -	\$ -
11			\$ -	0%	\$ -	\$ -
12	All Other	Remaining Construction Items	\$ -	0.0%	\$ -	\$ -
13	30 PLANNING, ENGINEERING, AND DESIGN	Planning, Engineering, & Design	\$ -	0%	\$ -	\$ -
14	31 CONSTRUCTION MANAGEMENT	Construction Management	\$ -	0%	\$ -	\$ -
XX	FIXED DOLLAR RISK ADD (EQUALLY DISPERSED TO ALL, MUST INCLUDE JUSTIFICATION SEE BELOW)				\$ -	\$ -

Totals							
	Real Estate	\$ -	0%	\$ -	\$ -	\$ -	
	Total Construction Estimate	\$ 8,804,360	24%	\$ 2,081,823	\$ -	\$ 10,886,183	
	Total Planning, Engineering & Design	\$ -	0%	\$ -	\$ -	\$ -	
	Total Construction Management	\$ -	0%	\$ -	\$ -	\$ -	
	Total Excluding Real Estate	\$ 8,804,360	24%	\$ 2,081,823	\$ -	\$ 10,886,183	
		<b>Base</b>					<b>50%</b>
		<b>Confidence Level Range Estimate (\$000's)</b>					<b>80%</b>
		\$8,804k			\$10,053k	\$10,886k	

\* 50% based on base is at 5% CL.

**Fixed Dollar Risk Add:** (Allows for additional risk to be added to the risk analysis. Must include justification. Does not allocate to Real Estate.)

**Project Example N/A**

Feasibility (Recommended Plan)  
Abbreviated Risk Analysis

Meeting Date: 6-Jan-12

		Risk Level				
Very Likely	2	3	4	5	5	
Likely	1	2	3	4	5	
Possible	0	1	2	3	4	
Unlikely	0	0	1	2	3	
	Negligible	Marginal	Moderate	Significant	Critical	

**Risk Register**

Risk Element	Feature of Work	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Impact	Likelihood	Risk Level
<b>Project Management &amp; Scope Growth</b>				Maximum Project Growth		<b>40%</b>
PS-1	Mob/Demob	None	No Issue	Negligible	Unlikely	0
PS-2	Dredging	Potential for scope changes before and after construction contract award	As design are further developed, there is a potential that the location in the PA may change	Marginal	Likely	2
PS-3	Placement Area (PA)	Potential for scope changes before and after construction contract award	As design are further developed, there is a potential that the location in the PA may change	Negligible	Likely	1
<b>Acquisition Strategy</b>				Maximum Project Growth		<b>30%</b>
AS-1	Mob/Demob	Bidding Climate	PDT feels this is not likely to be an issue. There is always a chance of a disaster response that would occupy the available dredge fleet. Historically this has not been a problem	Moderate	Possible	2
AS-2	Dredging	Bidding Climate	PDT feels this is not likely to be an issue. There is always a chance of a disaster response that would occupy the available dredge fleet. Historically this has not been a problem	Moderate	Possible	2
AS-3	Placement Area (PA)	None	No Issue	Moderate	Possible	2
<b>Construction Elements</b>				Maximum Project Growth		<b>15%</b>
CON-1	Mob/Demob	None	Standard type work for the district	Negligible	Unlikely	0
CE-2	Dredging	None	Standard type work for the district	Negligible	Unlikely	0
CE-3	Placement Area (PA)	None	Potential modification	Marginal	Likely	2
<b>Specialty Construction or Fabrication</b>				Maximum Project Growth		<b>50%</b>
SC-1	Mob/Demob	None	N/A	Negligible	Unlikely	0
SC-2	Dredging	None	N/A	Negligible	Unlikely	0
SC-3	Placement Area (PA)	None	N/A	Negligible	Unlikely	0
<b>Technical Design &amp; Quantities</b>				Maximum Project Growth		<b>20%</b>

T-1	Mob/Demob	None	No Issue	Negligible	Unlikely	0	
T-2	Dredging	None	No Issue	Negligible	Unlikely	0	
T-3	Placement Area (PA)	Design has not been finalized	Quantities may increase or decrease based on final design	Marginal	Likely	2	
<b>Cost Estimate Assumptions</b>						<b>Maximum Project Growth</b>	<b>25%</b>
EST-1	Mob/Demob	Don't know what the bid climate at time of bid opening	PT feels this is not likely to be an issue. There is always a chance of a disaster response that would occupy the available dredge fleet. Historically this has not been a problem	Marginal	Likely	2	
EST-2	Dredging	Don't know what the bid climate at time of bid opening	Depending on the bidding climate the estimate could go up	Marginal	Likely	2	
EST-3	Placement Area (PA)	Don't know what the bid climate at time of bid opening	Depending on the bidding climate the estimate could go up	Marginal	Possible	1	
<b>External Project Risks</b>						<b>Maximum Project Growth</b>	<b>20%</b>
EX-1	Mob/Demob	None	No Issue	Negligible	Unlikely	0	
EX-2	Dredging	Potential for political influence	Political pressure to use another PA. This could increase the unit cost, if the pipeline lengths need to increase	Marginal	Unlikely	0	
EX-3	Placement Area (PA)	Potential for political influence	Political pressure to use another PA. This could increase the unit cost, if the pipeline lengths need to increase	Marginal	Unlikely	0	