Appendix J3

Outer Channel Sediment Sampling Report

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October 23, 2023

U.S. Army Corps of Engineers Galveston District
2000 Fort Point Road
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U.S. Environmental Protection Agency Region 6
1445 Ross Avenue
Dallas, Texas 75202

Re: ***Sampling, Chemical Analysis, and Bioassessment for Offshore Disposal of Dredge Material***
Port of Corpus Christi Authority
Channel Deepening Project – Outer Channel
Port Aransas, Texas

To Whom It May Concern:

On behalf of the Port of Corpus Christi Authority (PCCA), Terracon Consultants, Inc. (Terracon) is pleased to submit this report which details the field sampling, analysis and results of Marine Protection, Research, and Sanctuaries Act (MPRSA) Section 103 sediment testing and analysis in support of the new work dredging for the PCCA Channel Deepening Project (CDP) in Port Aransas, Texas. The project area is composed of nine dredged material management units (DMMUs) which includes the offshore extension/outer channel deepening DMMUs CDP-01 through CDP-05 and the Inner Harbor/Port Aransas Channel deepening DMMUs CDP-06 through CDP-09. The project also included sampling at the offshore Reference Area and the New Work ocean dredged material disposal site (ODMDS).

This report presents the results of the investigation completed in August 2022 for the offshore extension/outer channel deepening DMMUs CDP-01 through CDP-05. A separate report has been prepared for the February/March 2022 and January 2023 (re-sampling event) for the Inner Harbor/Port Aransas Channel deepening DMMUs CDP-06 through CDP-09, including applicable data for the offshore Reference Area and New Work ODMDS area.

Sincerely,
Terracon Consultants, Inc.
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Sampling, Chemical Analysis, and Bioassessment for Offshore Disposal of Dredge Material
Port of Corpus Christi Authority
Channel Deepening Project – Outer Channel
Port Aransas, Texas

Submitted to:

U.S. Army Corps of Engineers Galveston District
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Galveston, Texas 77550

and

U.S. Environmental Protection Agency Region 6
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Prepared by:

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Date

October 23, 2023

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ACRONYMS, ABBREVIATIONS, & INITIALISMS

ADDAMS	Automated Dredging and Disposal Alternatives Modeling System
CFR	Code of Federal Regulations
CCSP	Corpus Christy Ship Channel
CCSCIP	Corpus Christi Ship Channel Improvement Project
CDP	Channel Deepening Project
CMC	criteria maximum concentration
CQAR	Chemical Quality Assurance Report
DEHP	Bis(2-ethylhexyl) phthalate
DMMU	dredged material management unit
ECD/ELCD	electron capture detectors/electrolytic conductivity detectors
EET	ecological effect threshold
EPA	U.S. Environmental Protection Agency
ERDC	U.S. Army Engineer Research and Development Center
ERED	Environmental Residue Effects Database
ERL	effects range-low
FDA	U.S. Food and Drug Administration
GPS	global positioning system
Green Book	*Evaluation of Dredged Material Proposed for Ocean Disposal - Testing Manual*
HPAH	high molecular weight PAH
ICP/MS	inductively coupled plasma/mass spectrometry
ITM	Inland Testing Manual
LC_{50}	lethal concentration affecting 50% of a population
LOAEL	lowest observed adverse effect level
LPAH	low molecular weight PAHs
LPC	limiting permissible concentration
LRL	laboratory reporting limit
MDL	method detection limit
MLLW	mean lower low water
MPRSA	Marine Protection, Research, and Sanctuaries Act of 1972
MRL	method reporting limit
MS/MDS	matrix spike/matrix spike duplicate
NOAEL	no observed adverse effect level
NWDLS	North Water District Laboratory Services, Inc.
ODMDS	ocean dredged material disposal site
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCCA	Port of Corpus Christi Authority
QA/QC	Quality Assurance/Quality Control
RIA	Regional Implementation Agreement
SAP	Sampling and Analysis Plan
SP	solid phase
SPP	suspended particulate phase
SERIM	Southeastern Regional Implementation Manual (EPA USACE 2008)
STFATE	Short-Term Fate [of Dredged Material Disposal in Open-Water Models]
SVOC	semi-volatile organic
TEL	threshold effects level
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TSS	Total Suspended Solids
TWQS	Texas water quality standard
USACE	U.S. Army Corps of Engineers
VOA	Volatile organic analysis

EXECUTIVE SUMMARY

This report details the field sampling, analyses, and results of Marine Protection, Research, and Sanctuaries Act (MPRSA) Section 103 sediment testing and analyses in support of the new work dredging, to include deepening and widening from current elevation of Port of Corpus Christi Authority (PCCA) Channel Deepening Project (CDP) in Port Aransas, Texas. The project area is composed of nine dredged material management units (DMMUs) which includes the Offshore Extension/Outer Channel deepening DMMUs CDP-01 through CDP-05 and the Inner Harbor/Port Aransas Channel deepening DMMUs CDP-06 through CDP-09. The project also included sampling at the offshore Reference Area and the New Work ocean dredged material disposal site (ODMDS).

This report presents the results of the investigation completed in August 2022 for the Offshore Extension/Outer Channel deepening DMMUs CDP-01 through CDP-05, and sampling at the offshore Reference Area. This report includes the results of the New Work ODMDS composite collected during the February/March 2022 Inner Harbor/Port Aransas channel field sampling effort. Note that additional material was collected in January 2023 at CDP-03 to perform a re-analysis of the 10-day solid phase benthic test using *Americamysis bahia.*

A separate report will be prepared to include the results of the investigations completed between February/March 2022 and January 2023 (re-sampling event) for the Inner Harbor/Port Aransas Channel deepening DMMUs CDP-06 through CDP-09, including applicable data for the offshore Reference Area and New Work ODMDS area.

Sampling Approach

Mobilization and field sampling for the CDP project area and Reference Area took place between August 16 and August 25, 2022. The New Work ODMDS composite sediment sample and site water sample were collected during the March 3, 2022, field sampling effort. Additional material was collected in January 2023 at CDP-03 and the Reference Area to perform a re-analysis of only the 10-day solid phase benthic test using *Americamysis bahia.*

Sampling efforts consisted of collecting sediment and water samples for physical, chemical, toxicological, and bioaccumulation analysis. A copy of the U.S. Environmental Protection Agency (EPA)-approved PCCA Sampling and Analysis Plan (SAP), dated July 2021-Version 2, including the Errata Memos #1, #2 and #3 (dated January 10, 2022, February 22, 2022, and June 10, 2022, respectively), and subsequent email correspondences dated January 28, 2022, January 31, 2022, February 3, 2022, February 14, 2022, February 22, 2022, June 21, 2022, August 3, 2022, January 17, 2023, February 3, 2023, and February 14, 2023 are presented in Appendix A.

This portion of the CDP project area being evaluated was divided into five DMMUs (CDP-01 through CDP-05). Each DMMU was expected to have relatively consistent characteristics, and each DMMU covered a specific area and dredge material volume within the overall dredging footprint.

- DMMUs CDP-01 to CDP-05 include the open bay channel extension from Substations -330+00 to -620+00

Sample locations from the various DMMUs within the proposed CDP dredge footprint were selected by PCCA and approved by EPA/U.S. Army Corps of Engineers (USACE) based on a combination of previous shoaling patterns and results of bathymetric surveys conducted in 2020 to anticipate shoaling by the time of field sampling. The distribution and number of cores collected at substation locations provided adequate representation for each DMMU. The material collected from the substations represents dredged material to be disposed at the New Work ODMDS.

Sediment samples were collected from two substations (A and C) located in three of the five DMMUs CDP-01 through CDP-03 using a sonic drill rig equipped with a 6-inch diameter core barrel. In addition, grab samples were collected from DMMUs CDP-04 and CDP-05 using a double van Veen™ sampler from two substations (A and C) and from three substations (A, B and C) within the offshore Reference Area located to the north of the Entrance Channel. Sediment samples were collected using a double van Veen™ sampler from three substations within the New Work ODMDS (A, B and C) located south of the Entrance Channel. Additional material was collected in January 2023 at CDP-03 (A and C) using a sonic drill rig and grab samples were collected from the three stations in the Reference Area using a double van Veen sampler.

The sediment subsamples collected from each of the DMMUs were analyzed discretely for physical grain size, then subsamples from each DMMU were composited and homogenized to create one composite per DMMU for physical, sediment chemistry, elutriate chemistry, and toxicology/bioaccumulation analysis. The Reference composite underwent physical, sediment chemistry, and toxicological/bioaccumulation analysis. The New Work ODMDS composite underwent physical and sediment chemistry analysis. Additional material was collected in January 2023 at CDP-03 (A and C) and the Reference Area to perform a re-analysis of the 10-day solid phase benthic test using *Americamysis bahia.*

Site water for elutriate preparation was collected from one substation located within each of the DMMUs. The locations were chosen to best represent the hydrochemical conditions for each DMMU. Water for chemical analysis was collected from the Reference Area during the offshore field sampling effort completed in August 2022. Water for chemical analysis was collected from the New Work ODMDS area during the March 3, 2022, field sampling effort.

Sediment Physical Results

Grain size distributions among the project DMMU composite samples tested are summarized below. CDP subsample grain size distribution results are included in Section 3.2.1.

- CDP-01-Composite was predominantly silt (43.8%) with clay (35.9%) and sand (20.3%).
- CDP-02-Composite sample was predominantly silt (47.2%) with clay (38.2%) and sand (14.6%).
- CDP-03-Composite sample was predominantly clay (45.6%) with silt (43.8%) and sand (10.6%). CDP-03 Duplicate Composite sample was predominantly clay (50.2%) with silt (40.6%) and sand (9.2%).
- CDP-04-Composite was predominantly clay (46.8%) with silt (34.4%) and sand (18.8%).
- CDP-05-Composite was predominantly clay (57.5%) with silt (32.1%) and sand (10.4%).
- CDP-REF composite was predominantly sand (44.2%) with clay (28.0%) and silt (27.8%).

- The New Work ODMDS composite was predominantly sand at 90.3% with clay at 5.9%, trace gravel at 2.4% and trace silt at 1.4%.

Sediment Chemistry Results

Sediment chemistry analyses were performed on the five DMMU composite samples from CDP-01 through CDP-05, including one duplicate composite sample collected from CDP-03 (Core #2), the Reference Area composite, and the New Work ODMDS composite.

Metals, Ammonia, Cyanide, Total Petroleum Hydrocarbons (TPHs), Total Organic Carbon (TOC), and Total Solids

Most of the 13 metals analyzed were detected in concentrations above the laboratory reporting limit (LRL) in the composite samples tested except for antimony (U-qualified). The metals detected above the LRL were each below their respective threshold effects level (TEL) and (or) effects range-low (ERLs).

Trivalent chromium ranged from 7.18 milligrams per kilogram (mg/kg) to 12.1 mg/kg among the composite samples tested. Hexavalent chromium was not detected above the method detection limit (MDL / U-qualified) in the composite samples tested.

Ammonia (as nitrogen) concentrations ranged from 24.9 mg/kg to 111 mg/kg among the composite samples tested.

Total cyanide was not detected above the MDL (U-qualified) in the composite samples tested.

TPHs were not detected above the MDL (U-qualified) in the composite samples tested with the exception of CDP-05 (26.1 mg/kg).

TOC concentrations ranged from 0.22% to 0.64% among the composite samples tested.

Total solids ranged from 48.7% to 71.9% among the composite samples tested.

Pesticides and Total Polychlorinated Biphenyls (PCBs)

Pesticide analytes were reported below MDLs (U-qualified) in the composite samples tested except for the analytes chlordane (technical), dieldrin, γ-BHC (lindane) and toxaphene. These analytes were reported above MDLs in at least one sample that exceeded the respective TEL and (or) ERL, including the Reference Area composite sample.

Total PCBs were not detected above the MDL (U-qualified) in the composite samples tested. Project sediment samples were reported with a MDL ranging from 1.10 micrograms per kilogram (µg/kg) to 2.05 µg/kg, slightly greater than the target detection limit for Total PCBs (1.0 µg/kg) in the SAP. This slightly elevated MDL was due to low total solid content in the sediment samples.

Polynuclear Aromatic Hydrocarbons (PAHs)

The 15 PAH analytes tested were detected below the MDLs (U-qualified) in the composite samples tested. MDLs for the PAH compounds were below applicable TELs and ERLs and below target detection levels specified in the SAP.

Total low molecular weight PAHs (LPAHs) ranged from 10.0 µg/kg to 15.4 µg/kg. Total high molecular weight PAHs ranged from to 16.7 µg/kg to 25.7 µg/kg. Total PAHs ranged from 26.7

µg/kg to 41.1 µg/kg. Total LPAHs, Total HPAHs, and Total PAHs were below applicable TELs and ERLs for the composite samples tested.

Semi-Volatile Organic Compounds (SVOCs)

Most SVOCs were reported below MDLs (U-qualified) with specific SVOC analytes detected above the LRL in one or more composite samples tested. SVOC analytes detected above the MDLs (J-qualified) or LRLs include bis(2-ethylhexyl) phthalate, di-n-butyl phthalate, and total phenol. TEL or ERL criteria values are not listed for the SVOC analytes with the exception of bis(2-ethylexyl) phthalate. The reported concentrations for bis(2-ethylexyl) phthalate (3.48 µg/kg to 6.15 µg/kg) in the samples tested are below the TEL concentration value of 182 µg/kg.

Elutriate and Water Chemistry Results

Elutriates were generated from the five DMMU sediment composites. Project elutriates, site water samples and water samples collected from the Reference Area and New Work ODMDS were analyzed for the parameters summarized below. Results for elutriate and water samples are compared to applicable criteria maximum concentration (CMC [synonymous with 'acute']) and Texas Water Quality Standard (TWQS) values.

Metals, Ammonia, Cyanide, TPHs, and TOC

One or more metals were detected at either J-qualified concentrations or above the LRLs in the site water and elutriate samples tested with the exception of beryllium, cadmium, mercury, silver, and thallium, which were U-qualified in the samples tested. Metals were not reported at concentrations above CMCs or TWQS in these samples with the single exception of copper in water samples CDP-01 (6.90 micrograms per liter [µg/L]) and the Reference (15.7 µg/L). The reported concentrations for copper in these samples exceeded the CMC (4.8 µg/L), and the TWQS (13.5 µg/L) in the Reference site water sample only.

Trivalent chromium was not detected above the MDL (U-qualified) in the site water and elutriate samples tested. Hexavalent chromium results ranged from less than (<) 0.00150 µg/L to 10.8 µg/L in the site water and elutriate samples tested. Hexavalent chromium concentrations in the samples tested were below the CMC (1,100 µg/L) and TWQS (1,090 µg/L).

Ammonia (as nitrogen) ranged from 0.0932 milligrams per liter (mg/L) to 2.14 mg/L in the site water and elutriate samples tested.

Total cyanide was detected above the MDL (J-qualified) at 0.001 mg/L in the site water and elutriate samples tested. The reported concentration is equal to the CMC (0.001 mg/L).

TPH concentrations ranged from <0.18 mg/L to 2.82 mg/L in the site water or elutriate samples tested.

TOC ranged from <0.35 mg/L to 3.1 mg/L in the site water and elutriate samples tested.

Total Suspended Solids (TSS) ranged from 2.63 mg/L to 28.6 mg/L in the site water and elutriate samples tested.

Pesticides and Total PCBs

Pesticide analytes were reported below the MDL (U-qualified) in the site water and elutriate samples tested. The MDL and LRL for toxaphene was 0.300 µg/L and above the CMC (0.21 µg/L) and TWQS (0.21) for the samples tested.

Total PCBs were not detected above the MDL (U-qualified) in the site water and elutriate samples tested.

PAHs

PAHs were not detected above the MDL (U-qualified) in the site water and elutriate samples tested. The calculated concentrations for total LPAHs were 1.69 µg/L, total HPAHs (2.81 µg/L) and total PAHs (4.50 µg/L) among the samples tested.

SVOCs

Three of the 41 SVOC analytes tested (diethyl phthalate, di-n-butyl phthalate and total phenol) were detected above the LRL in one or more site water and/or elutriate samples tested. All SVOC analyte concentrations were below the applicable CMC or TWQS in the samples tested.

Toxicology Results

Toxicity analyses were performed on the five project composites and the Reference Area. Site water samples from the five DMMUs were analyzed as part of the water column bioassays.

Water Column (Suspended Particulate Phase [SPP]) Bioassays

Water column SPP tests were performed with the atherinoid fish *Menidia beryllina* (inland silverside) and planktonic and juvenile life stages of the mysid crustacean *Americamysis bahia* (opossum shrimp).

A. bahia 96-Hour Bioassay: Survival in the site water controls for project samples CDP-01 through CDP-05 ranged from 96% to 100%, meeting the acceptability criterion of greater than or equal to (≥) 90% survival. Mean survival in the 100% elutriate concentration ranged from 96% to 98% among the project elutriates and was 96% in the Reference. The sample results were not statistically different than the control. The estimated lethal concentration affecting 50% of a population (LC_{50}) was greater than (>)100% for these project samples.

M. beryllina 96-Hour Bioassay: Survival in the site water controls for project samples CDP-01 through CDP-05 ranged from 94% to 100%, meeting the acceptability criterion of ≥90% survival. Mean survival in the 100% elutriate concentration ranged from 92% to 98% among the project elutriates and was 98% in the Reference. The sample results were not statistically different than the control. The estimated LC_{50} values were >100% for these project samples.

A. bahia Plankton 48-Hour Bioassay: Survival in the site water controls for project samples CDP-01 through CDP-05 ranged from 96% to 100%, meeting the acceptability criterion of ≥90% survival. Mean survival in the 100% elutriate concentration ranged from 94% to 98% among the project elutriates and was 94% in the Reference. The sample results were not statistically different than the control. The estimated LC_{50} values were >100% for these project samples.

Whole Sediment (Solid Phase) Bioassays

The solid phase toxicity tests were performed with the amphipod crustacean *Leptocheirus plumulosus* and the mysid crustacean *Americamysis bahia*.

L. plumulosus 10-day Bioassay: Mean survival in the project sediment samples CDP-01 through CDP-05 ranged from 85% to 94% and was 93% in the Reference. Significant differences between the project sediments and the reference sediment were not observed. Mean survival in the project samples was either greater than the Reference or less than 20% below the Reference, indicating that the samples meet the LPC for benthic toxicity as defined in the *Regional Implementation Agreement for Testing and Reporting Requirements for Ocean Disposal of Dredged Material off the Louisiana and Texas Coasts under Section 103 of the Marine Protection, Research and Sanctuaries Act* (EPA and USACE 2003, referred to herein as the 'RIA').

A. bahia 10-day Bioassay:

> August 2022 Results: Mean survival in the project sediment samples CDP-01 through CDP-05 ranged from 87% to 98% and was 99% in the Reference. Sample CDP-03 resulted in mean survival greater than 10% different from that of the Reference, indicating that sample did not meet the LPC for benthic toxicity as defined in the RIA.
>
> January 2023 Results: A re-sampling event was conducted at CDP-03 including the Reference Area in January 2023. Mean survival in the project sediment CDP-03 Re-Sample was 96% and was 90% in the Reference. Mean survival in CDP-03 Re-Sample was less than 10% different from that of the Reference, indicating this sample met the LPC for benthic toxicity as defined in the RIA.
>
> Conclusion: Based on the sample test results, the project samples resulted in mean survival that were not significantly different or greater than 10% different from that of the Reference (August 2023 and January 2023), indicating that all samples met the LPC for benthic toxicity as defined in the RIA.

Bioaccumulation Potential

Bioaccumulation tests were conducted with the bivalve mollusk *Mercenaria mercenaria* (quahog clam) and the polychaete worm *Alitta virens* (sand worm). Mean survival in the control was 75% for *M. mercenaria* and 93% for *A. virens*. Mean survival in the Reference was 70% for *M. mercenaria* and 83% for *A. virens*. Survival in the project sediment samples ranged from 70% to 87% in *M. mercenaria* and from 67% to 81% for *A. virens*.

Tissue Chemistry Results

Tissue chemistry results for project samples are compared to the Reference CDP-REF and to applicable screening benchmarks. Sample results that are statistically significantly greater than the Reference are further evaluated in the General Risk Based Evaluation section (Section XX) using the 8 Factors. Results are summarized below.

Total Solids

> *Mercenaria mercenaria:* Total solids ranged from 7.74% to 10.6% in the project samples, the Reference and pre-exposure tissue sample.
>
> *Alitta virens:* Total solids ranged from 10.7% to 15.8% in the project samples, the Reference and pre-exposure tissue sample.

Metals and TPH

Thirteen metals and TPH were tested in *M. mercenaria* and *A. virens* tissues from the five project samples , the Reference and pre-exposure tissues.

> *Mercenaria mercenaria:* Most metals tested in *M. mercenaria* tissue were detected at concentrations greater than the MDL (in one or more replicates) in one or more project

samples. The exception was mercury which was not detected above the MDL (U-qualified) for the tissue samples. Mean concentrations for arsenic beryllium, lead, selenium, and/or thallium in M*. mercenaria* tissues from project samples CDP-01, CDP-02, and/or CDP-03 were statistically significantly greater than those of the Reference tissue. The results do not exceed the U.S. Food and Drug Administration (FDA) action levels. Mean concentrations for lead in CDP-03 (0.131 mg/kg) exceeded the ecological effects threshold (EET) criteria concentration of 0.1 mg/kg.

Chromium, copper, nickel, and zinc were detected in both the sample and the method blank (V-qualified) in one or more replicates in the project samples, the Reference, and the pre-exposure tissue samples. The impact to data is minimal.

TPH mean wet weight concentrations in *M. mercenaria* tissues ranged from 42.1 mg/kg to 45.5 mg/kg and were highest in CDP-01. TPH concentrations in the *M. mercenaria* tissues for the project samples were not statistically significantly greater than that of the Reference tissue.

Alitta virens: Most metals tested in *A. virens* tissue were detected in concentrations greater than the MDL (in one or more replicates) in one or more project samples. The exception was mercury which was not detected above the MDL (U-qualified) in the samples. Mean concentrations for beryllium in CDP-03 in *A. virens* tissue were statistically significantly greater than those of the Reference tissue. Mean concentrations for lead and nickel in CDP-01, CDP-02 and CDP-03 in *A. virens* tissue were statistically significantly greater than those of the Reference tissue. The sample mean results did not exceed the FDA action level for the metal tested. However, mean concentrations for lead in CDP-01 (0.166 mg/kg), CDP-02 (0.169 mg/kg) and CDP-03 (0.174 mg/kg) exceeded the EET concentration of 0.01 mg/kg.

Chromium, copper, nickel, and zinc were detected in all project samples, the Reference, the pre-exposure tests, and the associated method blanks (V-qualified). The reported concentrations for these metals in the Method Blanks were either J-qualified or greater than the LRL, and the detected concentrations were below applicable FDA action levels, EET, and North Gulf of Mexico Background criteria concentrations. The General Risk Based Evaluations for these metals are presented in Section 3.9.

TPH mean wet weight concentrations in *A. virens* tissues ranged from 424 mg/kg to 1,126 mg/kg and were highest in CDP-03. Mean concentrations for TPH in tissues from project samples CDP-03 and CDP-04 were statistically significantly greater than that of the Reference tissue.

- The fact sheet from the Agency for Toxic Substances and Disease Registry (ATSDR 1999) states that TPH is a term used to describe a large family of several hundred chemical compounds originally from crude oil. Crude oil is used to make petroleum products, which can contaminate the environment. Because there are so many different chemicals in crude oil and in other petroleum products, it is not practical to measure each one separately. However, it is useful to measure the total amount of TPH at a site to evaluate and screen potential constituents of concern and intensity. Scientists do this by dividing TPH into groups of petroleum hydrocarbons that act alike in soil or water. These groups are called petroleum hydrocarbon fractions. Each fraction contains many individual chemicals, including both volatile and extractable petroleum hydrocarbons (VPHs and EPHs), encompassing the gasoline range organics (>C_6–C_{12}), diesel range organics (>C_{12}–C_{28}), and oil range organics (>C_{28}–C_{35}).

Generally, TPH testing provides a means to quantify the magnitude (in relative terms) of petroleum contamination that remains in the environment. For dredging projects, this exposure would come from biomagnification starting at low level organisms and working up to humans through a food chain. Upon their discharge into the environment, petroleum hydrocarbons can pose risks to human health, ecosystems, and groundwater. Since there are no FDA action levels for TPH resulting from the lack of scientific studies that document the effects of TPH on local marine-based organisms due to its large chemical composition, where mean concentrations for TPH were statistically significantly greater than that of the Reference, the effects of the TPH were addressed through SVOC analyses which provide an estimate of more toxic components found within the TPH fractions (as further discussed below and in Section 3.8.3). SVOCs were not identified as a concern for *A. virens*.

SVOCs

SVOCs including bis(2-ethylhexyl) phthalate and di-n-butyl phthalate were tested in *M. mercenaria* and *A. virens* tissues from project samples CDP-01, CDP-02 and CDP-03, along with the Reference and pre-exposure tissues.

Mercenaria mercenaria: SVOCs were detected in *M. mercenaria* tissues above the LRL in one or more replicates in the project tissues, the Reference and the pre-exposure tissues. *M. mercenaria* tissues from CDP-01 had adjusted mean concentrations for di-n-butyl phthalate that statistically significantly exceeded those of the Reference tissue. There are no applicable FDA action levels nor north Gulf of Mexico background concentration for this SVOC. All adjusted mean concentrations for bis(2-ethylhexyl) phthalate in *M. mercenaria* were below the ecological effects threshold.

The two SVOC analytes were detected in both the sample and the method blank (V-qualified) in one or more replicates in the project tissues, the Reference and the pre-exposure tissues. The General Risk Based Evaluations for these SVOCs are presented in Section 3.9.

Alitta virens: SVOCs were detected in *A. virens* tissues above the LRL in one or more replicates in the project tissues with the exception of bis(2-ethylhexyl) phthalate in the Reference tissues (all replicates U-qualified). *A. virens* tissues from CDP-01, CDP-02 and CDP-03 had mean adjusted concentrations for bis(2-ethylhexyl) phthalate that statistically significantly exceeded those of the Reference. There are no applicable FDA action levels, ecological effects thresholds or north Gulf of Mexico background concentration for this SVOC.

The two SVOC analytes were detected in both the sample and the method blank (V-qualified) in one or more replicates in some of the project tissues, the Reference and the pre-exposure tissues. Bis(2-ethylhexyl) phthalate was detected in the method blank (B-qualified) in some of the replicates in project samples CDP-01, CDP-03, the Reference replicates, and pre-exposure replicates. Di-n-butyl phthalate was detected in the method blank (B-qualified) in the project samples, the Reference and pre-exposure tissues. The General Risk Based Evaluations for these SVOCs are presented in Section 3.9.

Automated Dredging and Disposal Alternatives Modeling System (ADDAMS) Model Results

Based on the elutriate chemistry results, since the analytes tested (metals, pesticides, or ammonia) did not exceed the corresponding CMC, Tier II STFATE modeling was not required for the project samples CDP-01 through CDP-05.

Based on the toxicology results, the sample results for suspended particulate phase analysis did not statistically significantly exceed the control; therefore, Tier III STFATE modeling was not required for the project samples CDP-01 through CDP-05.

Since neither Tier II nor Tier III STFATE modeling is required, the dredge material from the outer channel DMMU's CDP-01 through CDP-05 may be disposed in the Corpus Christi New Work ODMDS without restriction with respect to disposal location or volume per load.

Exhibit ES-1. Summary of Analytical Results for PCCA Channel Deepening Project

Dredging Unit	Substation and Composite ID	Sediment Physical					Sediment Chemistry					Elutriate Chemistry			
		Gravel	Sand	Silt	Clay	Solids	Metals, Cyanide, & TPHs	TOC	Pesticides & Total PCBs	PAHs	SVOCs	Metals, Ammonia, Cyanide, & TPHs	Pesticides & Total PCBs	Total PAHs	SVOCs
		%	%	%	%	%	# of analytes > TEL or ERL	(% mean concentration)	# of analytes > TEL or ERL	# of analytes > TEL or ERL	# of analytes > TEL or ERL	# of analytes > CMC or TWQS	# of analytes > CMC or TWQS	µg/L	# of analytes > CMC or TWQS
DMMU 1	**CDP-01A, -1C, and CDP-01-Composite**	0.0	19.8 to 25.9	23.7 to 43.8	32.5 to 56.5	67.0	(none)	0.31	(none) [A]	(none)	(none)	(none)	(none)[B]	4.50	(none)
DMMU 2	**CDP-02A, -2C, and CDP-02-Composite**	0.0	10.0 to 20.2	41.1 to 47.2	38.2 to 43.0	71.9	(none)	0.22	(none) [A]	(none)	(none)	(none)	(none)[B]	4.50	(none)
DMMU 3	**CDP-03A, -3C, CDP-03-Composite, and CDP-Duplicate-Composite**	0.0	9.2 to 10.6	40.6 to 46.6	44.0 to 50.2	67.6 and 68.1	(none)	0.27 and 0.27	(none) [A]	(none)	(none)	(none)	(none)[B]	4.50 and 4.50	(none)
DMMU 4	**CDP-04A, -4C, and CDP-04 Composite**	0.0	18.8 to 20.0	22.9 to 34.4	46.8 to 58.2	55.7	(none)	0.61	(none) [A]	(none)	(none)	(none)	(none)[B]	4.50	(none)
DMMU 5	**CDP-05A, -5C, and CDP-05 Composite**	0.0	10.4 to 11.7	32.1 to 35.2	54.4 to 57.5	48.7	(none)	0.64	(none) [A]	(none)	(none)	(not analyzed)			
Reference (Offshore DMMUs)	**CDP-REF**	0.0	44.2	27.8	28.0	51.8	(none)	0.51	(none) [A]	(none)	(none)	(not analyzed)			
New Work ODMDS Placement Area	**CDP-ODMDS**	2.4	90.3	1.4	5.9	79.2	(none)	0.10	(none) [A]	(none)	(none)	(not analyzed)			

[A] Although no pesticide analytes concentration exceeded the TEL or ERL (U-qualified), the MDLs for either chlordane, dieldrin, lindane, and/or toxaphene exceeded the associated TEL or ERL.

[B] Although the concentrations were reported below the MDL (U-qualified), the MDLs for toxaphene exceeded the associated CMC or TWQS.

Exhibit ES-1 (continued)

		Water Column Bioassays						Whole Sediment Bioassays				Bioaccumulation Bioassay		Bioaccumulation			
		Mysid 96-hr *Americamysis bahia*		Fish 96-hr *Menidia beryllina*		Planktonic Stage 48-hr *Americamysis bahia*		Amphipod *Leptocheirus plumulosus*		Mysid *Americamysis bahia*		Mollusk Mercenaria mercenaria	Polychaeta Alitta virens	Metals and TPH		SVOCs	
Dredging Unit	Composite ID	Significantly different from control? (yes or no)	EC$_{50}$ (%)	Significantly different from control? (yes or no)	EC$_{50}$ (%)	Significantly different from control? (yes or no)	EC$_{50}$ (%)	Mean Survival (%)	Significantly different from reference? (yes or no)	Mean Survival (%)	Significantly different from reference? (yes or no)	Mean Survival (%)	Mean Survival (%)	*Mercenaria mercenaria* (# of analytes stat. sig. > reference)	*Alitta virens* (# of analytes stat. sig. > reference)	*Mercenaria mercenaria* (# of analytes stat. sig. > reference)	*Alitta virens* (# of analytes stat. sig. > reference)
DMMU 1	**CDP-01**	No	>100	No	>100	No	>100	89	No	98	No	70	70	3[A]	2[D]	1[G]	1[H]
DMMU 2	**CDP-02**	No	>100	No	>100	No	>100	94	No	95	No	80	80	2[B]	2[D]	0	1[H]
DMMU 3	**CDP-03**	No	>100	No	>100	No	>100	85	No	87	Yes	78	67	2[C]	3[E]	0	1[H]
DMMU 3	**CDP-03 (Re-Sample)**	(not applicable)						(not applicable)		96*	No	(not applicable)					
DMMU 4	**CDP-04**	No	>100	No	>100	No	>100	91	No	98	No	81	81	0	1[F]	0	0
DMMU 5	**CDP-05**	No	>100	No	>100	No	>100	88	No	92	No	87	68	0	0	0	0
Reference (Offshore DMMUs)	**CDP-REF**	(not applicable)						93	(not applicable)	99	(not applicable)	70	83	(not applicable)		(not applicable)	
Reference	**CDP-REF (Re-Sample)**	(not applicable)						(not applicable)		90*	(not applicable)	(not applicable)		(not applicable)		(not applicable)	
ODMDS	**ODMDS Composite**	(not applicable)						(not applicable)				(not applicable)		(not applicable)		(not applicable)	

N/A = Not analyzed for that parameter.
Stat. Sig. = Statistically significantly greater (>) the Reference.
[A] = Arsenic, Beryllium, and Thallium
[B] = Selenium and Zinc
[C] = Lead and Selenium
[D] = Lead and Nickel
[E] = Lead, Nickel, and TPH
[F] = TPH
[G] = Di-n-butyl phthalate
[H] = Bis(2-ethylhexyl) phthalate
* = Resample Event 10-day Mysid Benthic Test Only on CDP-03

1 INTRODUCTION

The Port of Corpus Christi Authority (PCCA) submitted an application to the U.S. Army Corps of Engineers (USACE), Galveston under Section 10 of the Rivers and Harbors Act of 1899, Section 404 of the Clean Water Act, and Section 103 of the Marine Protection, Research and Sanctuaries Act (MPRSA) for deepening of the Corpus Christi Ship Channel (CCSC). The proposed channel deepening project (CDP) area is composed of nine dredged material management units (DMMUs), which include five Offshore Extension/Outer Channel DMMUs (CDP-01 through CDP-05) and four Inner Harbor DMMUs (CDP-06 though CDP-09).

This report presents the results of the investigation completed in August 2022 for the Offshore Extension/Outer Channel deepening DMMUs CDP-01 through CDP-05, and sampling at the offshore Reference Area. This report includes the results of the New Work ocean dredged material disposal site (ODMDS) composite collected during the February/March 2022 Inner Harbor/Port Aransas channel field sampling effort. Note that additional material was collected in January 2023 at CDP-03 to perform a re-analysis of the 10-day solid phase benthic test using *Americamysis bahia.*

A separate report will be prepared to include the results of the investigations completed in January 2023 (re-sampling event) for the Inner Harbor/Port Aransas Channel deepening DMMUs CDP-06 through CDP-09, including applicable data for the offshore Reference Area and New Work ODMDS area.

1.1 Project Area Description

The CCSC, located approximately 200 miles southwest of Galveston and 150 miles north of the mouth of the Rio Grande River, provides deep water access from the Gulf of Mexico to the PCCA via Port Aransas through Redfish Bay and Corpus Christi Bay. The CCSC is currently authorized by the USACE to –54 feet and –56 feet mean lower low water (MLLW) from Substation 110+00 to Substation –330+00 as part of the Corpus Christi Ship Channel Improvement Project (CCSCIP). The current authorized width of the CCSC is 600 feet inside the Port Aransas Jetties and 700 feet along the entrance channel in the Gulf of Mexico.

The proposed CDP is located within the existing channel bottom of the CCSC starting at Substation 110+00 near the southeast side of Harbor Island, traversing easterly through Aransas Pass, and extending beyond the currently authorized terminus Substation –330+00 an additional 29,000 feet terminating out into the Gulf of Mexico at the proposed new Terminus Substation –620+00, an approximate distance of 13.8 miles, in Port Aransas, Nueces County, Texas.

The proposed CDP dredge area is approximately 1,150 acres and would deepen the channel from Substation 110+00 to Substation –72+50 to a maximum depth of –79 feet MLLW (–75 feet MLLW plus 2.0 feet of advanced maintenance and 2.0 feet of allowable overdredge), and from Substation –72+50 to Substation –620+00, the channel would be deepened to a maximum depth of –81 MLLW (–77 feet MLLW plus 2.0 feet of advanced maintenance and 2.0 feet of allowable overdredge). Approximately 46 million cubic yards of material would be dredged by Cutter

Suction Dredges, Trailing Hopper Dredges, or a combination of both. Of this, a total of 38.4 million cubic yards from the CDP is proposed for placement in the expanded New Work ODMDS.

This project area description was approved by the U.S. Environmental Protection Agency (USEPA) and the USACE in PCCA's Sampling and Analysis Plan (SAP), dated July 2021-Version 2.

1.2 Dredging History

As stated in the Site Management and Monitoring Plan prepared by the EPA and USACE in 2018 for the Corpus Christi Maintenance and New Work ODMDSs, "*the ODMDSs were approved in 1989 for the placement of dredged material from the U.S. Navy Homeport Project in Ingleside, Texas. Upon approval, the original designation for the Corpus Christi New Work ODMDS site was Homeport Project, Port Aransas, Texas ODMDS; however, the Homeport project was never implemented and thus the site was not utilized.*

In a Final Rule published in the Federal Register on August 2, 2014, the USEPA modified the period of use and use restriction for the ODMDS to change the use of the site to include suitable dredged material from the greater Texas vicinity over an indefinite period of time. The modification also changed the name to Corpus Christi New Work ODMDS.

On September 15, 2015, the EPA modified Title 40 of the Code of Federal Regulations (CFR), Part 228 to allow other entities besides the USACE to seek permit approval by USEPA to dispose of dredged material into ocean waters pursuant to the Marine Protection Research and Sanctuaries Act (Ocean Dumping Regulations). It is under this regulation that the PCCA is requesting the new work material dredged from the CDP dredge footprint be approved for disposal at the Corpus Christi New Work ODMDS."

A detailed history related to the proposed CDP is provided in the EPA/USACE-approved PCCA SAP, dated July 2021-Version 2, in Appendix A.

1.3 Description of the Testing Approach

1.3.1 Evaluation of Dredged Material for Disposal

MPRSA Section 103 requires that all proposed operations involving the transportation and discharge of dredged material into ocean waters be evaluated to determine the potential environmental impact of such activities. In addition to Tier I and Tier II requirements, Tier III toxicity and bioaccumulation testing are required under MPRSA Section 103 to determine the suitability of the dredged material for ocean disposal. The proposed dumping must be evaluated using criteria published by EPA in Title 40 CFR Parts 220–228. Specific testing methods are described in the following documents: Evaluation of Dredged Material Proposed for Ocean Disposal - Testing Manual (EPA and USACE 1991, referred to here as the 'Green Book') and the Regional Implementation Agreement for Testing and Reporting Requirements for Ocean Disposal of Dredged Material off the Louisiana and Texas Coasts under Section 103 of the Marine Protection, Research and Sanctuaries Act (EPA and USACE 2003, referred to herein as the 'RIA'). These testing manuals provide guidance to support the tiered testing procedure for evaluating compliance with the limiting permissible concentration (LPC) as defined by the ocean dumping regulations. The procedure includes levels of increasing investigative intensity that provide information to make ocean disposal decisions and is comprehensive enough to enable sound decision-making without unnecessary expenditure of time and resources.

1.3.2 Objectives and Deliverables

The objective of this MPRSA Section 103 report is to evaluate the suitability of dredged material from five DMMUs (CDP-01 through CDP-05) from the PCCA CDP for ocean disposal by addressing the transport and disposal of the material at the New Work ODMDS. Terracon Consultants, Inc. (Terracon) was contracted to provide oversight of the sediment collection activities, conduct required analyses, and present the results in a report. The field effort, laboratory methods, and this report are in accordance with the SAP (Appendix A).

Deliverables associated with this project include:

- Daily Quality Control Reports (DQCRs)
- Preliminary sediment physical and chemical data for tissue testing recommendations
- Laboratory electronic data deliverables and report
- Section 103 sediment testing report and supporting documentation
- A Chemical Quality Assurance Report (CQAR)

Terracon coordinated with USACE and EPA to develop sampling and analyses schemes, schedules, and deliverables. This report summarizes the results of the physical, chemical, and toxicological analyses of sediment, elutriate, water, and tissue samples of the proposed dredge material collected from the project area. Exhibits 1-1 and 1-2 list the principal data users and subcontractors associated with this testing report and their respective areas of responsibility.

Exhibit 1-1. Principal Data Users and Decision-Makers Associated with This Project

Agency or Company	Area(s) of Responsibility
U.S. Army Corps of Engineers, Galveston District (Galveston, Texas)	Permit and maintain the federal channels with the dredge material to be disposed of at the maintenance and New Work ODMDS
U.S. Environmental Protection Agency, Region 6, (Dallas, Texas)	Give concurrence to environmental requirements of dredged sediment for approval of offshore disposal per the Green Book and the RIA
Port of Corpus Christi Authority (Corpus Christi, Texas)	Applicant proposing to deepen channel to -75 feet MLLW. Manage port terminals and determine the need for maintenance and new work dredging and develop long-term dredged material management strategies.

Exhibit 1-2. Prime and Subcontractors and Responsibilities Associated with This Report

Company, Location, Website	Area(s) of Responsibility
Terracon Consultants, Inc. (Houston, Texas) www.terracon.com	Primary contractor, project management team, oversight of field operations including health and safety, drilling service provider, coordinate with laboratories, and prepare project deliverables
ANAMAR Environmental Consulting, Inc. (Gainesville, Florida) www.anamarinc.com	Provide field support for sediment core sample collection, coordinate with laboratories, data Quality Assurance/Quality Control (QA/QC), and prepare portions project deliverables
Laredo Offshore Services (Galveston, Texas) http://www.laredogroup.org	Provide sampling vessel (*L/B Dularge*), captain and crew
Ryan Marine Services (Galveston, Texas) https://www.ryanmarine.com	Provide sampling vessel (M/*V Orion* and M/V *Hercules*), captain, and crew
Cascade Drilling L.P. (Weatherford, Texas) http://www.cascade-env.com	Provide sonic drill rig and crew
North Water District Laboratory Services, Inc. (NWDLS) (The Woodlands, Texas) http://www.nwdls.com	Laboratory sample preparation and chemical analysis of sediment (including physical analysis), elutriate and water; toxicology analysis, tissue sample preparation and analysis (except TPH), sample holding and archiving
ALS Environmental (Kelso, Washington) www.caslab.com/Kelso-Laboratory	Laboratory sample preparation and chemical analysis of total cyanide in elutriate and water
Eurofins Houston (Stafford, Texas) www.eurofinsus.com	Laboratory responsible for chemical analysis of TPH in tissues
Taylor Engineering Coastal & Marine Geosciences Laboratory (Jacksonville, Florida) www.taylorengineering.com	Laboratory preparation and physical analysis of sediment; sample holding and archiving

2 MATERIALS AND METHODS

2.1 Project Design and Rationale

In 2018, a majority of the proposed CDP reach was tested for offshore disposal under MPRSA Section 103 as part of the CCSCIP. Based on the results of the testing, *"no adverse environmental effects would be expected from dredging or placement of the sediment from the CDP project area into the New Work ODMDS. Chemicals of concern were not present in the CCSC Entrance Channel (Jetties to Harbor Island Transition Flare), Entrance Channel Extension (Approach Channel), and Lower Bay (Harbor Island Transition Flare, Harbor Island Junction, and Corpus Christi Channel) (Substations –330+00 to +70+00)".* However, due to the site history of Harbor Island, additional sampling points in the vicinity of Harbor Island within the Harbor Island Junction and CCSC were recommended, and a full Tier II and Tier III evaluation is required. The prior results of the chemistry analysis in 2018 would subsequently be used for reference purposes only.

Thus, in accordance with the EPA-approved PCCA SAP dated July 2021 (Version 2), sediment and marine water samples were collected from five DMMUs as depicted on Figure 2.1, as well as from the Reference Area and New Work ODMDS (Figures 2.2 and 2.3), for physical, chemical, and/or toxicological/bioaccumulation analysis to evaluate the suitability of the proposed dredged material for disposal in the New Work ODMDS. Five DMMUs are located in the offshore entrance channel project area (CDP-01 through -05) and four DMMUs are located in the inner harbor project area (CDP-06 through -09). Sampling locations from the various DMMUs within the proposed CDP dredge footprint were selected by PCCA and approved by EPA/USACE based on a combination of previous shoaling patterns and results of bathymetric surveys conducted in 2020 (USACE) to anticipate shoaling by the time of field sampling. The distribution and number of cores collected at substation locations provided adequate representation of material to be excavated and to adequately address the vertical component of the proposed dredging activities.

This report summarizes results for a portion of the CDP project area including DMMUs CDP-01 to CDP-05 for the open bay channel extension from Substations -330+00 to -620+00. Sediment samples were collected from two sampling substations within each of the DMMUs CDP-01 through CDP-05 (A and C). Composite samples from each individual DMMU were prepared at the analytical laboratory for physical and chemical analyses in addition to elutriate preparation and toxicological/bioaccumulation analyses. One duplicate composite sample was collected for physical and chemical analyses in addition to elutriate preparation.

Reference sediment was a composite of three samples collected in the Reference Area as outlined in the SAP. A composite of three sediment samples was also collected from the New Work ODMDS for physical and chemical analyses as outlined in the SAP.

Coordinates of the sampled locations, project depths and sample composite IDs are provided in Table 1 and presented in Exhibit 2-1. The sample locations are depicted in Figures 2.1 through 2.3. Summaries of field sampling materials and methods, analytes of interest, and bioassay test species are provided in Exhibits 2-2 through 2-3, respectively.

Exhibit 2-1. Dredged Material Management Units, Sample IDs, Bottom Elevations, Composite IDs, and Analyses

Dredged Material Management Unit	Sample ID	Sediment Elevation (ft, MLLW*) or Sampling Depth (ft)	Project Depth Including Allowable Overdepth (ft, MLLW)	Composite ID and Analyses (see Exhibit 2-3 for more information)
CDP-01	CDP-01-1A	-59.5 to -82.4 ft.	-81 ft.	**CDP-01 Composite** (physical, chemical, toxicological, and bioaccumulation)
	CDP-01-1C	-60.8 to -82.8 ft.		
CDP-02	CDP-02-2A	-63.9 to -87.5 ft.	-81 ft.	**CDP-02 Composite** (physical, chemical, toxicological, and bioaccumulation)
	CDP-02-2C	-63.9 to -87.4 ft.		
CDP-03	CDP-03-3A	-68.9 to -93.9 ft.	-81 ft.	**CDP-03 Composite** (physical, chemical, toxicological, and bioaccumulation)
	CDP-03-3C	-68.9 to -94.9 ft.		
CDP-03 (Re-Sample)	CDP-03-3A	-66.2 to -81.2 ft.	-81 ft.	**CDP-03 Composite** (Toxicological only for *A. bahia* 10-day SP benthic test)
	CDP-03-3C	-70.5 to -86.5 ft.		
CDP-04	CDP-04-4A	-73.1 ft.**	-81 ft.	**CDP-04 Composite** (physical, chemical, toxicological, and bioaccumulation)
	CDP-04-4C	-73.3 ft.**		
CDP-05	CDP-04-4A	-76.5 ft.**	-81 ft.	**CDP-05 Composite** (physical, chemical, toxicological, and bioaccumulation)
	CDP-04-4C	-76.6 ft.**		
CDP-ODMDS (New Work ODMDS)	CDP-ODMDS-A	-44.8 ft.	Not Applicable	**CDP-ODMDS** (physical and sediment chemistry)
	CDP-ODMDS-B	-44.8 ft.		
	CDP-ODMDS-C	-44.8 ft.		
CDP-Reference	CDP-REF A	-43.7 ft.	Not Applicable	**CDP-REF Offshore** (physical, sediment chemistry, toxicological, and bioaccumulation)
	CDP-REF B	-43.8 ft.		
	CDP-REF C	-43.8 ft.		

* Feet mean lower low water were calculated from water depth (measured by fathometer and lead line) and tide height using real-time data.

Sediment collected below the project depth of -81 feet MLLW was discarded.

** Samples were collected utilizing a using a double van Veen™ sampler per Errata Memos #1 and #2 (dated January 10, 2022, and February 22, 2022, respectively). Errata Memo June 21, 2022.

Exhibit 2-2. Summary of Field Sampling Materials and Methods

FIELD SAMPLE COLLECTION:

- 5 project sediment composites (1 composite each from DMMUs CDP-01 through CDP-05 composed of 2 subsamples each), 1 duplicate composite sample, 1 Reference composite (composed of 3 samples), and 1 New Work ODMDS placement area composite (composed of 3 samples). The New Work ODMDS was collected during the February/March 2022 field sampling effort.
- 7 water samples (one from each DMMU CDP-01 through CDP-05, 1 from the Reference, and 1 from New Work ODMDS placement area) for water chemistry. The New Work ODMDS water sample was collected during the February/March 2022 field sampling effort.
- 6 elutriate preparation (1 per DMMU, plus Duplicate).
- 6 toxicology testing (1 per DMMU and 1 Reference).
- 1 additional sediment composite was collected in January 2023 from DMMU CDP-03 to perform a re-analysis of the 10-day solid phase benthic test using *Americamysis bahia*.

SAMPLING GEAR:

- Marine Borings
  - Sediment samples CDP-01 through CDP-03 were collected from borings advanced by a Monitor Well Driller licensed in the State of Texas utilizing a drill rig equipped with sonic technology. The drill rig was mounted on a lift boat (the Dularge Class 170 liftboat).
  - Sediment samples CDP-04 through CDP-05 were collected utilizing a double van Veen™ grab sampler.
- Reference and New Work ODMDS Sample
  - Offshore Reference and New Work ODMDS grab samples were collected utilizing a double van Veen™ grab sampler.
- Site marine water samples were collected with a stainless-steel submersible pump in laboratory supplied glassware or teflon-lined buckets for site water and elutriate chemistry and/or clean food grade 5-gallon buckets for toxicology bioassays.

VESSELS:

- The Dularge Class 170 liftboat (CDP-01 through CDP-03).
- Orion crew boat (sediment and water from New Work ODMDS during March 3, 2022, field sampling effort).
- Hercules crew boat (sediment from CDP-04, CDP-05, and the Reference, including water from CDP-01 through CDP-05 and from the Reference during August 24, 2022, field sampling effort).

PRESERVATION:

- Sediment chemistry samples were kept at or below 4°C.
- Water samples in various containers, with or without stabilizing agents, were kept at or below 4°C.
- Holding-time requirements were analyte-specific and test-specific.

IN-SITU WATER COLUMN MEASUREMENTS AT SITE WATER SAMPLING SUBSTATIONS:

- Horiba multiparameter meter.

Exhibit 2-3. Analytical Requirements for Physical, Chemical, and Toxicological Testing

SEDIMENT GRAIN SIZE DISTRIBUTION AND PERCENT TOTAL SOLIDS ANALYSES

- Individual subsamples from five project DMMUs (outer channel)
- Composite samples from five project DMMUs
- Reference composite
- New Work ODMDS composite

SEDIMENT CHEMICAL ANALYSES
(Outer Channel composite samples, Reference, and New Work ODMDS composites):

- Ammonia (as nitrogen)
- Cyanide
- 13 metals, plus tri- and hexavalent chromium (Inner Harbor samples only)
- 41 semi-volatile organic compounds (SVOCs)
- 21 organochlorine pesticides (includes derivatives)
- 15 polynuclear aromatic hydrocarbons (PAHs), plus total PAH calculations
- Total polychlorinated biphenyls (PCBs)
- Total organic carbon (TOC)
- Total petroleum hydrocarbons (TPHs)

ELUTRIATE AND WATER ANALYSES
(water samples and project elutriate):

- Ammonia (as nitrogen)
- Cyanide
- 13 metals, plus tri- and hexavalent chromium
- 41 semi-volatile organic compounds (SVOCs)
- 21 organochlorine pesticides (includes derivatives)
- 15 PAHs, plus total PAH calculations
- Total PCBs
- TOC
- TPHs

BIOASSAY AND BIOACCUMULATION TESTS (five project composites and the reference):

Water Column (Suspended Particulate Phase) 48-hour and 96-hour tests using two species:

- Mysid crustacean: *Americamysis bahia* (opossum shrimp)
  - Juvenile life stage (7 days old)
  - Planktonic life stage (<1 day old)
- Atherinoid fish: *Menidia beryllina* (inland silverside)

Whole Sediment (Solid Phase) Bioassay 10-day toxicity tests using two species:

- Amphipod crustacean: *Leptocheirus plumulosus* (burrower amphipod)
- Mysid crustacean: *Americamysis bahia* (opossum shrimp)

Whole Sediment Bioaccumulation Potential 28-day exposure tests using two species:

- Bivalve mollusk: *Mercenaria* (bent-nose clam)
- Infaunal polychaete worm: *Alitta virens* (formerly known as *Neanthes virens* or *Nereis virens*) (sand worm). Referred to as *Nereis virens* in the NWDLS toxicology report.

TISSUE CHEMICAL ANALYSES: Outer Channel Samples (CDP-01 to CDP-05):
Based on results of sediment chemical analyses, tissues were analyzed for total solids (all samples); metals (all samples); TPH (all samples), and selected SVOC compounds (bis (2-ethylhexyl) phthalate and di-n-butyl phthalate) in CDP-01, CDP-02, and CDP-03.

The reference and pretest tissue samples were analyzed for the same parameters for each batch of samples as recommended above. Tissue recommendations are discussed in Subsection 2.5.

2.2 Sample Collection Techniques

2.2.1 Field Effort

Mobilization and field sampling for the outer channel project area was completed between August 16 and August 25, 2022. The field effort consisted of collecting sediment and water samples for physical, chemical, toxicological, and bioaccumulation analyses. Terracon and ANAMAR personnel were present throughout the field activities to direct the work, log the borings, and collect samples. As part of the scope of work, core samples were advanced throughout the proposed dredge footprint at representative locations within DMMUs CDP-01 through CDP-03, including approved grab sediment samples at CDP-04 and CDP-05, as depicted in Figure 2.1 for collection of marine water and sediment samples for physical, chemical, toxicological, and bioaccumulation analyses. Sampling locations were evenly distributed across the proposed dredge footprint to be spatially representative of the estimated cubic yards of material to be excavated and to adequately address the vertical component of the proposed dredging activities.

- Note that additional sediment was collected in January 2023 from DMMU CDP-03 to perform a re-analysis of the 10-day solid phase benthic test using *Americamysis bahia*.

Sampling was conducted as outlined in the SAP and subsequent Errata Memos #1, #2 and #3 (dated January 10, 2022, February 22, 2022, and June 10, 2022, respectively), and subsequent email correspondences dated January 28, 2022, January 31, 2022, February 3, 2022, February 14, 2022, February 22, 2022, June 21, 2022, August 3, 2022, January 17, 2023, February 3, 2023, and February 14, 2023. The February 14, 2023, email includes clarification from USACE regarding CDP-03 re-sampling requirements for the benthic test.

The outer channel CDP project area was divided into five DMMUs. Each DMMU was expected to have relatively consistent characteristics and covers a specific area and dredge material volume within the overall dredging footprint.

- DMMUs CDP-01 to CDP-05 include the open bay channel extension from Substations -330+00 to -620+00.

<u>Reference and New Work ODMDS</u>

Sediment grab samples were collected using a double van Veen™ sampler from the offshore Reference Area to the north of the Entrance Channel during the August 2022 field sampling effort. In addition, grab samples were collected using a double van Veen™ sampler within the New Work ODMDS during the March 3, 2022, field sampling effort. Additional sediment was collected from the Reference Area in January 2023 for the CDP-03 re-analysis of the 10-day solid phase benthic test using *Americamysis bahia*.

Site water for elutriate preparation was collected from one substation located within each of the DMMUs. Water for chemical analysis was also collected from the Reference Area during the outer channel field sampling effort completed in August 2022, and from the New Work ODMDS during the field sampling effort completed on March 3, 2022.

Details regarding the various daily sampling activities are presented on the Daily Log Sheets and/or Daily Quality Control Reports in Appendix B. Photographs taken during the field activities are presented in Appendix H.

2.2.2 Site Positioning

Sampling locations from the various DMMUs within the proposed CDP dredge footprint were selected by PCCA and approved by EPA/USACE based on a combination of previous shoaling patterns and results of bathymetric surveys conducted in 2020 (USACE) to anticipate shoaling by the time of field sampling. The distribution and number of cores collected at substation location provided adequate representation for each DMMU. The material collected from the substations represent dredged material to be disposed at the New Work ODMDS. The locations of the water sampling stations were chosen to represent the hydrochemical conditions within each DMMU, Reference Area, and New Work ODMDS.

Target coordinates for each sample station were uploaded to a Trimble Global Positioning System (GPS - GeoExplorer® 6000 Series, Geo XH 3.5 H edition, model #88951) unit, with an accuracy of approximately ± 3 feet to ensure that the samples were collected as close as possible to the target locations provided in the SAP. Uploaded coordinates in the GPS unit were reviewed and compared with the original coordinates for verification prior to field sampling.

Sediment and water samples were taken within 300 feet of the target locations.

Sampled locations are depicted in Figures 2.1 through 2.3. Tables 1 and 2 contain spatial and temporal data along with field observations taken during sediment grab and site water sampling, respectively.

2.2.3 Sediment Sampling with Sonic Drill Rig

Sediment samples CDP-01 Composite through CDP-03 Composite (including duplicate) were collected from a total of eight soil borings advanced by a Monitor Well Driller licensed in the State of Texas through the top of the mudline utilizing a sonic drill rig equipped with a 6-inch diameter core barrel to depths ranging from -82.4 to -94.9 feet MLLW. In addition, CDP-04 Composite and CDP-05 Composite consisted of grab samples collected using a double van Veen™ sampler. Sediment samples for CDP-03 Re-Sample (3A and 3C) were collected utilizing a sonic drill rig equipped with a 4-inch diameter core barrel to depths of -81.2 to -86.5 feet MLLW. Sediment collected below the project depth of 81 feet MLLW was discarded.

A sonic drill rig was mounted on a lift boat (the Dularge Class 170 liftboat). A Trimble Global Positioning System (GPS - GeoExplorer® 6000 Series, Geo XH 3.5 H edition, model #88951) unit, with an accuracy of approximately ± 3 feet, was loaded with the coordinates for each boring location to ensure that the samples were collected as close as possible to the boring locations provided in the SAP. Prior to commencement of drilling, a water level meter equipped with a lead shackle was slowly lowered from the water surface to the mudline to determine boring depths, which were subsequently adjusted to account for tidal fluctuations observed at the time of drilling (refer to Table 1 for boring depths in relation to tide levels at time of drilling).

The sediment cores were examined in the field to document lithology, color, moisture content, and visual or olfactory evidence of impact. At some stations, the core barrel was pushed beyond the project depth to help retain the sample in the core barrel. Material below project depth was logged and then discarded from the sample. GPS coordinates for each boring location are provided in Table 1.

2.2.4 Sediment Sampling Procedures

Sediment collected from each DMMU substation was placed within Teflon® bags in 5-gallon buckets for each composite sample collected from offshore DMMU substations CDP-01 through CDP-05 and processed for physical and chemistry analyses. For each DMMU, approximately 35-gallons of sediment total was collected and composited for elutriate preparation and toxicological/bioaccumulation analyses (i.e., CDP-01-E through CDP-05-E).

After the core sample was retrieved and opened, the core penetration and recovery length were recorded on the field log and volume of sediment collected were documented. A photograph of the core material was taken, and notes on the sample's appearance and physical characteristics were recorded on a project-specific field log. Immediately after collection, the food grade 5-gallon buckets containing the various sediment samples were labeled and transferred to a refrigerated trailer stored on the liftboat. The samples were subsequently monitored for preservation at or below 4°C. Upon return to Martin Energy, the samples were offloaded and transferred to a portable refrigerated trailer provided by the analytical laboratory, North Water District Laboratory Services, Inc. (NWDLS). The samples were then transported and monitored for preservation at or below 4°C during mobilization to the NWDLS in The Woodlands, Texas.

Sediment grab samples were collected from the Reference Area, CDP-04 and CDP-05, onboard the Ryan marine vessel *Hercules*, including all site water samples for each outer channel DMMU and the Reference Area. Once sufficient sediment volume was collected from each DMMU substation or Reference Area, a photograph of the sediment was taken, and notes on the sample's appearance and physical characteristics were recorded on a sediment collection field log. The grab sediment samples, including site water samples, were stored in a refrigerator trailer provided by NWDLS that was maintained on the *Hercules*. The refrigerator trailer was monitored for preservation at or below 4°C. Upon return to the Ryan Marine dock in Galveston, Texas, laboratory courier received the trailer with samples and transported them back to NWDLS in The Woodlands, Texas.

Table 1 and the field logs in Appendix B provide additional information on the sediment sampling process.

Sediment Elutriate and Bioassay Sampling Procedures

As stated above, approximately 35 gallons of sediment were collected from the various substations that make up each specific DMMU for the purposes of elutriate analysis and bioassay testing. Upon receipt of the various 5-gallon buckets of sediment, NWDLS composited the various substation subsamples to create one composite per DMMU for elutriate preparation and toxicological/bioaccumulation analysis (i.e., CDP-01-E through CDP-05-E). The composite sediment samples were later mixed with marine water collected from within the dredge prism at a 4 to 1 ratio prior to undergoing the specified analyses. Table 1 and the field logs in Appendix B provide additional information on the sediment sampling process.

2.2.5 Sediment Sampling with Double van Veen™

During the March 3, 2022, field sampling effort, Offshore New Work ODMDS grab samples were collected aboard the sampling vessel *Orion* using a double van Veen™ sampler that was lowered and raised using a cable winch with a pivoting davit on the starboard side of the vessel. During the August 24, 2022, field sampling effort, grab samples obtained from the Reference Area and DMMU substations CDP-04 (-4A and -4C) and CDP-5 (-5A and -5C) were collected aboard the sampling vessel *Hercules* using a double van Veen™ sampler in the same process as referenced above. During the re-sampling field effort on January 27, 2023, Reference Area grab samples were collected aboard the sampling vessel *Hercules* using a double van Veen™ sampler in the same process as referenced above. During each field event a Ryan Marine crew member operated the winch/hoist. A Terracon team member moved/positioned/secured the davit during deployment and retrieving, and two additional team members guided the sampler into a decontaminated stainless-steel bin on the vessel. An additional team member assisted with sample collection during the offshore grab sampling effort in August 2022. Excess water was allowed to drain from the sampler prior to placing sample material in the bin. When the required volume of sediment (~35 gallons) was collected, a photograph of the material was taken and notes on the sample's appearance and characteristics were recorded on a project-specific field log. Using decontaminated stainless-steel utensils and disposable nitrile gloves, the sample was placed in pre-cleaned, labeled Teflon® bags and stored in a refrigerator trailer onboard the vessel.

The samples collected during the March 3, 2022, field sampling effort were transported back to the Martin Energy dock and transferred to a refrigerated trailer stored on the Martin Energy property. The samples collected during the August 2022 field sampling effort were stored inside a refrigerator trailer secured on the sampling vessel *Hercules* and transported back to the Ryan Marine dock in Galveston, Texas. The samples collected during the January 2023 re-sampling field effort were transported to the Martin Energy dock and transferred to a refrigerated trailer stored on the Martin Energy property. All samples were monitored for preservation at or below 4°C. Samples were received by the laboratory courier the next day (or within 3 days) following respective field sampling efforts and transported to the laboratory in a refrigerated trailer at or below 4°C. Table 1 and the field logs in Appendix B provide additional information on grab sampling.

2.2.6 Water Column Measurements and Sampling

Offshore New Work ODMDS marine water samples were collected aboard the sampling vessel *Orion* on March 3, 2022. Marine water samples from DMMUs CDP-01 through CDP-05, as well as from the offshore Reference marine water sample were collected aboard the sampling vessel Hercules August 24, 2022. A Trimble GPS unit (GeoExplorer® 6000 Series, Geo XH 3.5 H edition, model #88951) with an accuracy of approximately ± 3 feet loaded with the coordinates for each sampling location was utilized to ensure that the marine water samples were collected as close as possible to the boring locations provided in the SAP.

- *Boring CDP-01A* – Marine water sample CDP-01A-SW was collected for elutriate, bioassay and water chemistry.

- *Boring CDP-02A* – Marine water sample CDP-02A-SW was collected for elutriate, bioassay and water chemistry.

- *Boring CDP-03A* – Marine water sample CDP-03A-SW was collected for elutriate, bioassay and water chemistry.

- *Grab Sample CDP-04A* – Marine water sample CDP-04A-SW was collected for elutriate, bioassay and water chemistry.

- *Grab Sample CDP-05A* – Marine water sample CDP-05A-SW was collected for elutriate, bioassay and water chemistry.

- *Reference B* – Marine water sample CDP-REF-B-SW (Offshore) was collected for bioassay and water chemistry during the outer channel field sampling effort completed in August 2022.

- *ODMDS-B* – Marine water sample CDP-ODMDS-B-SW was collected for water chemistry.

Prior to commencement of sampling, a water level meter equipped with a lead shackle was slowly lowered over the side of the liftboat and/or crew boat from the water surface to the mudline to determine the depth of the water column. A stainless-steel monsoon pump equipped with phthalate free hoses was then lowered, in tandem with the water level meter, by personnel wearing clean, disposable nitrile gloves, to a depth determined to be in the middle of the water column while avoiding contact with the boat deck and other surrounding equipment to prevent contamination. New phthalate free hoses were utilized at each sampling location. Approximately 5 to 10-gallons of water was purged through the pump, an amount greater than five times the hose volume, prior to sample collection.

A Horiba multiparameter meter was used to measure water column parameters at water sampling substations within the project area. The instrument was calibrated prior to use according to manufacturer's instructions. A summary of standard sampling parameters (including time of reading, depth, pH, dissolved oxygen, specific conductance, oxidation/reduction potential, turbidity, temperature) obtained for marine water samples collected during field activities are presented in Table 2.

Marine Water / Elutriate / Bioassay Sampling Procedures

Marine water samples were collected in laboratory-supplied volatile organic analysis (VOA) vials/polyethylene bottles/glassware equipped with Teflon®-lined caps provided by the analytical laboratory by personnel wearing clean, disposable nitrile gloves in accordance with the SAP. All VOA vials were filled to a positive meniscus, sealed, and visually checked for the presence of air bubbles. The remaining containers were filled to capacity to limit the amount of headspace. Note that water samples to be analyzed for metals, other than mercury and selenium, were collected in unpreserved containers to be filtered by the analytical laboratory through a dedicated 0.45-micron (µm) filter prior to analysis.

- Additional water was collected from each DMMU and the Reference Area in laboratory-supplied containers and/or 5-gallon food grade buckets for the purpose of providing marine water to the laboratory for mixing with the various sediment samples collected throughout the dredge prism. The marine water was mixed with the various sediment samples upon receipt by the analytical laboratory at a 4 to 1 ratio prior to performing the elutriate and/or bioassay analyses.

Immediately after collection, the water samples were labeled and placed in bubble wrap within a sealed, Ziploc®-type, plastic bag, placed in coolers and chilled to an approximate temperature of 40°F (4°C). A separate cooler was utilized for each sampling location. During the March 3, 2022, field sampling effort, the samples collected were transported to the Martin Energy dock and transferred to a refrigerated trailer stored on the Martin Energy property. During the August 2022 field sampling effort, the samples collected were stored inside a refrigerator trailer secured on the sampling vessel *Hercules* and transported to the Ryan Marine dock in Galveston, Texas. Collected samples were monitored for preservation at or below 4°C. Samples were received by the laboratory courier the next day following respective field sampling efforts and transported to the laboratory in a refrigerated trailer at or below 4°C. Table 2 and the field logs in Appendix B provide additional information regarding water sampling.

2.2.7 Decontamination Procedures

Sampling equipment (including the core barrel sampler, double van Veen™ grab sampler, submersible water pump, and sampling utensils) that contacted sediment or water samples was cleaned and decontaminated as described below.

Decontamination of Sediment Sampling Equipment
Core barrels and sampling utensils were cleaned and decontaminated as described below.

Prior to sampling at the first DMMU substation, and prior to sampling at the next DMMU, the core barrel and sampling utensils were flushed with ambient water to remove any remnant sample material, washed with a nonphosphate detergent (Alconox), and thoroughly rinsed with deionized water. Prior to collecting sediment grab samples from the Reference Area, CDP-04, CDP-05, and/or the New Work ODMDS placement area, the van Veen™ grab sampler was flushed with ambient water and decontaminated following the same procedures referenced above. Disposable nitrile gloves used at a given sampling substation were replaced with new gloves prior to sampling at the next substation. These decontamination methods conform to those summarized in the SAP (Appendix A).

Decontamination of Marine Water Sampling Equipment
Decontamination procedures for stainless-steel sampling equipment (monsoon pump) and water level meter were conducted in 5-gallon buckets and consisted of using a nonphosphate detergent (Alconox) and potable water wash followed by a distilled water rinse prior to commencement of the project and between sampling locations.

These above referenced decontamination methods conform to those summarized in the SAP (Appendix A).

2.2.8 Field Quality Control

Field Duplicates – One sediment sample and one elutriate duplicate sample were collected during field activities to satisfy the general frequency per matrix specified in the SAP. The sediment duplicate sample was collected from CDP-03-3A on August 18, 2022, while the marine water sample CDP-03A-SW used to create the duplicate elutriate sample CDP-03-E (Duplicate) was collected on August 25, 2022. Analytical results for the field duplicate samples are provided in Tables 3 through 11.

Matrix Spike/Matrix Spike Duplicate (MS/MSD) Samples – To assess the accuracy and precision of the analytical methods used in the sample matrix, NWDLS prepared MS/MSD samples of each media sampled (sediment, marine water and elutriate) by Terracon. The MS/MSD samples are provided in the analytical laboratory reports in Appendix E.

2.2.9 Sample Transport, Processing, and Custody

2.2.9.1 Transport and Shipping to the Laboratories

As previously discussed in Sections 2.2.3 through 2.2.5, immediately after collection, sediment and marine water samples were stored in refrigerator trailers onboard the marine vessels and/or at the Martin Energy property for preservation at or below 4°C. Samples were received by the laboratory courier on an as needed basis, typically within one or two days of sample collection, and transported back to NWDLS in The Woodlands, Texas in a refrigerated trailer at or below 4°C.

Chemical analyses were performed by NWDLS in The Woodlands, Texas, except for those constituents that were subcontracted to the following analytical laboratories:

- The sediment sample analyses for Total Organic Carbon (TOC) were subcontracted to ALS Environmental located at 1317 South 13th Avenue in Kelso, Washington.
- The water and elutriate analyses for TOC and total cyanide were subcontracted to ALS Environmental located at 1317 South 13th Avenue in Kelso, Washington.
- The tissue sample analysis for total petroleum hydrocarbons (TPH) was subcontracted to Eurofins Xenco located at 4145 Greenbriar Drive in Stafford, Texas.
- The sediment sample analysis for grain size was subcontracted to Taylor Engineering Coastal & Marine Geosciences Laboratory located at 10199 southside Boulevard, Suite 310 in Jacksonville, Florida.

2.2.9.2 Compositing and Homogenizing

Homogenization and compositing of samples was conducted by staff at NWDLS according to the compositing scheme stated in the SAP. Decontamination of the stainless-steel compositing equipment was performed before and between groups of samples and was conducted in accordance with methods outlined in the SAP and Errata dated January 10, 2022.

2.2.9.3 Chain-of Custody

Proper chain-of-custody documentation was maintained throughout the sampling process. Chain-of-custody forms for each laboratory were completed to reflect the final sample names and to identify the analyses and analytical methods required and accompanied the samples during shipment to the laboratories. Copies of the final signed chain-of-custody forms are included in the laboratory reports (Appendices C, E, and G).

2.3 Physical and Chemical Analytical Procedures

2.3.1 Physical Procedures

2.3.1.1 Grain Size Distribution

Gradation tests were performed by Taylor Engineering in general accordance with method ASTM D422. Sieve analysis utilized U.S. standard sieve numbers 4, 10, 20, 40, 50, 70, 100, 140, and 200. Each DMMU subsample and each DMMU composite sample was air-dried and dry-prepped in accordance with method ASTM D422, and results of the sieve analysis of material larger than a #10 sieve (2.00-mm mesh size) were determined.

2.3.1.2 Moisture Content

Moisture content analyses were performed by NWDLS in general accordance with method ASTM D-2216-80 and Plumb (1981). The sample weight was recorded, and the sample was placed in an oven and dried to a constant mass at 110°C. Once a constant dry mass was obtained, the percent moisture was determined by subtracting the dry mass weight from the wet mass weight, then dividing the loss in mass due to drying (the mass of just moisture) by the wet mass. The percent total solids were reported on a 100% wet weight basis.

2.3.2 Chemical Analytical Procedures

The chemical analyses of sediment, water, elutriate, and tissue samples were performed in accordance with published procedures. Target detection limits for these analyses are provided in Table 5 of the SAP (Appendix A). Analytical and preparation methods were performed following guidelines in EPA (2012).

Elutriates were generated using methods described in Subsection 10.1.2.1 of the Green Book, equivalent to Subsection 10.1.2.1 of the *Inland Testing Manual* (ITM) (EPA and USACE 1998). ANAMAR performed QA/QC on these data and presented them in summary tables. Complete laboratory reports are in Appendix E. Exhibit 2-4 presents a summary of analytical methods used for chemical analysis of sediment, elutriate, and tissue samples.

Exhibit 2-4. Summary of Methods and Equipment Used during Sediment, Elutriate, and Tissue Analysis

EPA Method	Instrument/ Procedure	Methodology Summary
200.8 (trace metals)	ICP and ICP/MS for trace metals	Inductively coupled plasma mass spectrometry (ICP/MS), with or without mass spectrometry, is applicable to the determination of sub-microgram per liter (µg/L) concentrations of many elements in water samples and in waste extracts or digests. Acid digestion prior to filtration and analysis is required for aqueous samples, sediments, and tissues for which total (acid-leachable) elements are required.
350.1, 350.2, and SM 4500 (modified)	Autoanalyzer Spectrophotometer	Methods 350.1, 350.2, and 4500 are used for measuring ammonia in sediments. This method utilizes a reaction of the sample with phenolate and hypochlorite to form a blue color, which is proportional to the concentration of ammonia in the sample. The color is intensified with sodium nitroprusside and is measured by spectrophotometer.
245.1 (mercury in water)	Mercury Analyzer Cold Vapor Atomic Absorption (water)	Method 245.1 is a cold-vapor atomic absorption procedure approved for determining the concentration of mercury in mobility-procedure extracts and aqueous wastes. The samples are subjected to an appropriate dissolution step before analysis.
7471 (mercury in sediment and tissues)	Mercury Analyzer Cold Vapor Atomic Absorption	Method 7471 is approved for measuring total mercury (organic and inorganic) in sediments and tissues. The samples are subjected to an appropriate dissolution step before analysis. If this dissolution procedure is not sufficient to dissolve a specific matrix type or sample, this method is not applicable for that matrix.
TX-1005 (TPHs C6–C35)	Gas Chromatograph/ Flame Ionization Detector	This method is designed to determine total concentrations of TPHs in solid and aqueous matrices using gas chromatography. This method can be used for the quantitative analysis of petroleum hydrocarbons in the gasoline and diesel ranges and portions of the heavier fuel and lubricating oil range.
8081 (pesticides)	Gas Chromatograph	Method 8081 is used to determine the concentrations of various organochlorine pesticides in extracts from solid and liquid matrices using fused-silica, open-tubular capillary columns with electron capture detectors (ECD) or electrolytic conductivity detectors (ELCD). The compounds that can be run by this method may be determined by a single- or dual-column analysis system.

EPA Method	Instrument/ Procedure	Methodology Summary
8082A (PCB Aroclors)	Gas Chromatograph	Method 8082A is used to determine the concentrations of PCBs as individual PCB congeners or Aroclors in extracts from solid, tissue, and aqueous matrices using open-tubular capillary columns with ECD or ELCD. The target compounds may be determined by a single- or dual-column analysis system. Total PCBs are calculated from the sum of congeners or Aroclors.
8270 SIM (PAHs and semi-volatiles)	Gas Chromatograph/ Mass Spectrometer	This method is used to determine the concentration of semi-volatile/PAH organic compounds in extracts prepared from many types of solid matrices and water samples. Direct injection of a sample may be used in limited applications.
9060 and 415.1 (modified*)	TOC Analyzer	EPA methods 9060 and 415.1 are used to determine the concentration of organic carbon in sediment by catalytic combustion or wet chemical oxidation. The carbon dioxide formed from this procedure is measured and is proportional to the TOC in the sample.
9014 and SM 4500-CN-E (cyanide)	Colorimetric Analysis	EPA methods 9014 and 4500-CN-E use colorimetric procedures to determine the total concentration of cyanide in sediment and water samples, respectively. The analysis uses linear regression of the signal measured by the instrument compared to the signal determined by known standards to evaluate the sample concentration.
7196 and SM3500-Cr B	Colorimetric Analysis	EPA methods 7196 and SM 3500-Cr B use colorimetric procedures to determine the total concentration of hexavalent chromium in sediment and water samples, respectively. The analysis uses linear regression of the signal measured by the instrument compared to the signal determined by known standards to evaluate the sample concentration.

***** Minor modifications were made to method 9060 that were approved by the National Environmental Laboratory Accreditation Conference.

2.4 Bioaccumulation and Toxicology Procedures

NWDLS conducted toxicology testing using sediment samples collected by Terracon as part of this MPRSA Section 103 sediment testing report. The outer channel sample collection was completed in August 2022 (NWDLS November 2022 Report). The outer channel re-sample collection for sediments at CDP-03 and only for the *A. bahia* 10-day SP benthic test was completed on January 22, 2023. The information presented in this subsection is based on the toxicology laboratory reports by NWDLS. The complete laboratory report is in Appendix G.

The material under consideration for ocean disposal was evaluated in accordance with procedures and criteria outlined in the Green Book and the RIA and with guidance outlined in the ITM. Biological analyses using Reference sediment were performed concurrently with the test sediment evaluations.

This testing program included bioassay analysis of five outer channel project sediment composites (CDP-01 through CDP-05) and a Reference composite. In addition, appropriate laboratory control samples were run with each of the selected test species. Bioassay testing for all project DMMUs consisted of three water column bioassays, two whole sediment bioassays and two whole sediment bioaccumulation potential tests. The bioassay and bioaccumulation tests are summarized in Table 3-2 of the SAP (Appendix A) and Exhibit 2-5.

Exhibit 2-5. Toxicity and Bioaccumulation Potential Testing Performed for Dredged Material Evaluation

Test Type	Taxonomic Group	Test Species	Project Sediments (yes/no)	Reference Sediment (yes/no)	Control Sediment or Water (yes/no)
Water column (suspended particulate phase)	Mysid crustacean (planktonic [<1-day-old] and adult [6-7 days-old] life stages)	*Americamysis bahia* [1] (opossum shrimp)	Yes [2]	No (not applicable)	Yes
	Atherinoid fish (15-days-old)	*Menidia beryllina* (inland silverside)	Yes [2]	No (not applicable)	Yes
Whole sediment (solid phase)	Amphipod crustacean	*Leptocheirus plumulosus* (no common name)	Yes	Yes	Yes
	Mysid crustacean	*Americamysis bahia* [1] (opossum shrimp)	Yes	Yes	Yes
Bioaccumulation potential	Bivalve mollusk	*Mercenaria* (quahog clam)	Yes	Yes	Yes
	Infaunal polychaete worm	*Alitta virens* [3] (sand worm)	Yes	Yes	Yes

[1] Referred to as *Mysidopsis bahia* (a junior synonym of *Americamysis bahia*) in the NWDLS toxicology report.
[2] Sediment elutriates of project material.
[3] Formerly known as *Neanthes virens* and *Nereis virens*. Referred to as *Nereis virens* in the NWDLS toxicology report.

2.4.1 Ammonia and Salinity Screening in Sediments

While elevated ammonia concentrations in the porewater are transient qualities in dredged material, they can influence organism survival and development in laboratory tests. If high concentrations of ammonia were found in the test composites, they would be considered non-persistent effects under Green Book and RIA guidance.

Prior to testing, initial sediment overlying water ammonia concentrations and salinity were measured to determine if supplemental testing or modifications to the methods used would be required. The results of these analyses are summarized in Exhibit 2-6.

Exhibit 2-6. Initial Sediment Overlying Water Measurements

Sample ID	Benthic Test Species	Total Ammonia (mg/L)	Un-ionized Ammonia (mg/L)	Salinity (ppt)	pH
Outer Channel Test Samples – July 2022 (NWDLS Report November 2022)					
CDP-1 (sediment)	*L. plumulosus*[1]	0.004	<0.001	25	8.1
CDP-2 (sediment)		0.005	<0.001	25	8.1
CDP-3 (sediment)		0.009	<0.001	25	8.1
CDP-4 (sediment)		0.006	<0.001	25	8.1
CDP-5 (sediment)		0.009	<0.001	25	8.1
Control		0.001	<0.001	24	8.3
REF (reference)		0.003	<0.001	25	8.2

Sample ID	Benthic Test Species	Total Ammonia (mg/L)	Un-ionized Ammonia (mg/L)	Salinity (ppt)	pH
Outer Channel Test Samples – July 2022 (NWDLS Report November 2022)					
CDP-1 (sediment)	*A. bahia*[2]	0.007	<0.001	25	8.0
CDP-2 (sediment)		0.003	<0.001	25	8.0
CDP-3 (sediment)		0.007	<0.001	25	8.1
CDP-4 (sediment)		0.006	<0.001	25	8.0
CDP-5 (sediment)		0.004	<0.001	25	8.0
Control		0.001	<0.001	25	8.0
REF (Reference)		0.004	<0.001	25	8.0

Sources: [1] PDF page 88 and [2] PDF page 98 of NWDLS toxicology report date 11/21/22 (Appendix G)

In accordance with the SAP, ammonia is to be measured in sediment overlying water to evaluate which sample(s) may have sufficiently elevated ammonia present to produce negative biological effects with the targeted test organisms. If the ammonia concentration is greater than (>) 0.4 milligrams per liter (mg/L) un-ionized ammonia or >30 mg/L total ammonia, the test sediment will be flushed with overlying water at up to six volume replacements per 24 hours, as described in *Methods for Measuring the Toxicity and Bioaccumulation of Sediment-Associated Contaminants with Marine Invertebrates* (EPA 1994). Based on the initial water quality readings, ammonia concentrations were not predicted to cause ammonia-related effects for either of the test species; therefore, flushing of test sediments was not required.

2.4.2 Water for Bioassay Testing

Water used in this study is laboratory-prepared artificial seawater (Instant Ocean Sea Salt or Hawaiian Marine Mix 7) mixed with freshwater to the salinity requirements of the test species. This water was used for the control treatment and as the diluent for less than (<) 100% elutriate concentrations. Lab seawater parent analytical standard records are included in the toxicology laboratory reports by NWDLS (Appendix G).

2.4.3 Water Column (Suspended Particulate Phase) Phase Bioassay Procedures

Two species were used in the suspended particulate phase (SPP) testing: *Americamysis bahia* (opossum shrimp) and *Menidia beryllina* (inland silverside). SPP tests were performed to estimate the potential impact of dredged material disposal on organisms within the water column. Two life stages of *A. bahia* were tested: a zooplankton stage of <1 day old and an adult stage of seven (7) days old. The *A. bahia* and *M. beryllina* were cultured at the NWDLS toxicology laboratory. SPP bioassay procedures and the sources of the two test species are described in detail in the toxicity laboratory reports by NWDLS (Appendix G).

After preparation, the SPP bioassays were transferred to the test containers. Test chambers consisting of 1,000- or 500-milliliter (mL) disposable food-grade, polypropylene cups with test solution were mixed with laboratory-prepared artificial seawater in appropriate proportions to give three replicates each of 10%, 50% and 100% concentrations of elutriates per DMMU. Containers filled with 100% laboratory-prepared seawater were used as controls for the tests.

After the test containers were prepared and determined to be at the appropriate temperature, 10 *M. beryllina* or 10 adult *A. bahia* were added randomly to each 1,000-mL test chamber. Ten post-larval *A. bahia* were added to each 500-mL test chamber. The loading factor in all vessels was less than 0.5 grams of test organism tissue per liter of medium. The number of live organisms remaining were counted after 24 and 48 hours in the post-larval mysid bioassays and after 24, 48, 72, and 96 hours in the adult mysid and *M. beryllina* bioassays to monitor the number of surviving organisms. Using hand-held meters, temperature, dissolved oxygen, pH, salinity, and ammonia were recorded daily. The fish were not fed, but the mysids, being prone to cannibalism, were given one drop of suspended *Artemia* sp. (brine shrimp) nauplii per test cup twice daily.

2.4.4 Whole Sediment (Solid Phase) Bioassay Procedures

The 10-day solid phase (SP) tests were performed using the amphipod crustacean *Leptocheirus plumulosus* and the mysid crustacean *Americamysis bahia*. SP tests were performed to estimate the potential impact of ocean disposal of dredged material on benthic organisms that attempt to re-colonize the area after disposal has occurred. Field collected *L. plumulosus* organisms were supplied by Aquatic Research Organisms, Inc. in Hampton, New Hampshire. The *A. bahia* were cultured at the NWDLS toxicology laboratory. SP bioassay procedures and the sources of the two test species are described in the toxicity laboratory reports by NWDLS (Appendix G).

The SP bioassay consisted of a 1-day settling period after the sediment was added, followed by 10 days (Days 1–10) of test-organism exposure. The bioassay vessels were partially filled with artificial seawater and enough sediment (test substation, Reference, or control) was placed in each vessel to meet the needs of the test organisms: a 2-centimeter (cm) layer on the bottom. Five replicates were prepared for each of the test substations, Reference, and control. Separate 1-liter jars were used for the amphipods and for the mysids. Initial ammonia levels in the samples were below the target level in the project SAP, and ammonia reduction procedures were not required. After 10 days, the SP bioassay was terminated. The sediment was wet-sieved (0.5-mm screen) to remove surviving organisms, which were counted. To evaluate the relative sensitivity of the organisms, reference toxicity tests were performed using standard reference toxicants (Lee 1980).

2.4.5 Bioaccumulation Procedures

Assessment of bioaccumulation potential was carried out using the bivalve mollusk *Mercenaria* (quahog clam) and the polychaete worm *Nereis virens* (sand worm) over a 28-day test period. The bioaccumulation study was conducted for 28 days following the same procedures as the SP bioassay. Field collected *M. mercenaria* and *A. virens* organisms were supplied by Aquatic Research Organisms, Inc. in Hampton, New Hampshire. Procedures for assessment of bioaccumulation potential and test organism and control sediment sources are described in the toxicity laboratory reports by NWDLS (Appendix G).

Ten-gallon aquaria were used in the bioaccumulation study for both clams and polychaetes. A loading factor of no more than 0.5 grams of test organism tissue per liter of medium was maintained. Twenty-four hours after the addition of the sediment, or the end of the acclimation period for the new work material, the water was changed, and organisms were placed in the test vessels (20 organisms per replicate for the polychaete and 25 for the clams).

Following laboratory exposures, the gut contents of the test organisms were purged for 24 hours in clean aquaria filled with artificial seawater and clean sand. The *M. mercenaria* were then frozen, their valves were removed and discarded, and the soft tissue was placed in certified pre-cleaned glass jars, frozen, and distributed for tissue chemistry analysis. Whole specimens of *A. virens* were frozen in certified pre-cleaned glass containers and distributed for tissue chemistry analysis. Chemical analysis of tissue samples (except for the laboratory treatments) were analyzed at NWDLS for chemical contaminants. To evaluate the relative sensitivity of the organisms, reference toxicity tests were performed using standard reference toxicants (Lee 1980).

2.5 Tissue Analysis Recommendations

Sediment physical and chemistry results were reviewed to determine which analytes should be tested in the corresponding tissue samples based on guidance provided in Subsection 10.2.2 of the RIA and Subsection 9.5.1 in the Green Book and the ITM. The proposed tissue analyses and the rationale were provided to EPA Region 6 and USACE Galveston District for review and approval. Contaminants analyzed from tissue samples are summarized in Exhibit 2-7. Recommendations for tissue analysis are in Appendix E. EPA reviewed and provided concurrence on the tissue recommendations (Appendix I).

Exhibit 2-7. Contaminants of Concern Analyzed in Tissue Samples from PCCA Channel Deepening Project

Analyte	Outer Channel					
	CDP-01	CDP-02	CDP-03	CDP-04	CDP-05	Reference and Pre-exposure
Total cyanide	No	No	No	No	No	No
TPH	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Metals	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Hexavalent chromium	No	No	No	No	No	No
Pesticides	No	No	No	No	No	No
PCBs	No	No	No	No	No	No
PAHs	No	No	No	No	No	No
SVOCs (di-n-butyl phthalate and bis (2-ethylhexyl) phthalate)	**Yes**	**Yes**	**Yes**	No	No	**Yes**
All other SVOC compounds	No	No	No	No	No	No

Yes = Contaminant included with tissue analysis (**blue font**) / No = Contaminant omitted from tissue analysis

2.6 Data Reduction and Applicable Technical Quality Standards

Raw field and laboratory data were summarized, compiled into tables, and reviewed for errors. The CQAR is in Appendix D. Figures 2.1 through 2.4 are used to associate the results spatially with respect to sampling locations.

2.6.1 Sediment Chemistry

Analytical results for sediment samples are compared to published sediment screening values as appropriate and in conformance with the Green Book and the RIA. These levels are the threshold effects level (TEL) and the effects range low (ERL). The TEL represents the concentration below which adverse effects are expected to occur only rarely. The ERL is the value at which toxicity may begin to be observed in sensitive species (Buchman 2008). These comparisons are for reference use only and are not intended for regulatory decision-making.

2.6.2 Elutriate and Water Chemistry

Analytical results for elutriate and water samples were compared to the latest published EPA water quality criteria of criteria maximum concentration (CMC [synonymous with 'acute']) established in EPA (2006, 2015). The CMC is an estimate of the highest concentration of a pollutant in saltwater to which an aquatic community can be exposed briefly without resulting in an unacceptable effect (EPA 2006, Buchman 2008). The CMC for total ammonia was calculated using methods from EPA (1989). The site water sample having the lowest calculated concentration of total ammonia was used as the CMC value (in Table 8) for comparison with all site water and elutriate results. Results for elutriate and water samples were also compared with Texas Water Quality Standards (TWQS [acute]) in Table 1 of *Texas Surface Water Quality Standards* by the Texas Commission on Environmental Quality (TCEQ [2018]).

2.6.3 Toxicity

Statistical analyses are described in the SAP and the RIA and are designed to determine whether the test results are significantly different from the results of the Reference. Statistical comparisons were all at the 95% confidence level and are included herein, if needed.

Statistical calculations were performed for any SPP bioassay if survival in any 100% test treatment was less than the survival in the control and the difference exceeded 10%. For the SP bioassay, statistical comparisons of mean survival were made for each species and for the total number of organisms, if (1) mean survival for any substation test was less than that for the Reference, and (2) the difference between Reference and test survival was at least 10% (20% for the amphipods). For the bioaccumulation assessment, statistical comparisons of mean concentrations were made for each parameter and species, if the mean concentration of the parameter for any substation test tissue was greater than that for the Reference tissue.

2.6.4 Tissue Chemistry

Analytical results for tissue samples were compared to published tissue screening values. Most U.S. Food and Drug Administration (FDA) action levels were obtained from the original FDA source documents (i.e., FDA 2001, 2020). According to FDA (2020), the action levels for arsenic, cadmium, lead, and nickel in tissue are no longer in effect. Additionally, Table 9-1 of FDA (2020) lacks action levels for chromium and mercury in tissue, although an earlier version of the document (FDA 2001) does provide action levels for these metals. Regardless, it was decided to use previous FDA action levels for arsenic, cadmium, chromium, lead, and nickel in this report as it is possible that such action levels may be put into effect in the future.

Analytical results for tissues from *Mercenaria* and (or) *Alitta virens* tests were compared to the FDA levels for crustacea as suggested in Appendix H of the *Southeast Regional Implementation Manual* (SERIM / EPA and USACE 2008), as there are no FDA levels published for polychaete worm tissue and the RIA does not address this topic. Additionally, mean tissue analytical results found to statistically significantly exceed those of the Reference tissue and contain at least one replicate result greater than the method detection limit (MDL) were then compared with ecological non-specific effects threshold concentrations and northern Gulf of Mexico background concentrations from Appendix H of the SERIM (the RIA lacks these background concentrations). Northern Gulf of Mexico background concentrations were chosen over other background concentrations because the survey area from which the concentrations are based included waters as far west as Gulfport, Mississippi. These waters are closest to the project area in Port Aransas, Texas. If results statistically significantly exceeded mean Reference tissue results and exceeded effects threshold or background concentrations, such results may be used in a risk-based evaluation by USACE.

All project and Reference tissue samples had five replicates (except for the pre-exposure tissue results, which had three replicates). The mean of results of each set of five replicates per sample and analyte combination was calculated and compared to the mean of the Reference tissue result per analyte. Mean values of analyte concentrations were calculated as follows:

- For non-detects/U-flagged data, the MDL was used in the statistical calculations.
- For J-flagged and non-flagged data, the result was used in the statistical calculations.

Whenever the dry weight mean concentration (or mean adjusted concentration) of an analyte in *M. mercenaria* or *A. virens* tissue was found to exceed that of the Reference tissue, and at least one of the five replicate samples had concentrations above the MDL, the software program ToxCalc v5.0.32 (Tidepool Scientific, LLC) was used to determine the relative distribution and variances among each group of replicates tested. If the distribution was determined to be abnormal or if the variances were unequal, the data were treated with a reciprocal transformation and the distribution and variances were re-evaluated. If no mean tissue contaminant concentration (or mean adjusted concentration) was found to statistically significantly exceed that of the Reference tissue, then no additional analysis was necessary to demonstrate compliance with the LPC (Green Book). Project sample mean values that statistically significantly exceeded those of the Reference were compared with screening benchmarks such as relevant ecological effects threshold and the northern Gulf of Mexico background concentrations.

2.7 Reporting Limits

Sediment chemical concentrations, MDLs and laboratory reporting limits (LRLs, essentially the same as the more widely used method reporting limits [MRLs]) were reported on a dry weight basis. Chemical concentrations, MDLs and LRLs for water and elutriates were reported on a wet weight basis. Tissue chemical concentrations, MDLs and MRLs were reported on dry weight and wet weight bases. The LRL and MRL refers to the minimum concentration at which the laboratory will report analytical chemistry data with confidence in quantitative accuracy of a given datum. Common laboratory procedures for defining an LRL or MRL include assigning it to a fixed factor above the MDL or by using the lowest calibration standard. LRLs and MRLs are often adjusted by the laboratory for sample-specific parameters such as sample weight, percent solids, or dilution.

3 RESULTS AND DISCUSSION

3.1 Field Sampling

A summary of the August 16 through August 25, 2022, sampling effort is provided in Tables 1 and 2 for sediment and water sampling, respectively. The field sampling data for the New Work ODMDS sediment and water sample collected on March 3, 2022, is provided in Table 1 and Table 2. The field sampling data for the CDP-03 sediment only re-sampling event, completed on January 22, 2023, and Reference Area grab sampling event, completed on January 27, 2023, are provided in Table 1. Samples were collected and processed in accordance with the SAP and Errata approved by EPA and USACE (Appendix A).

3.2 Sediment Physical Results

Physical analyses were conducted for each DMMU subsample (CDP-01A and -01C; CDP-02A and -02C; CDP-03A and -03C; and CDP-04A and -04C; CDP-05A and -05C), each DMMU composite sample (CDP-01 through CDP-05), a duplicate composite (CDP-03-Duplicate), and the Reference composite sample (CDP-REF). Each DMMU subsample and composite samples referenced above underwent grain size distribution analysis in accordance with the SAP (Appendix A). Exhibit 3-1 summarizes and compares percent grain size distributions for each outer channel sample. Complete results of physical testing are in Table 3. The laboratory report of physical analytical results is in Appendix C.

DMMU CDP-01 Subsamples -1A, -1C, and CDP-01-Composite

- CDP-01 subsamples 1A and 1C had varying portions of clay (56.5% and 32.5%), silt (23.7% and 41.6%) and sand (19.8% and 25.9%), respectively.
- CDP-01-Composite was predominantly silt (43.8%) with clay (35.9%) and sand (20.3%).

DMMU CDP-02 Subsamples -2A, -2C, and CDP-02-Composite

- CDP-02 subsamples -2A and -2C had varying proportions of sand (20.2% and 10.0%) with silt (41.1% and 47.0%) and clay (38.7% and 43.0%), respectively.
- CDP-02-Composite sample was predominantly silt (47.2%) with clay (38.2%), and sand (14.6%).

DMMU CDP-03 Subsamples -3A, -3C, CDP-03-Composite, and CDP-03-Duplicate-Comp.

- CDP-03 subsamples -3A and -3C had similar proportions of silt (43.9% and 46.6%), clay (46.5 and 44.0) and sand (9.6% and 9.4%), respectively.
- CDP-03-Composite sample was predominantly clay (45.6%) with silt (43.8%) and sand (10.6%).
- CDP-03 Duplicate Composite sample was predominantly clay (50.2%) with silt (40.6%) and sand (9.2%).

DMMU CDP-04 Subsamples -4A, -4C, and CDP-04-Composite

- CDP-04 subsamples -4A and -4C were predominantly clay (58.2% and 55.1%) with silt (22.9% and 24.9%) and sand (18.9% and 20.0%), respectively.
- CDP-04-Composite was predominantly clay (46.8%) with silt (34.4%) and sand (18.8%).

DMMU CDP-05 Subsamples -5A and -5C, and CDP-05-Composite

- CDP-05 subsamples -5A and -5C had similar proportions of clay (54.4% and 54.9%), silt (35.2% and 33.4%) and sand (10.4% and 11.7%), respectively.
- CDP-05-Composite was predominantly clay (57.5%) with silt (32.1%) and sand (10.4%).

CDP Reference (Outer Channel) Composite

- The Reference composite was predominantly sand (44.2%) with clay (28.0%) and silt (27.8%).

CDP ODMDS Composite (March 2022)

- The New Work ODMDS composite was predominantly sand (90.3%) with clay (5.9%) trace gravel (2.4) and trace silt (1.4%).

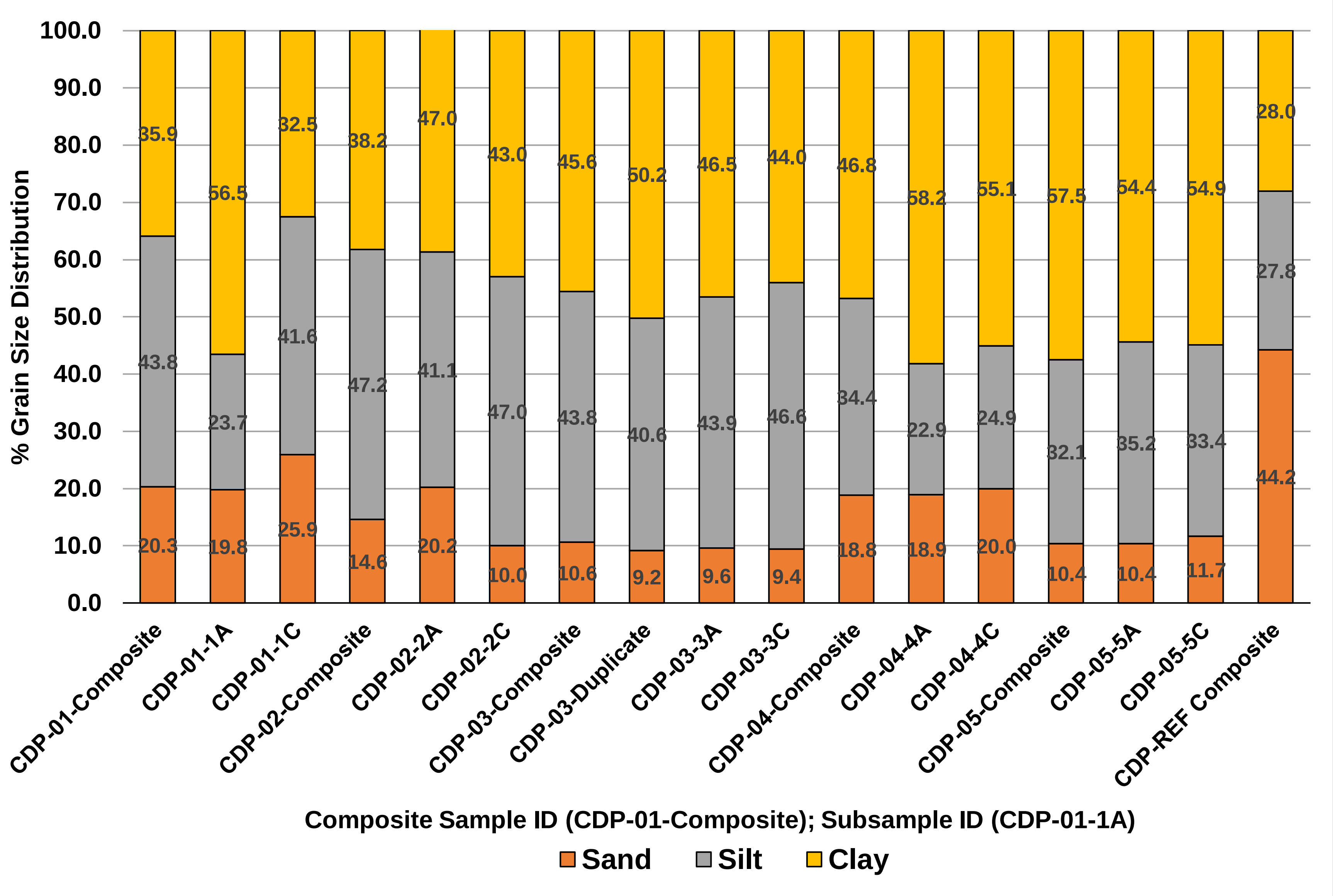


Exhibit 3-1. Percent Grain Size Distribution by DMMU Subsample and Composite

Notes: sand = 0.075–4.749 mm, silt = 0.0005–0.074 mm, clay <0.005 mm

3.3 Sediment Chemistry

Analytical results for sediment chemistry are provided in Tables 4 through 7. Sediment chemistry analyses were performed on composite samples collected from the five DMMUs (CDP-01 through -05), including one duplicate sample collected at CDP-03 (Core 2), the Reference (collected in August 2022), and the New Work ODMDS composite sample. In accordance with the SAP, the sample analyses consisted of metals, ammonia (as nitrogen), trivalent and hexavalent chromium, total cyanide, TPH, total solids, TOC, pesticides, total PCBs, PAHs, and SVOCs. Total low-molecular-weight PAHs (LPAHs) and total high-molecular-weight PAHs (HPAHs) were calculated from the sum of individual PAHs and are defined following Table-4-1 of the SAP. Analytical results were compared to published sediment screening criteria TEL and ERL, which are defined in Subsection 2.6.1.

3.3.1 Metals, Ammonia, Cyanide, TPHs, TOC, and Total Solids

Most of the 13 metals analyzed were detected at concentrations above the LRL in the composite samples tested with the exception of antimony (U-qualified). The metals detected above the LRL were all below the respective TEL and (or) ERL.

The laboratory included data qualifier V for specific metals in most of the composite samples tested. V-qualified values indicate the analyte was detected in both the sample and the method blank. The MDLs did not exceed the TEL or ERL, therefore impact to data quality is considered minimal.

Trivalent chromium ranged from 7.18 milligrams per kilogram (mg/kg) to 12.1 mg/kg among the samples tested. Hexavalent chromium was not detected above the MDL (U-qualified) in the composite samples tested.

Ammonia (as nitrogen) concentrations ranged from 24.9 mg/kg to 111 mg/kg among the samples tested.

Total cyanide was not detected above the MDL (U-qualified) in the composite samples tested.

TPHs were not detected above the MDL (U-qualified) in the samples tested with the exception of CDP-05 (26.1 mg/kg).

TOC concentrations ranged from 0.22% to 0.64% among the samples tested.

Total solids ranged from 48.7% to 71.9% among the samples tested.

Exhibit 3-2 summarizes the analytical results for these analytes in the sediment samples compared to the TEL and ERL. Complete results are in Table 4.

Exhibit 3-2. Analytical Results for Metals, Ammonia, Cyanide, TPHs, Total Solids, and TOC in Composite Sediment Samples

Analyte	Concentration (mg/kg or as otherwise indicated)									
	Composite IDs									
	CDP-01	CDP-02	CDP-03	CDP-03 (Duplicate)	CDP-04	CDP-05	CDP-REF	CDP-ODMDS	TEL	ERL
METALS										
Antimony	<0.0307	<0.0277	<0.0293	<0.0302	<0.0360	<0.0427	<0.0397	<0.268	x	x
Arsenic	5.61	4.53	6.95	7.31	5.78	6.62	2.80	<0.0268	7.24	8.2
Beryllium	0.490	0.409	0.542	0.554	0.623	0.693	0.380	<0.00538	x	x
Cadmium	0.0383	0.0324	0.0507	0.0492	0.0418	0.0410	0.0346	<0.0268	0.676	1.2
Chromium	8.21	7.18	8.75	9.30	10.9	12.1	6.47	<0.0805	52.3	81
Chromium (III)	8.21	7.18	8.75	9.30	10.9	12.1	6.47	<2.22	x	x
Chromium (IV)	<2.60	<2.37	<2.66	<2.51	<3.05	<3.44	<3.48	<2.14	x	x
Copper	5.58	4.79	7.33	7.38	6.70	7.62	4.18	<0.107	18.7	34
Lead	9.12	7.90	9.88	10.2	12.4	13.2	6.72	<0.0268	30.24	46.7
Mercury	0.0146	0.0161	0.0194	0.0196	0.0328	0.0382	0.0175	0.00526	0.13	0.15
Nickel	9.57	8.41	11.0	11.3	11.7	13.2	6.92	<0.538	15.9	20.9
Selenium	1.82	1.59	1.91	1.86	1.97	2.13	1.36	<0.538	x	x
Silver	0.0211	0.0189	0.0236	0.0269	0.0307	0.0336	0.0203	<0.0134	0.73	1
Thallium	0.0829	0.0742	0.0902	0.0960	0.0991	0.112	0.0638	<0.0134	x	x
Zinc	33.0	30.3	38.2	36.1	46.6	49.4	24.4	<0.538	124	150
OTHERS										
Ammonia (as N)	111	24.9	38.1	37.3	39.2	46.0	35.5	<12.6	x	x
Cyanide, Total	<0.0352	<0.0351	<0.0363	<0.0350	<0.0449	<0.0467	<0.0439	<0.0347	x	x
TPHs	<6.88	<6.88	<6.88	<6.88	<6.88	26.1	<6.88	<3.74	x	x
Solids, Total (%)	67.0	71.9	67.6	68.1	55.7	48.7	51.8	79.2	x	x
TOC (%)	0.31	0.22	0.27	0.27	0.61	0.64	0.51	0.10	x	x

"<" Less-than symbol indicates that the analyte concentration was not detected above the MDL (U-qualified). Value indicates the MDL.

x = No TEL or ERL published for that parameter.

See Table 4 for complete results

3.3.2 Pesticides and Total PCBs

Pesticide analytes were reported below the MDLs (U-qualified) in the composite samples tested except for the analytes chlordane (technical), dieldrin, γ-BHC (lindane) and toxaphene. These analytes were reported above MDLs in at least one sample that exceeded the respective TEL and (or) ERL, including the Reference Area composite sample. Specific pesticide analyte results in each composite sample including the Reference were C+ qualified, which indicates the associated calibration QC is higher than the established quality control criteria for accuracy. There were no pesticide concentrations detected in the sample; therefore, data was not affected and acceptable to report.

Total PCBs were not detected above the MDL (U-qualified) in the composite samples tested. Project sediment samples were reported with a MDL ranging from 1.10 micrograms per kilogram (µg/kg) to 2.05 µg/kg, slightly greater than the target detection limit for Total PCBs (1.0 µg/kg) in the SAP. This slightly elevated MDL was due to low total solid content in the sediment samples.

Complete results for pesticides and total PCBs are in Table 5.

3.3.3 PAHs

The 15 PAH analytes tested were detected below the MDLs (U-qualified) in the composite samples tested. MDLs for the PAH compounds were below applicable TELs and ERLs and below target detection levels specified in the SAP.

Total LPAHs ranged from 10.0 µg/kg to 15.4 µg/kg. Total HPAHs ranged from to 16.7 µg/kg to 25.7 µg/kg. Total PAHs ranged from 26.7 µg/kg to 41.1 µg/kg. Total LPAHs, Total HPAHs and Total PAHs were below applicable TELs and ERLs for composite samples.

Complete results are in Table 6.

3.3.4 SVOCs

Most SVOCs were reported below MDLs (U-qualified) with specific SVOC analytes detected above the LRL in one or more composite samples tested. SVOC analytes detected above the MDLs (J-qualified) or LRLs include bis(2-ethylhexyl) phthalate, di-n-butyl phthalate, and total phenol. TEL or ERL criteria values are not listed for the SVOC analytes with the exception of bis(2-ethylexyl) phthalate. The reported concentrations for bis(2-ethylexyl) phthalate (3.48 µg/kg to 6.15 µg/kg) in the samples tested are below the TEL concentration value of 182 µg/kg.

Additional data qualifiers B and V were listed for specific SVOC analytes, in specific samples tested. B-qualified values indicate that the analyte was found in the associated method blank. V-qualified values indicate that the analyte was detected in both the sample and the method blank. The MDLs did not exceed the TEL or ERL; therefore, impact to data quality is considered minimal.

Complete results are in Table 7.

3.4 Elutriate and Water Chemistry

Analytical results for site water samples and elutriates generated from the DMMU composites are presented in Tables 8 through 11 along with results for the Reference composite and the New Work ODMDS composite samples. Results for water and elutriate samples are compared to applicable CMC and Texas Water Quality Standard (TWQS) acute values. The CMC is defined in Subsection 2.6.2. The elutriate and water chemistry laboratory case narrative and data are in Appendix E.

3.4.1 Metals, Ammonia, Cyanide, TOC, TSS, and TPHs

One or more metals were detected at either J-qualified concentrations or above the LRLs in the site water and elutriate samples tested with the exception of beryllium, cadmium, mercury, silver, and thallium, which were U-qualified in the samples tested. Metals were not reported at concentrations above CMCs or TWQS in these samples with the single exception of copper in water samples CDP-01 (6.90 µg/L) and the reference (15.7 µg/L). The reported concentrations for copper in these samples exceeded the CMC (4.8 µg/L), and the TWQS (13.5 µg/L) in the Reference site water sample only.

Additional data qualifiers B, V, CQb, CQd, CQe, CQf, and CQg were listed for most metals analyzed in the elutriate and site water samples tested. The MDLs did not exceed the CMC or TWQS, therefore impact to data quality is considered minimal. CQb qualified results indicate the analyte was analyzed in the sample and the associated leach blank. CQc/CQd/CQf qualified results indicate the analyte was detected in the associated leach blank. CQe qualified results indicate the analyte was detected in the sample and the associated leach blank. CQg qualified results indicate the analyte was found in the sample and the associated leach blank.

Trivalent chromium was not detected above the MDL (U-qualified) in the site water and elutriate samples tested. Hexavalent chromium ranged from less than (<) 0.00150 µg/L to 10.8 µg/L in the site water and elutriate samples tested. Hexavalent chromium concentrations in the samples tested were below the CMC (1,100 µg/L) and TWQS (1,090 µg/L).

Ammonia (as nitrogen) ranged from 0.0932 mg/L to 2.14 mg/L in the site water and elutriate samples tested.

Total cyanide was detected above the MDL (J-qualified) at 0.001 mg/L in site water and elutriate samples tested. The detected concentration is equal to the CMC (0.001 mg/L).

TPH concentrations ranged from <0.18 mg/L to 2.82 mg/L in the site water or the elutriate samples tested.

TOC ranged from <0.35 mg/L to 3.1 mg/L in the site water and elutriate samples tested.

Total Suspended Solids (TSS) ranged from 2.63 mg/L to 28.6 mg/L in the site water and elutriate samples tested.

CDP outer channel elutriate and water sample results are summarized in Exhibits 3-3 and 3-4, respectively. Complete results are in Table 8.

Exhibit 3-3. Elutriate Analysis Results for Metals, Ammonia, Cyanide, TOC, TSS, and TPHs Detected in One or More Samples

Analyte	Elutriate Samples						CMC	TWQS Acute
	CDP-01-E	CDP-02-E	CDP-03-E	CDP-03-Duplicate	CDP-04-E	CDP-05-E		
Metals	**Concentration (µg/L)**							
Antimony	3.86	3.70	3.87	2.64	1.99	1.52	x	x
Arsenic	14.9	14.4	14.1	12.2	9.72	7.34	69	149
Chromium	1.48	<0.400	<0.400	<0.400	<0.400	<0.400	x	x
Chromium, Hexavalent	<0.00150	0.00228	0.00160	<0.00150	0.00211	<0.00150	1100	1090
Lead	<0.500	1.87	<0.500	<0.500	<0.500	<0.500	210	133
Nickel	3.11	15.9	1.41	4.56	0.791	0.969	74	118
Selenium	2.16	2.12	2.37	2.44	<1.65	<1.65	290	564
Zinc	<1.00	3.75	<1.00	1.12	<1.00	1.34	90	92.7
Others	**Concentration (mg/L)**							
Ammonia (as N)	1.89	1.88	2.07	2.14	1.05	1.18	x	x
TOC	3.1	2.2	2.0	2.0	2.0	2.0	x	x
Cyanide, Total	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.0056
TSS	28.6	4.10	3.03	7.37	14.3	9.89	x	x
TPHs	<0.18	<0.18	0.507	<0.18	<0.18	<0.18	x	x

x = No CMC and (or) Texas water quality standard values published for this parameter.
<#.## = The analyte was not detected at or above the MDL (= U-qualified). The value after the less-than symbol represents the MDL.
See Table 8 for complete results.

Exhibit 3-4. Site Water Analysis Results for Metals, Ammonia, Cyanide, TOC, TSS, and TPHs Detected in One or More Samples

Analyte	Site Water Samples							CMC	TWQS Acute
	CDP-01-W	CDP-02-W	CDP-03-W	CDP-04-W	CDP-05-W	CDP-REF	CDP-ODMDS (March 2022)		
Metals	**Concentration (µg/L)**								
Arsenic	1.91	2.12	1.96	2.12	1.92	1.89	6.65	69	149
Chromium	0.570	0.635	0.659	0.835	0.653	1.34	<0.800	x	x
Chromium, Hexavalent	7.05	10.8	9.00	<1.50	2.90	<1.50	6.34	1100	1090
Copper	**6.03**	<1.00	<1.00	3.49	<1.00	**15.7**	<2.00	4.8	13.5
Nickel	0.436	0.419	0.431	1.26	0.534	1.52	1.20	74	118
Zinc	<1.00	3.34	<1.00	1.58	4.38	1.65	<2.00	90	92.7
Others	**Concentration (mg/L)**								
Ammonia (as N)	0.0932	0.551	0.480	0.210	0.322	0.355	0.480	x	x
TOC	1.4	1.1	<0.35	1.1	<0.35	1.3	0.16	x	x
Cyanide, Total	0.001	0.001	0.001	0.001	0.001	0.001	<0.0005	0.001	0.0056
TSS	3.79	3.58	2.63	2.95	3.26	2.84	3.05	x	x
TPHs	<0.18	2.25	<0.18	2.82	<0.18	<0.18	<0.442	x	x

x = No CMC and (or) Texas water quality standard values published for this parameter.
<#.## = The analyte was not detected at or above the MDL (= U-qualified). The value after the less-than symbol represents the MDL.
Bolded values meet or exceed the CMC and (or) Texas surface water quality (acute) standard.
See Table 8 for complete results.

3.4.2 Pesticides and Total PCBs

The 21 pesticides tested were not detected above the MDL in the site water and elutriate samples tested (U-qualified). The MDL and LRL for toxaphene were 0.300 µg/L and above the CMC (0.21 µg/L) and TWQS (0.21) in the samples tested. The laboratory included data qualifiers C+ for specific pesticide analytes in the samples tested. C+-qualified values indicate the associated calibration QC is higher than the established quality control criteria for accuracy. There was not a detected hit in sample; therefore, the data is not affected and acceptable to report.

Total PCBs were not detected above the MDL (U-qualified) in the site water and elutriate samples tested.

Complete results are in Table 9.

3.4.3 PAHs

PAHs were not detected above the MDL (U-qualified) in the site water and elutriate samples tested. The calculated concentrations for total LPAHs were 1.69 µg/L, total HPAHs (2.81 µg/L), and total PAHs (4.50 µg/L) in the samples tested. Complete results are presented in Table 10.

3.4.4 SVOCs

Three of the 41 SVOC analytes tested (diethyl phthalate, di-n-butyl phthalate and total phenol) were detected above the LRL in one or more site water samples and elutriate samples tested. The SVOC analyte concentrations were below the applicable CMC or TWQS among the samples tested. The laboratory included data qualifiers B, V and V2 for specific SVOCs. The data qualifiers for B and V were previously defined. V2 qualified results indicate the analyte was detected in the sample and the associated leach blank. The MDLs did not exceed the CMC or TWQS; therefore, impact to data quality is considered minimal. Complete results are in Table 11.

3.5 Water Column Bioassays

SPP tests were performed with the atherinoid fish *Menidia beryllina* (inland silverside) and planktonic and juvenile life stages of the mysid crustacean *Americamysis bahia* (opossum shrimp). Elutriate test results were compared to results of the control (laboratory-prepared artificial seawater [Instant Ocean Sea Salt or Hawaiian Marine Mix]). The complete toxicity testing report by NWDLS is in Appendix G.

3.5.1 *Americamysis bahia* 96-Hour Bioassay

The 96-hour SPP tests with *A. bahia* were initiated on September 27, 2022, and terminated on October 1, 2022. Survival in the site water controls for project samples CDP-01 through CDP-05 ranged from 96% to 100%, meeting the acceptability criterion of greater than or equal to (≥) 90% survival. Mean survival in the 100% elutriate concentration ranged from 96% to 98% among the project elutriates and was 96% in the Reference. The results were not statistically different than the controls. The estimated LC_{50} was >100% for these project samples. Survival rates for the samples are summarized in Exhibit 3-5.

Summaries of the test conditions including survivorship raw data bench sheets, water quality measurements, and ammonia concentrations are provided in PDF pages 113 through 119 of the toxicity testing report (Appendix G). The results of the Reference toxicant test using copper with *A. bahia* are provided as PDF pages 128 through 133 of the NWDLS toxicity testing report (Appendix G).

Exhibit 3-5. Summary of Survival Data for 96-hour SPP Tests Using *Americamysis bahia*

Sample ID	Concentration (%)	Mean Survival (% [± SD])	Statistically Significantly Less Than Control? (yes/no)	LC_{50} (%)
Outer Channel*				
REF (site water control)		98 (± 4.5)		
CDP-01 (site water control)		100 (± 0.0)		
CDP-02 (site water control)		100 (± 0.0)		
CDP-03 (site water control)		98 (± 4.5)		
CDP-04 (site water control)		100 (± 0.0)		
CDP-05 (site water control)		96 (± 5.5)		
REF (elutriate)	100	96 (± 5.5)	No	>100
CDP-01 (elutriate)	100	98 (± 4.5)	No	>100
CDP-02 (elutriate)	100	98 (± 4.5)	No	>100
CDP-03 (elutriate)	100	96 (± 8.9)	No	>100
CDP-04 (elutriate)	100	96 (± 8.9)	No	>100
CDP-05 (elutriate)	100	98 (± 4.5)	No	>100

*Source: PDF Pages 6 and 113 to 119 of the toxicology laboratory report (11/21/2022) by NWDLS (Appendix G)

3.5.2 *Menidia beryllina* 96-Hour Bioassay

The 96-hour SPP tests with *M. beryllina* were initiated on September 27, 2022, and terminated on October 1, 2022. Survival in the site water controls for project samples ranged from 94% to 100%, meeting the acceptability criterion of ≥90% survival. Mean survival in the 100% elutriate concentration ranged from 92% to 98% among the project elutriates and was 98% in the Reference. The results were not statistically different than the controls. The estimated LC_{50} values were >100% for these project samples. The mean survival results for these tests are summarized in Exhibit 3-6.

Summaries of the test conditions, including survivorship raw data bench sheets, water quality measurements and ammonia concentrations, are provided in PDF pages 121 through 127 of the toxicity testing report (Appendix G). Results of the Reference toxicant test using copper with *M. beryllina* are provided as PDF pages 164 through 165 of the toxicity testing report (Appendix G).

Exhibit 3-6. Summary of Survival Data for 96-hour SPP Tests Using *Menidia beryllina*

Sample ID	Concentration (%)	Mean Survival (% [± SD])	Statistically Significantly Less Than Control? (yes/no)	LC_{50} (%)
Outer Channel*				
REF (site water control)		98 (± 4.5)		
CDP-01 (site water control)		96 (± 5.5)		
CDP-02 (site water control)		100 (± 0.0)		
CDP-03 (site water control)		98 (± 4.5)		
CDP-04 (site water control)		96 (± 5.5)		
CDP-05 (site water control)		94 (± 8.9)		
REF (elutriate)	100	98 (± 4.5)	No	>100
CDP-01 (elutriate)	100	96 (± 5.5)	No	>100
CDP-02 (elutriate)	100	98 (± 4.5)	No	>100
CDP-03 (elutriate)	100	96 (± 8.9)	No	>100
CDP-04 (elutriate)	100	94 (± 5.5)	No	>100
CDP-05 (elutriate)	100	92 (± 4.5)	No	>100

*Source: PDF Pages 7 and 121 to 127 of the toxicology laboratory report (11/21/2022) by NWDLS (Appendix G).

3.5.3 *Americamysis bahia* Plankton 48-Hour Bioassay

The 48-hour SPP tests with planktonic life stage *A. bahia* were initiated on September 27, 2022, and terminated on September 29, 2022. Survival in the site water controls for project samples ranged from 96% to 100%, meeting the acceptability criterion of ≥90% survival. Mean survival in the 100% elutriate concentration ranged from 94% to 98% in the project elutriates samples and was 94% in the Reference. The results were not statistically different than the controls. The estimated LC_{50} values were >100% for these project samples. The mean survivorship results for the samples are summarized in Exhibit 3-7.

Summaries of the test conditions including survivorship raw data bench sheets, water quality measurements, and ammonia concentrations are provided in PDF pages 105 through 111 in the toxicity testing report (Appendix G). Results of the 48-hour acute Reference toxicant test using copper with *A. bahia* are provided as PDF pages 155 through 160 of the toxicity report (Appendix G).

Exhibit 3-7. Summary of Survival Data for 48-hour SPP Tests Using Planktonic Life Stage *Americamysis bahia*

Sample ID	Concentration (%)	Mean Survival (% [± SD])	Statistically Significantly Less Than Control? (yes/no)	LC_{50} (%)
Outer Channel*				
REF (site water control)		96 (± 5.5)		
CDP-01 (site water control)		98 (± 4.5)		
CDP-02 (site water control)		100 (± 0.0)		
CDP-03 (site water control)		96 (± 5.5)		
CDP-04 (site water control)		100 (± 0.0)		
CDP-05 (site water control)		96 (± 5.5)		
REF (elutriate)	100	94 (± 5.5)	No	>100
CDP-01 (elutriate)	100	98 (± 4.5)	No	>100
CDP-02 (elutriate)	100	98 (± 4.5)	No	>100
CDP-03 (elutriate)	100	94 (± 5.5)	No	>100
CDP-04 (elutriate)	100	96 (± 5.5)	No	>100
CDP-05 (elutriate)	100	96 (± 5.5)	No	>100

*Source: PDF Page 5 and 105 to 111 of the toxicology laboratory report (11/21/2022) by NWDLS (Appendix G)

3.6 Whole Sediment (Solid Phase) Bioassays

The SP toxicity tests were performed with the amphipod crustacean *Leptocheirus plumulosus* and the mysid crustacean *Americamysis bahia*.

3.6.1 *Leptocheirus plumulosus* 10-day Bioassay

The 10-day SP tests with *L. plumulosus* were initiated on September 12, 2022, and terminated on September 22, 2022. Mean survival in the control was 98%, which met the RIA recommended acceptability criterion of ≥90%. Mean survival in the project sediments ranged from 85% to 94% and was 93% in the Reference. Mean survival across the project samples was either greater than the Reference or less than 20% below the Reference, indicating that all samples met the LPC for benthic toxicity as defined in the RIA. Mean survival for the samples is summarized in Exhibit 3-8.

Summaries of the test conditions including raw survivorship data bench sheets, water quality parameters, and ammonia concentrations are summarized in PDF pages 84 through 93 of the toxicity report (Appendix G). The results of the 48-hour Reference toxicant test using cadmium chloride ($CdCl_2$) with *L. plumulosus* are provided as PDF page 128 of the toxicity report (Appendix G).

Exhibit 3-8. Summary of Survival Data for the 10-Day SP Tests Using *Leptocheirus plumulosus*

Sample ID	Mean Survival (%)	Standard Deviation (%)	Significant Effect? (>20% Effect?)	Statistically Significantly Less Than Reference? (yes/no)	Exceeds LPC? (yes/no)
Outer Channel*					
Control	98		-5.38		
REF (Reference)	93		0.00		
CDP-01 Composite	89	8.4	4.30, No	No	No
CDP-02 Composite	94	4.2	-1.08, No	No	No
CDP-03 Composite	85	5.0	8.60, No	No	No
CDP-04 Composite	91	8.9	2.15, No	No	No
CDP-05 Composite	88	5.7	5.38, No	No	No

LPC = limiting permissible concentration
*Source: PDF Page 7 and 84 to 85 of the toxicology laboratory report (11/21/2022) by NWDLS (Appendix G)

3.6.2 *Americamysis bahia* 10-Day Bioassay

3.6.2.1 CDP-01 through CDP-05 Initial Test Results

The 10-day SP tests with *A. bahia* were initiated September 12, 2022, and terminated on September 22, 2022. The tests were validated by 96% mean survival in the control, meeting the acceptability criterion of ≥90%. Mean survival in the project sediments ranged from 87% to 98% and was 99% in the Reference. Sample CDP-03 resulted in mean survival that was greater than 10% different from that of the Reference, indicating that sample did not meet the LPC for benthic toxicity as defined in the RIA. The remaining project samples did not result in mean survival that was greater than 10% different from that of the Reference, indicating that the rest of the samples met the LPC for benthic toxicity as defined in the RIA. Mean survival for test samples is summarized in Exhibit 3-9.

Summaries of the test conditions including raw survivorship data bench sheets, water quality parameters, and ammonia concentrations are summarized in PDF pages 84 through 93 of the toxicity report (Appendix G). The results of the 7-day Reference toxicant test using copper with *A. bahia* are provided as PDF pages 145 through 165 of the toxicity report (Appendix G).

3.6.2.2 CDP-03 Re-Sample Test Results

The CDP-03 Re-Sample 10-day SP tests with *A. bahia* were initiated February 7, 2023, and terminated on February 17, 2023. The tests were validated by 94% mean survival in the control, meeting the acceptability criterion of ≥90%. Mean survival in the project sediment CDP-03 Re-Sample was 96% and was 90% in the Reference. Mean survival in CDP-03 Re-Sample was less than 10% different from that of the Reference, indicating this sample met the LPC for benthic toxicity as defined in the RIA. Based on the CDP-03 Re-Sample test results, mean survival was not significantly different or greater than 10% different from that of the Reference, indicating that the sample met the LPC for benthic toxicity as defined in the RIA. Mean survival for the re-sample test sample is summarized in Exhibit 3-9.

Summaries of the CDP-03 Re-Sample test conditions including raw survivorship data bench sheets, water quality parameters, and ammonia concentrations are summarized in PDF pages 6 through 26 of the toxicity report (Appendix G). The results of the 7-day Reference toxicant test using potassium chloride with *A. bahia* are provided as PDF pages 27 through 33 of the toxicity report (Appendix G).

Exhibit 3-9. Summary of Survival Data for the 10-Day SP Tests Using *Americamysis bahia*

Sample ID	Mean Survival (%)	Standard Deviation (%)	Significant Effect? (>10% Effect?)	Statistically Significantly Less Than Reference? (yes/no)	Exceeds LPC? (yes/no)
Outer Channel - Initial Testing Results*					
Control	96		3.03		
REF (Reference)	99		0.00		
CDP-01 Composite	98	4.5	1.01, No	No	No
CDP-02 Composite	95	6.1	4.04, No	No	No
CDP-03 Composite	87	9.7	12.12, Yes	**Yes**	**Yes**
CDP-04 Composite	98	2.7	1.01, No	No	No
CDP-05 Composite	92	10.4	7.07, No	No	No
Outer Channel – CDP-03 Re-Sample Test Results**					
Control	94		-4.26		
REF (Reference)	90		0.00		
CDP-03 Composite	96	1.8	-6.67	No	No

LPC = limiting permissible concentration
*Source: PDF Page 8 and 94 to 95 of the toxicology laboratory report (11/21/2022) by NWDLS (Appendix G)
**Source: PDF Page 5 through 7 of the toxicology laboratory report (02/28/2023) by NWDLS (Appendix G)

3.7 Bioaccumulation Potential Tests

The bioaccumulation potential tests were performed with the bi-valve mollusk *Mercenaria* (hard clam/quahog) and polychaete *Nereis Virens* (sand worm).

The 28-day bioaccumulation tests with *A. virens* and *M. mercenaria* were initiated on September 16, 2022, and both tests were terminated on October 14, 2022. Mean survival in the control was 75% for *M. mercenaria* and 93% for *A. virens*. Mean survival in the Reference was 70% for *M.*

mercenaria and 83% for *A. virens*. Survival in the project sediment samples ranged from 70% to 87% in *M. mercenaria* and from 67% to 81% for *A. virens*. Mean survival results for the samples are summarized in Exhibit 3-10.

Summaries of the test conditions including raw survivorship data bench sheets, water quality measurements, ammonia concentrations, and tissue weight for *A. virens* and *M. mercenaria* are provided as PDF pages 64 through 73, and 74 through 83, respectively, in the toxicity report (Appendix G).

Exhibit 3-10. Summary of Survival Data for *Mercenaria* and *Alitta virens*

Sample ID	Mean Survival (%)	
	M. mercenaria	***A. virens***
Outer Channel*		
Control	75	93
REF (Reference)	70	83
CDP-01 Composite	70	70
CDP-02 Composite	80	80
CDP-03 Composite	78	67
CDP-04 Composite	81	81
CDP-05 Composite	87	68

*Source: PDF Page 8 of the toxicology laboratory report (11/21/2022) by NWDLS (Appendix G)

3.8 Tissue Chemistry

Wet and dry weight tissue chemistry results for *M. mercenaria* and *A. virens* for the project samples CDP-01 through CDP-05, the Reference sample and pre-exposure tests are presented in Tables 12 through 20.

Tissue chemistry results for the project samples are compared to the Reference CDP-REF and to applicable screening benchmarks. The laboratory reports for tissue chemistry analyses are in Appendix E. Complete results of statistical analyses and transformations for *M. mercenaria* and *A. virens* are in Appendices F-1 and F-2, respectively.

3.8.1 Total Solids

Total solids were analyzed in *M. mercenaria* and *A. virens* tissues from the project samples along with the Reference and pre-exposure tissues. Analytical results for dry weight total solids tissue in *M. mercenaria* and *A. virens* tissues are in Table 12.

Total solids in *M. mercenaria* tissue ranged from 7.74% to 10.6% in project samples, the Reference, and pre-exposure tissue. Total solids in *A. virens* tissue ranged from 10.7% to 15.8% in project samples, the Reference and pre-exposure tissue.

3.8.2 Metals and Total Petroleum Hydrocarbons (TPHs)

Thirteen metals and TPH were tested in *M. mercenaria* and *A. virens* tissues from the project samples along with the Reference and pre-exposure tissues.

Mercenaria

Most metals tested in *M. mercenaria* tissue were detected in concentrations greater than the MDL (in one or more replicates) in one or more project samples. The exception was mercury which was not detected above the MDL (U-qualified) for the tissue samples. Mean concentrations for arsenic beryllium, lead, selenium, and/or thallium in *M. mercenaria* tissues from project samples CDP-01, CDP-02, and/or CDP-03 were statistically significantly greater than those of the Reference tissue. The results do not exceed the FDA action levels. Mean concentrations for lead in CDP-03 (0.131 mg/kg) exceeded the ecological effects threshold (EET) criteria concentration of 0.1 mg/kg.

Chromium, copper, nickel, and zinc were detected in both the sample and the method blank (V-qualified) in one or more replicates in the project samples, the Reference, and the pre-exposure tissues. The reported concentrations for these metals in the method blanks were either J-qualified or greater than the LRL, and all concentrations were below applicable FDA action levels, EET, and North Gulf of Mexico Background criteria concentrations. The General Risk Based Evaluations for these metals are presented in Section 3.9.

TPH mean wet weight concentrations in *M. mercenaria* tissues ranged from 42.1 mg/kg to 45.5 mg/kg and were highest in CDP-01. The TPH concentrations in the *M. mercenaria* tissues for the project samples were not statistically significantly greater than that of the Reference tissue.

Alitta virens

Most metals tested in *A. virens* tissue were detected in concentrations greater than the MDL (in one or more replicates) in one or more project samples. The exception was mercury which was not detected above the MDL (U-qualified) in the samples. Mean concentrations for beryllium in CDP-03 in *A. virens* tissue were statistically significantly greater than those of the Reference tissue. Mean concentrations for lead and nickel in CDP-01, CDP-02 and CDP-03 in *A. virens* tissue were statistically significantly greater than those of the Reference tissue sample. The sample mean results did not exceed the FDA action level for any metal tested. However, mean concentrations for lead in CDP-01 (0.166 mg/kg), CDP-02 (0.169 mg/kg) and CDP-03 (0.174 mg/kg) exceeded the EET concentration of 0.01 mg/kg.

Chromium, copper, nickel, and zinc were detected in the project samples, the Reference, the pre-exposure tests, and the associated method blanks (V-qualified). The reported concentrations for these metals in the method blanks were either J-qualified or greater than the LRL, and all concentrations were below applicable FDA action levels, EET, and North Gulf of Mexico Background criteria concentrations. The General Risk Based Evaluations for these metals are presented in Section 3.9.

TPH mean wet weight concentrations in *A. virens* tissues ranged from 424 mg/kg to 1,126 mg/kg and were highest in CDP-03. Mean concentrations for TPH in tissues from project samples CDP-03 and CDP-04 were statistically significantly greater than that of the Reference tissue.

- The fact sheet from the Agency for Toxic Substances and Disease Registry (ATSDR 1999) states that TPH is a term used to describe a large family of several hundred chemical compounds originally from crude oil. Crude oil is used to make petroleum products, which can contaminate the environment. Because there are so many different chemicals in crude oil and in other petroleum products, it is not practical to measure each one separately. However, it is useful to measure the total amount of TPH at a site to evaluate and screen potential constituents of concern and intensity. Scientists do this by dividing TPH into

> groups of petroleum hydrocarbons that act alike in soil or water. These groups are called petroleum hydrocarbon fractions. Each fraction contains many individual chemicals, including both volatile and extractable petroleum hydrocarbons (VPHs and EPHs), encompassing the gasoline range organics ($>C_6$–C_{12}), diesel range organics ($>C_{12}$–C_{28}), and oil range organics ($>C_{28}$–C_{35}).
>
> Generally, TPH testing provides a means to quantify the magnitude (in relative terms) of petroleum contamination that remains in the environment. For dredging projects, this exposure would come from biomagnification starting at low level organisms and working up to humans through a food chain. Upon their discharge into the environment, petroleum hydrocarbons can pose risks to human health, ecosystems, and groundwater. Since there are no FDA action levels for TPH resulting from the lack of scientific studies that document the effects of TPH on local marine-based organisms due to its large chemical composition, where mean concentrations for TPH were statistically significantly greater than that of the Reference, the effects of the TPH were addressed through SVOC analyses which provide an estimate of more toxic components found within the TPH fractions (as further discussed below and in Section 3.8.3). SVOCs were not identified as a concern for *A. virens*.

Mean wet weight concentrations of metals in *M. mercenaria* and *A. virens* tissues are summarized in Exhibits 3-11 and 3-12, respectively. Analytical results for wet and dry weight metals in *M. mercenaria* tissue are in Tables 13 through 16. Complete results of the ToxCalc runs for *M. mercenaria* are in Appendix E.

Exhibit 3-11. *Mercenaria mercenaria* Tissue: Summary of Mean Wet Weight Metals Results

	Mean Concentration of Replicates (mg/kg)									
Analyte	**CDP-01**	**CDP-02**	**CDP-03**	**CDP-04**	**CDP-05**	**CDP-REF**	**Pre-exposure**	**FDA Action Level (mg/kg)**	**EET (mg/kg)**	**N. Gulf of Mexico Bkgd. (mg/kg)**
Antimony	0.00176	0.00160	0.00173	0.00160	0.00177	0.00173	0.00172	x	x	0.22-0.47
Arsenic	**1.37 (109%)**	1.40	1.22	1.23	1.24	1.26	1.49	86	12.6	3.4-5.4
Beryllium	**0.00170 (123%)**	0.00157	0.00164	0.00146	0.00159	0.00138	0.00138	x	x	<0.14
Cadmium	0.0544	0.0534	0.0513	0.0570	0.0497	0.0517	0.0542	4	1.0	0.15-0.83
Chromium	0.0374	0.0435	0.0369	0.0419	0.0359	0.0319	0.0399	13	6.3	0.49-5.2
Copper	1.30	1.36	1.38	1.16	1.27	1.44	1.85	x	0.2	0.58-2.8
Lead	0.116	0.125	***0.131*** **(142%)**	0.0868	0.0869	0.0922	0.183	1.7	0.1	<0.47
Mercury	0.00408	0.00414	0.00444	0.00404	0.00488	0.00428	0.00439	1	0.3	<0.028
Nickel	0.459	0.424	0.450	0.471	0.492	0.475	0.504	80	2.2	0.7-3.1
Selenium	0.170	**0.250 (160%)**	**0.219 (140%)**	0.175	0.176	0.157	0.210	x	14.2	0.5-1.5
Silver	0.0189	0.0189	0.0296	0.0285	0.0270	0.0278	0.0224	x	1.0	0.11-0.56
Thallium	**0.00036 (129%)**	0.00030	0.00031	0.00024	0.00030	0.00028	0.00020	x	0.3	<0.47
Zinc	15.3	***19.6*** **(140%)**	16.8	13.1	14.2	13.9	14.9	x	11.6	7.0-30.0
TPHs	45.5	42.1	42.2	42.1	42.2	42.4	42.2	x	x	x

Bolded values indicate a mean concentration of project tissue that is statistically significantly greater than that of the Reference tissue and includes at least one replicate result greater than the MDL.

Bolded Italicized values indicate a mean concentration of project tissue that is statistically significantly greater than that of the Reference tissue and exceed the EET.

X = No FDA action level and (or) ecological effects threshold published for the given parameter. NA=Not Analyzed.

See Table 13 for complete results.

Exhibit 3-12. *Alitta virens* Tissue: Summary of Mean Wet Weight Metals Results

	Mean Concentration of Replicates (mg/kg)									
Analyte	**CDP-01**	**CDP-02**	**CDP-03**	**CDP-04**	**CDP-05**	**CDP-REF**	**Pre-exposure**	**FDA Action Level (mg/kg)**	**EET (mg/kg)**	**N. Gulf of Mexico Bkgd. (mg/kg)**
Antimony	0.00269	0.00302	0.00295	0.00217	0.00213	0.00297	0.00312	x	x	<0.31
Arsenic	2.35	2.88	2.69	2.50	2.59	2.61	2.83	76	12.6	7.4-37.0
Beryllium	0.00075	0.00051	**0.00129 (233%)**	0.00033	0.00049	0.00055	0.00196	x	x	<0.09
Cadmium	0.0348	0.0344	0.0355	0.0282	0.0311	0.0302	0.0294	3	27.8	0.34-1.4
Chromium	0.1051	0.0826	0.1216	0.0544	0.0710	0.0805	0.169	12	10.0	0.89-4.6
Copper	1.33	1.65	1.21	1.14	1.13	1.92	1.75	x	0.4	2.3-5.3
Lead	***0.166*** **(144%)**	***0.169*** **(147%)**	***0.174*** **(151%)**	0.108	0.113	0.115	0.143	1.5	0.1	0.31-1.2
Mercury	0.00453	0.00452	0.00500	0.00400	0.00450	0.00474	0.00445	1	0.3	0.03-0.04
Nickel	**0.223 (178%)**	**0.246 (196%)**	**0.228 (182%)**	0.135	0.141	0.125	0.179	70	2.2	0.53-3.5
Selenium	0.361	0.390	0.397	0.320	0.350	0.343	0.417	x	14.2	0.61-0.99
Silver	0.0202	0.0093	0.0172	0.0166	0.0204	0.0233	0.0290	x	1.0	<0.15
Thallium	0.000568	0.000630	0.000737	0.000608	0.000545	0.000580	0.000549	x	0.3	<0.13
Zinc	23.6	13.6	26.1	19.2	26.1	19.2	23.6	x	0.3	<0.13
TPHs	424	538	**1126 (221%)**	**956 (188%)**	727	510	618	x	x	x

Bolded value indicates a mean concentration in project tissue that is statistically significantly greater than that of the Reference and includes one or more replication results greater than the LRL.

Bolded Italicized values indicate a mean concentration of project tissue that is statistically significantly greater than that of the Reference tissue and exceed the EET.

x = No FDA action level and (or) ecological effects threshold published for the given parameter. NA=Not Analyzed

See Table 14 for complete results.

3.8.3 SVOCs

SVOCs including bis(2-ethylhexyl) phthalate and di-n-butyl phthalate were tested in *M. mercenaria* and *A. virens* tissues from project samples CDP-01, CDP-02 and CDP-03, along with the Reference and pre-exposure tissues.

Mercenaria mercenaria

SVOCs were detected in *M. mercenaria* tissues above the LRL in one or more replicates in the project samples, the Reference, and the pre-exposure. *M. mercenaria* tissues from CDP-01 had adjusted mean concentrations for di-n-butyl phthalate that statistically significantly exceeded those of the Reference tissue. There are no applicable FDA action levels nor north Gulf of Mexico background concentration for this SVOC. All adjusted mean concentrations for bis(2-ethylhexyl) phthalate in *M. mercenaria* were below the ecological effects threshold.

The two SVOC analytes were detected in both the sample and the method blank (V-qualified) in one or more replicates in the project samples, the Reference and the pre-exposure tissues.

Alitta virens

SVOCs were detected in *A. virens* tissues above the LRL in one or more replicates in the project tissues with the exception of bis(2-ethylhexyl) phthalate in the Reference tissues (all replicates U-qualified). *A. virens* tissues from CDP-01, CDP-02 and CDP-03 had mean adjusted concentrations for bis(2-ethylhexyl) phthalate that statistically significantly exceeded those of the Reference. There are no applicable FDA action levels, ecological effects thresholds or north Gulf of Mexico background concentration for this SVOC.

The two SVOC analytes were detected in both the sample and the method blank (V-qualified) in one or more replicates in some of the project samples, the Reference and the pre-exposure tissues. Bis(2-ethylhexyl) phthalate was detected in the method blank (B-qualified) in some of the replicates in project samples CDP-01, CDP-03, the Reference replicates, and pre-exposure replicates. Di-n-butyl phthalate was detected in the method blank (B-qualified) in the project samples, the Reference and pre-exposure tissues.

Mean adjusted wet weight concentrations of SVOC analytes in *M. mercenaria* and *A. virens* tissues from the outer channel project samples are summarized in Exhibit 3-13. Analytical results for wet and dry weight SVOCs in *M. mercenaria* and *A. virens* tissues are presented in Tables 17 through 20. Complete results of the ToxCalc runs for *M. mercenaria* and *A. virens* are in Appendix F.

Exhibit 3-13. *Mercenaria mercenaria* and *Alitta virens* Tissues: Summary of Mean Adjusted Wet Weight SVOCs Results

Analyte	Mean Adjusted Concentration of Replicates (µg/kg)					EET (µg/kg)	N. Gulf of Mexico Background (µg/kg)
	CDP-01	CDP-02	CDP-03	CDP-REF	Pre-exposure		
M. mercenaria							
Bis(2-ethylyhexyl) phthalate	13.3	19.5	17.3	11.5	2.72	847.0	x
Di-n-butyl phthalate	**9.65 (127%)**	8.77	9.79	7.58	6.89	x	x
A. virens							
Bis(2-ethylyhexyl) phthalate	**15.8 (226%)**	**30.3 (433%)**	**22.1 (315%)**	7.00	6.66	x	x
Di-n-butyl phthalate	12.7	14.3	20.5	27.4	37.1	x	x

Bolded values indicate a mean adjusted concentration of project tissue that is statistically significantly greater than that of the Reference tissue and includes at least one replicate result greater than the MDL.

x = No ecological effects threshold and northern Gulf of Mexico background concentration published for the given parameter.

* Indicates all replicates were below the MDL (U-qualified).

See Tables 21 and 22 for complete results.

3.9 General Risk-Based Evaluations

When analyte concentrations in project tissues statistically significantly exceed those of the Reference tissue, general risk-based evaluations must be conducted. Subsection 6.3 of the Green Book and Subsection 10.2.3 of the RIA provide eight factors to be considered in risk-based evaluations to evaluate compliance with 40 CFR §227.13(c)(3). Analyte concentrations in tissues that exceed these benchmarks warrant further evaluation.

Note that tissue chemistry results discussed in this section are compared to the reference sample that was collected in August 2022.

Factor 1. Statistical significance of the results from tests on sediment from the dredging site when compared to Reference sediment results.

Exhibit 3-14 summarizes mean concentrations in project tissues of *M. mercenaria* including those that statistically significantly exceeded mean concentrations in the Reference. Mean results that statistically significantly exceeded the Reference are shown in bold.

Exhibit 3-15 summarizes mean concentrations in project tissues of *A. virens* including those that statistically significantly exceeded mean concentrations in the Reference. Mean results that statistically significantly exceeded the Reference are shown in bold.

Exhibit 3-14. Analytical Results for *Mercenaria mercenaria* Wet Weight Tissue Compared to the Reference and Screening Benchmarks

Analyte	Mean Concentration	Percent of Reference	CDP-REF (Reference) (Aug. 2022)	Ecological Effects Threshold: Bivalves	Northern Gulf of Mexico Bkgd.: Bivalves
M. mercenaria					
CDP-01					
Arsenic	**1.37**	109%	1.26	12.6	3.4-5.4
Beryllium	**0.00170**	123%	0.00138	x	<0.14
Thallium	**0.00036**	129%	0.00028	0.3	<0.47
Di-n-butyl phthalate	**9.65**	122%	7.58	x	x
CDP-02					
Selenium	**0.250**	160%	0.157	14.2	0.5-1.5
Zinc	***19.6***	140%	13.9	11.8	7.0-30.0
CDP-03					
Lead	***0.131***	142%	0.0922	0.1	<0.47
Selenium	**0.219**	140%	0.157	14.2	0.5-1.5

Results in bold are statistically significantly greater than those of the Reference tissue.

Results that are Italicized and bolded indicate a mean concentration of project tissue that is statistically significantly greater than that of the Reference, and includes one or more replication results greater than the MDL, and also exceed the ecological effects threshold and northern Gulf of Mexico background concentration.

x = No ecological effects threshold published for the given analyte.

Exhibit 3-15. Analytical Results for *Alitta virens* Wet Weight Tissue Compared to the Reference and Screening Benchmarks

Analyte	Mean Concentration	Percent of Reference	CDP-REF (Reference) (Aug. 2022)	Ecological Effects Threshold: Polychaeta	Northern Gulf of Mexico Bkgd.: Polychaeta
A. virens					
CDP-01					
Lead	***0.166***	144%	0.115	0.1	0.31-1.2
Nickel	**0.223**	178%	0.125	2.2	0.53-3.5
Bis(2-ethylyhexyl) phthalate	**15.8**	226%	7.00	x	x
CDP-02					
Lead	***0.169***	147%	0.115	0.1	0.31-1.2
Nickel	**0.246**	196%	0.125	2.2	0.53-3.5
Bis(2-ethylyhexyl) phthalate	**30.3**	433%	7.00	x	x
CDP-03					
Beryllium	**0.00129**	233%	0.00055	x	<0.09
Lead	***0.174***	151%	0.115	0.1	0.31-1.2
Nickel	**0.228**	182%	0.125	2.2	0.53-3.5
TPHs	**1126**	221%	510	x	x
Bis(2-ethylyhexyl) phthalate	**22.1**	315%	7.00	x	x
CDP-04					
TPHs	**956**	188%	510	x	x

Results in bold are statistically significantly greater than those of the Reference tissue.

Results that are Italicized and bolded indicate a mean concentration of project tissue that is statistically significantly greater than that of the Reference, and includes one or more replication results greater than the MDL, and also exceed the ecological effects threshold concentration.

x = No ecological effects threshold published for the given analyte.

Factor 2. Magnitude by which the bioaccumulation in organisms exposed to sediment from the dredging site exceeds bioaccumulation in organisms exposed to the Reference sediment.

Exhibit 3-16 compares mean concentrations of contaminants in *M. mercenaria* project tissues with those of the Reference. Exhibit 3-17 compares mean concentrations of contaminants in *A. virens* project tissues with those of the Reference. Full results with percentages of Reference concentrations are in Tables 13 through 20. Of the analyte mean concentrations in tissues exposed to project sediment that statistically significantly exceeded those of the Reference in *M. mercenaria* project tissues, lead in CDP-03 and zinc in CDP-02 exceeded the applicable EET benchmarks (Exhibits 3-16). Of the analyte mean concentrations in tissues exposed to project sediment that statistically significantly exceeded those of the Reference in *A. virens* project tissues, lead in CDP-01, CDP-02 and CDP-03 exceeded the applicable EET benchmark (Exhibits 3-17).

Exhibit 3-16. *Mercenaria mercenaria* Tissue Mean Concentrations Statistically Significantly Greater Than Those of the Reference, Expressed as a Percent of Screening Benchmarks

Analyte	**Mean Concentration Relative to the EET and to the Northern Gulf of Mexico Background Concentration**	**Ecological Effects Threshold: Bivalves**	**Northern Gulf of Mexico Bkgd.: Bivalves**
	(% of EET || % of background)		
M. mercenaria			
CDP-01			
Arsenic (1.37 mg/kg)	(does not exceed) || (does not exceed)	12.6	3.4-5.4
Beryllium (0.00170 mg/kg)	(not applicable) || (does not exceed)	x	<0.14
Thallium (0.00036 mg/kg)	(does not exceed) || (does not exceed)	0.3	<0.47
Di-n-butyl phthalate (9.65 µg/kg)	(not applicable) || (not applicable)	x	x
CDP-02			
Selenium (0.250 mg/kg)	(does not exceed) || (does not exceed)	14.2	0.5-1.5
Zinc (***19.6*** mg/kg)	(***169%***) || (does not exceed)	11.6	7.0-30.0
CDP-03			
Lead (***0.131*** mg/kg)	(***131***%) || (does not exceed)	0.1	<0.47
Selenium (0.219 mg/kg)	(does not exceed) || (does not exceed)	14.2	0.5-1.5

x = No ecological effects threshold or Northern Gulf of Mexico background published for the given analyte.

Exhibit 3-17. *Alitta virens* Tissue Mean Concentrations Statistically Significantly Greater Than Those of the Reference, Expressed as a Percent of Screening Benchmarks

Analyte	Mean Concentration Relative to the EET and to the Northern Gulf of Mexico Background Concentration (% of EET || % of background)	Ecological Effects Threshold: Polychaeta	Northern Gulf of Mexico Bkgd.: Polychaeta
A. virens			
CDP-01			
Lead (***0.166*** mg/kg)	(***166%***) || (does not exceed)	0.1	0.31-1.2
Nickel (0.223 mg/kg)	(does not exceed) || (does not exceed)	2.2	0.53-3.5
Bis(2-ethylyhexyl) phthalate (15.8 µg/kg)	(not applicable) || (not applicable)	x	x
CDP-02			
Lead (***0.169*** mg/kg)	(***169%***) || (does not exceed)	0.1	0.31-1.2
Nickel (0.246 mg/kg)	(does not exceed) || (does not exceed)	2.2	0.53-3.5
Bis(2-ethylyhexyl) phthalate (30.3 µg/kg)	(not applicable) || (not applicable)	x	x
CDP-03			
Beryllium (0.00129 mg/kg)	(not applicable) || (does not exceed)	x	<0.09
Lead (***0.174*** mg/kg)	(***174%***) || (does not exceed)	0.1	0.31-1.2
Nickel (0.228 mg/kg)	(does not exceed) || (does not exceed)	2.2	0.53-3.5
TPHs (1126 mg/kg)	(not applicable) || (not applicable)	x	x
Bis(2-ethylyhexyl) phthalate 22.1 µg/kg)	(not applicable) || (not applicable)	x	x
CDP-04			
TPHs (956 mg/kg)	(not applicable) || (not applicable)	x	x

x = No ecological effects threshold or Northern Gulf of Mexico background published for the given analyte.

Factor 3. Number of contaminants for which bioaccumulation in organisms exposed to sediment from the dredging site is statistically greater than bioaccumulation in organisms exposed to the Reference sediment.

M. mercenaria tissues from CDP-01, CDP-02 and CDP-03 had mean concentrations of two or three metals each that statistically significantly exceeded those of the Reference. *M. mercenaria* tissues from CDP-01 had mean concentrations of di-n-butyl phthalate that statistically significantly exceeded those of the Reference.

A. virens tissues from CDP-01, CDP-02 and CDP-03 had mean concentrations of two or three metals each that statistically significantly exceeded those of the Reference. *A. virens* tissues from CDP-01, CDP-02 and CDP-03 had mean concentrations of bis(2-ethylhexyl) phthalate that statistically significantly exceeded those of the Reference.

Exhibit 3-18 lists the numbers of project tissue analyte concentrations that statistically significantly exceeded those of the Reference.

Exhibit 3-18. Number of Tissue Analyte Concentrations That Were Statistically Significantly Greater than Reference Concentrations

Sample ID	Number of Mean Concentrations for Analytes That Were Statistically Greater Than Those of the Reference
M. mercenaria	
CDP-01	4 (Arsenic, Beryllium, Thallium, and Di-n-butyl phthalate)
CDP-02	2 (Selenium and Zinc)
CDP-03	2 (Lead and Selenium)
CDP-04	0
CDP-05	0
A. virens	
CDP-01	3 (Lead, Nickel, and Bis(2-ethylhexyl) phthalate)
CDP-02	3 (Lead, Nickel, and Bis(2-ethylhexyl) phthalate)
CDP-03	5 (Beryllium, Lead, Nickel, TPHs, and Bis(2-ethylhexyl) phthalate)
CDP-04	1 (TPHs)
CDP-05	0

Factor 4. Number of species in which bioaccumulation organisms exposed to sediment from the dredging site is statistically greater than bioaccumulation in organisms exposed to the Reference sediment.

M. mercenaria and *A. virens* project tissues from CDP-01, CDP-02 and CDP-03 had mean concentrations of two or three metals each that statistically significantly exceeded that of the Reference. *M. mercenaria* project tissues from CDP-01 had mean concentrations of di-n-butyl phthalate that statistically significantly exceeded those of the Reference. *A. virens* project tissues from CDP-01, CDP-02 and CDP-03 had mean concentrations of bis(2-ethylhexyl) phthalate that statistically significantly exceeded that of the Reference. *A. virens* project tissues from CDP-03 and CDP-04 had mean concentrations of TPHs that statistically significantly exceeded that of the Reference.

Factor 5. Toxicological importance of the contaminants whose bioaccumulation in organisms exposed to sediment from the dredging site statistically exceeds that from the Reference sediment.

A literature search was conducted on February 7, 2023, that included a review of documents by the Agency for Toxic Substances Disease Registry (2002) and EPA (2000) as well as a search of the U.S. Army Engineer Research and Development Center’s (ERDC) Environmental Residue Effects Database (ERED; https://ered.el.erdc.dren.mil/). Results of the data-mining effort are summarized in the following paragraphs. Analyte concentrations in tissues are given as wet weight values.

Arsenic

Arsenic is a widely distributed element that occurs naturally in the marine environment as various chemical forms (Fattorini et al. 2006). These authors found that several marine taxonomic groups, including bivalves, generally bioaccumulate arsenic as complex organic compounds such as arsenobetaine, arsenocholine and arsenoribosides. These forms of arsenic are non-toxic and represent the result of transformation of toxic forms of arsenic to detoxified forms in the tissues of marine organisms. Fattorini et al. (2006) concluded their study of arsenic bioaccumulation in marine organisms by stating that although "*an elevated variability of natural arsenic concentrations can be expected in….*[various taxa including mollusks], *however,* [their study] *confirmed the predominance of organically non-toxic compounds*."

The mean concentration of arsenic in *M. mercenaria* tissue from CDP-01 (1.37 mg/kg) that exceeded concentrations in the Reference sample did not exceed the no observed adverse effect levels (NOAELs) for mortality and growth in mature blue mussels and mortality in mature St. Lawrence pondsnails. The mean concentration of arsenic in *M. mercenaria* tissue that exceeded concentrations in the Reference sample did not exceed the NOAELs for growth in juvenile daggerblade grass shrimp or the mature water flea. A search of over 5,000 toxicity endpoints in ERED produced the results shown in Exhibit 3-19.

Exhibit 3-19. Arsenic Concentrations in Project Tissue Samples Compared to Toxicity Values from Literature Review

Mean Concentrations in Tissue Sample CB-1 That Exceeded a Reference (mg/kg)	Toxicity Measure & Value (mg/kg)	Percent Sample Result Greater Than Toxicity Value	Relevant Species & Reference
NOAEL			
1.37 (*M. mercenaria*)	3.6	(does not exceed)	Mortality in mature *Mytilus edulis* (blue mussel): Spehar et al. (1980) and St. Jean et al. (2003) in ERED
	3.6	(does not exceed)	Growth in mature *Mytilus edulis* (blue mussel): St. Jean et al. (2003) in ERED
	3.6	(does not exceed)	Mortality in mature *Stagnicola emarginatus* (St. Lawrence pondsnail): Spehar et al. (1980) in ERED
	1.15–6.39	(does not exceed)	Growth in juvenile *Palaemonetes pugio* (daggerblade grass shrimp): Lindsey (1990) in ERED
	3.8–9.8	(does not exceed)	Mortality in mature *Daphnia magna* (water flea) Spehar et al. (1980) in ERED

Only population-level effects (growth, reproduction, development, mortality) on bivalves and other mollusks are included. (Biochemical and behavioral effects are excluded since they do not necessarily equate to population-level effects.)

Source: NOAELs as listed above from ERED. See ERED at https://ered.el.erdc.dren.mil/references.cfm for more information on the references listed above.

A comparison to arsenic concentrations measured in tissues of wild marine taxa caught off Jacksonville and Fort Lauderdale, Florida suggests that the arsenic concentrations observed in *M. mercenaria* tissue in the present study are less than the ranges of concentrations found in wild populations of benthic invertebrates (Exhibits 3-20 and 3-21).

Exhibit 3-20. Mean Arsenic Concentrations in Project Tissue Samples Compared to Concentrations in Wild Aquatic Species Caught off Jacksonville, Florida

Mean Concentration in Project Tissue CB-1 That Exceeded a Reference (mg/kg)	Does Mean Concentration in Project Tissue Exceed Concentrations in Wild Taxa?	2010 Concentrations in the Edible Tissues of the Following Species Caught off Jacksonville, Florida	
		Wild Mantis Shrimp (*Gibbesia neglecta*) (mg/kg)	Wild Penaeid Shrimp (mg/kg)
1.37 (*M. mercenaria*)	No (mantis shrimp) No (penaeid shrimp)	12.90–15.70 (composited samples)	1.890–11.00 (*n* = 6 samples)

Source: Concentrations in wild populations from Subsection 4.10 and Tables 58 and 59a through 59c of ANAMAR (2011)

Exhibit 3-21. Mean Arsenic Concentrations in Project Tissue Samples Compared to Concentrations in Wild Aquatic Species Caught off Fort Lauderdale, Florida

Mean Concentration in Project Tissue CB-1 That Exceeded a Reference (mg/kg)	Does Mean Concentration in Project Tissue Exceed Concentrations in Wild Taxa?	2011 Concentrations in the Edible Tissues of the Following Species Caught off Fort Lauderdale, Florida
		Jonah Crab (*Cancer borealis*) (mg/kg)
1.37 (*M. mercenaria*)	No	106–122 (1 composited and 2 individual samples)

Source: Concentrations in wild populations from Subsection 4.8 and Table 31 of ANAMAR (2012)

Beryllium

Beryllium is a naturally occurring metal with several important industrial uses. The available literature on the effects of beryllium on marine life is limited. A study by Dulka and Risby (1976) summarized by Gough et al. (1979) reported a concentration of 0.5 mg/kg body weight as the lethal dose of beryllium to cause mortality in 50% of a population of laboratory mice. The Subcommittee on Nutrient and Toxic Elements in Water (1974) suggested that the effects of beryllium on aquatic life such as goldfish, minnows, and snails was “not very toxic” at a concentration of 28.5 mg/L.

EPA’s (2000) synopsis of contaminants of importance to bioaccumulation in benthic fauna does not address beryllium. A search of the online database ERED found no NOAELs or lowest-observed-adverse-effects levels (LOAELs) reported to produce population-level impacts relevant to *Macoma nasuta* and other marine bivalves. The one endpoint was for a NOAEL for the freshwater bluegill (*Lepomis macrochirus*) with a whole-body burden of 5.13 mg/kg that resulted in mortality in this species (Barrows et al. 1980). The mean concentration in *M. mercenaria* tissue from project sample CDP-01 (0.00170 mg/kg), and the mean concentration in *A. virens* tissue from project sample CDP-03 (0.00129 mg/kg), represents less than 1% of the 5.13 mg/kg that caused mortality in bluegill in the Barrows et al. (1980) study.

Beryllium concentrations in project tissue samples that statistically significantly exceeded those of the Reference compared to concentrations in wild aquatic species caught off Jacksonville, Florida are presented in Exhibit 3-22.

Exhibit 3-22. Beryllium Concentrations in Project Tissue Samples That Statistically Significantly Exceeded Those of the Reference Compared to Concentrations in Wild Aquatic Species Caught off Jacksonville, Florida

Mean Concentrations in Project Tissue Samples That Exceeded Those of the Reference (mg/kg)	Does Mean Concentration in Project Tissue Exceed Concentrations in Wild Taxa?	2010 Concentrations in the Edible Tissues of the Following Species Caught off Jacksonville, Florida	
		Wild Mantis Shrimp (*Gibbesia neglecta*) (mg/kg)	Wild Penaeid Shrimp (mg/kg)
0.00170 (*M. mercenaria*) & 000129 (*A. virens*)	Yes (wild mantis shrimp and penaeid shrimp)	<0.0007 to <0.0008 (composited samples)	<0.0009 (*n* = 6 samples)

Sources: Table 14; concentrations in wild species from Subsection 4.10 and Tables 58 and 59a through 59c of ANAMAR (2011).

Lead

Lead is a poisonous contaminant with substantial research available on its effects on aquatic species. Endpoint values for eastern oyster (*Crassostrea virginica*) and zebra mussel (*Dreissena polymorpha*) were found in the literature and are relevant for comparison to lead concentrations in *M. nasuta* and *A. virens* tissue. The mean concentration of lead in *M. mercenaria* tissue sample CDP-03 (0.131 mg/kg) and *A. virens* tissue samples CDP-01 (0.166 mg/kg), CDP-02 (0.169 mg/kg) and CDP-03 (0.174 mg/kg) are below the relevant NOAELs and LOAELs obtained from the literature (see Exhibit 3-23).

Exhibit 3-23. Lead Concentrations in Project Tissue That Statistically Significantly Exceeded Those of the Reference Compared to Toxicity Values from Literature Review

Mean Concentrations in Project Tissue Samples that Exceeded Those of the Reference (mg/kg)	Toxicity Measure & Value (mg/kg)	Percent Sample Result Greater Than Toxicity Value	Relevant Species & Reference
NOAEL			
0.131 (*M. mercenaria*) & 0.166, 0.169, & 0.174 (*A. virens*)	2.28	(does not exceed)	Growth and mortality in *Crassostrea virginica* (Eastern Oyster) Zaroogian et al 1979 in ERED
	2.6	(does not exceed)	Reproduction in *Crassostrea virginica* (Eastern Oyster) Zaroogian et al 1979 in ERED
	34	(does not exceed)	Mortality in *Dreissena polymorpha* (Zebra Mussel) Kraak 1994 in ERED
	35	(does not exceed)	Growth in *Dreissena polymorpha* (Zebra Mussel) Kraak 1994 in ERED

Exhibit 3-24 (continued)

Mean Concentrations in Project Tissue Samples that Exceeded Those of the Reference (mg/kg)	Toxicity Measure & Value (mg/kg)	Percent Sample Result Greater Than Toxicity Value	Relevant Species & Reference
LOAEL			
0.131 (*M. mercenaria*) & 0.166, 0.169, & 0.174 (*A. virens*)	200	(does not exceed)	Mortality in *Dreissena polymorpha* (Zebra Mussel) Kraak 1994 in ERED

Only population-level effects (growth, reproduction, mortality) on marine or estuarine invertebrates are included. (Biochemical and behavioral effects are excluded since they do not necessarily equate to population-level effects.)

Sources: Table 14 and as listed above from ERED

The mean concentrations of lead in *M. mercenaria* sample CDP-03 and *A. virens* tissue samples CDP-01, CDP-02 and CDP-03 that exceeded those of the Reference were greater than the concentrations of lead found in wild populations of mantis shrimp (*Gibbesia neglecta*) and in penaeid shrimp caught off Jacksonville, Florida in 2010 by ANAMAR (2011) (Exhibit 3-24). The mean concentrations of lead in *M. mercenaria* and *A. virens* tissue samples also exceeded the concentrations of lead found in wild Jonah crab (*Cancer borealis*) caught off Fort Lauderdale, Florida in 2011 by ANAMAR (2012) (Exhibit 3-25). However, the mean concentrations of lead in *M. mercenaria* sample CDP-03 and in *A. virens* tissue samples CDP-01, CDP-02 and CDP-03 were lower than the concentrations of lead found in wild northern quahog (*Mercenaria mercenaria*) sampled from the Indian River Lagoon and analyzed by Trefry and Trocine (2011) (Exhibit 3-26).

Exhibit 3-25. Lead Concentrations in Project Tissue Samples That Statistically Significantly Exceeded Those of the Reference Compared to Concentrations in Wild Aquatic Species Caught off Jacksonville, Florida

Mean Concentrations in Project Tissue Samples That Exceeded Those of the Reference (mg/kg)	Does Mean Concentration in Project Tissue Exceed Concentrations in Wild Taxa?	2010 Concentrations in the Edible Tissues of Following Species Caught off Jacksonville, Florida	
		Wild Mantis Shrimp (*Gibbesia neglecta*) (mg/kg)	**Wild Penaeid Shrimp (mg/kg)**
0.131 (*M. mercenaria*) & 0.166, 0.169, & 0.174 (*A. virens*)	Yes (mantis shrimp and penaeid shrimp)	0.009–0.009 (*n* = 2 composited samples)	0.009–0.056 (*n* = 6 samples)

Sources: Tables 13 and 14; concentrations in wild species from Subsection 4.10 and Tables 58 and 59a through 59c of ANAMAR (2011).

Exhibit 3-26. Lead Concentrations in Project Tissue Samples That Statistically Significantly Exceeded Those of the Reference Compared to Concentrations in Wild Aquatic Species Caught off Fort Lauderdale, Florida

Mean Concentrations in Project Tissue Samples that Exceeded Those of the Reference (mg/kg)	Does Mean Concentrations in Project Tissue Exceed Concentrations in Wild Taxa?	2011 Concentrations in Edible Tissues of Wild Jonah Crab (*Cancer borealis*) Caught off Fort Lauderdale, Florida (mg/kg)
0.131 (*M. mercenaria*) & 0.166, 0.169, & 0.174 (*A. virens*)	Yes	0.0223–0.0257 (*n* = 3 composited samples)

Sources: Tables 13 and 14; concentrations in wild species from Subsection 4.10 and Tables 58 and 59a through 59c of ANAMAR (2011)

Exhibit 3-27. Lead Concentrations in Project Tissue Samples That Statistically Significantly Exceeded Those of the Reference Compared to Concentrations in Wild Northern Quahog from Indian River Lagoon, Florida

Mean Concentrations in Project Tissue Samples that Exceeded Those of the Reference (mg/kg)	Does Mean Concentration in Project Tissue Exceed Concentrations in Wild Clams?	2006–2007 Concentrations in Wild Northern Quahog (*Mercenaria mercenaria*) (mg/kg)	1992 Concentrations in Wild Northern Quahog (*Mercenaria mercenaria*) (mg/kg)
0.131 (*M. mercenaria*) & 0.166, 0.169, & 0.174 (*A. virens*)	No	33 ± 16 (mean ± SD) 10–70 (range) (*n* = 22)	8 ± 11 (mean ± SD) 1–42 (range) (*n* = 22)

SD = standard deviation

Sources: Tables 13 and 14; Concentrations in wild clams from Trefry and Trocine (2011)

Nickel

Nickel in the marine environment can partition to dissolved and particulate organic carbon. The bioavailability of nickel can also be influenced by the presence of calcium and magnesium (EPA 2000). The bioavailability of nickel in sediments is controlled by the concentration of acid-volatile sulfides. Bioaccumulation of nickel occurs to greatest extent in sediments when the ratio of simultaneously extracted metals to acid-volatile sulfide is greater than 1 (EPA 2000).

The common cockle (*Cerastoderma edule*) is the only marine invertebrate species having NOAEL or LOAEL endpoint values that could be found in the literature. The mean concentration of nickel in *A. virens* tissue samples CDP-01 (0.223 mg/kg), CDP-02 (0.246 mg/kg) and CDP-03 (0.228 mg/kg) were below the available NOAELs and LOAELs for bivalves obtained from the literature (see Exhibit 3-27).

Exhibit 3-28. Nickel Concentration in Project Tissue That Statistically Significantly Exceeded That of the Reference Compared to Toxicity Values from Literature Review

Mean Concentration in Project Tissue Sample that Exceeded That of the Reference (mg/kg)	Toxicity Measure & Value (mg/kg)	Percent Sample Result Greater Than Toxicity Value	Relevant Species & Reference
NOAEL			
0.223, 0.246, and 0.228(*A. virens*)	79	(does not exceed)	Mortality in mature *Cerastoderma edule* (common cockle) Wilson (1983) in ERED
	575	(does not exceed)	Growth in mature *Cerastoderma edule* (common cockle) Wilson (1983) in ERED
LOAEL			
0.223, 0.246, and 0.228 (*A. virens*)	575	(does not exceed)	Mortality in mature *Cerastoderma edule* (common cockle) Wilson (1983) in ERED

Only population-level effects (growth, reproduction, mortality) on marine or estuarine invertebrates are included. (Biochemical and behavioral effects are excluded since they do not necessarily equate to population-level effects.)

Sources: Table 14 and as listed above from ERED

The mean concentration of nickel in *A. virens* tissue samples CDP-01, CDP-02 and CDP-03 that exceeded that of the Reference was greater than the concentrations of nickel found in wild populations of mantis shrimp (*Gibbesia neglecta*) and in wild penaeid shrimp caught off Jacksonville, Florida in 2010 by ANAMAR (2011) (Exhibit 3-28). The mean concentration of nickel in *A. virens* tissue samples CDP-01, CDP-02 and CDP-03 also exceeded the concentrations of nickel found in wild Jonah crab (*Cancer borealis*) caught off Fort Lauderdale, Florida in 2011 by ANAMAR (2012) (Exhibit 3-29). However, the mean concentration of nickel in *A. virens* tissue samples CDP-01, CDP-02 and CDP-03 were lower than the concentrations of nickel found in wild northern quahog (*Mercenaria mercenaria*) sampled from the Indian River Lagoon and analyzed by Trefry and Trocine (2011) (Exhibit 3-30).

Exhibit 3-29. Nickel Concentration in Project Tissue Sample That Statistically Significantly Exceeded That of the Reference Compared to Concentrations in Wild Aquatic Species Caught off Jacksonville, Florida

Mean Concentration in Project Tissue Sample that Exceeded That of the Reference (mg/kg)	Does Mean Concentration in Project Tissue Exceed Concentrations in Wild Taxa?	2010 Concentrations in the Edible Tissues of Following Species Caught off Jacksonville, Florida	
		Wild Mantis Shrimp (*Gibbesia neglecta*) (mg/kg)	Wild Penaeid Shrimp (mg/kg)
0.223, 0.246, and 0.228, (*A. virens*)	Yes (mantis shrimp and penaeid shrimp)	0.132–0.186 (*n* = 2 composited samples)	0.070–0.150 (*n* = 6 samples)

Sources: Table 14; concentrations in wild species from Subsection 4.10 and Tables 58 and 59a through 59c of ANAMAR (2011).

Exhibit 3-29. Nickel Concentration in Project Tissue Sample That Statistically Significantly Exceeded That of the Reference Compared to Concentrations in Wild Aquatic Species Caught off Fort Lauderdale, Florida

Mean Concentration in Project Tissue Sample that Exceeded That of the Reference (mg/kg)	Does Mean Concentrations in Project Tissue Exceed Concentrations in Wild Taxa?	2011 Concentrations in Edible Tissues of Wild Jonah Crab (*Cancer borealis*) Caught off Fort Lauderdale, Florida (mg/kg)
0.223, 0.246, and 0.228 (*A. virens*)	Yes	0.140–0.188 (*n* = 3 composited samples)

Sources: Table 14; concentrations in wild species from Subsection 4.10 and Tables 58 and 59a through 59c of ANAMAR (2011)

Exhibit 3-30. Nickel Concentration in Project Tissue Sample That Statistically Significantly Exceeded That of the Reference Compared to Concentrations in Wild Northern Quahog from Indian River Lagoon, Florida

Mean Concentration in Project Tissue Sample that Exceeded That of the Reference (mg/kg)	Does Mean Concentration in Project Tissue Exceed Concentrations in Wild Clams?	2006–2007 Concentrations in Wild Northern Quahog (*Mercenaria mercenaria*) (mg/kg)	1992 Concentrations in Wild Northern Quahog (*Mercenaria mercenaria*) (mg/kg)
0.223, 0.246, and 0.228 (*A. virens*)	No	15 ± 6 (mean ± SD) 4–25 (range) (*n* = 22)	6 ± 5 (mean ± SD) 1–52 (range) (*n* = 22)

SD = standard deviation

Sources: Table 14; Concentrations in wild clams from Trefry and Trocine (2011)

Selenium

Selenium is a naturally occurring metal in the marine environment and plays an essential role as a trace element in a variety of enzymatic and non-enzymatic biochemical processes in marine organisms (Prince et al. 2007). Selenium also plays a role in making arsenic and mercury biologically unavailable for more toxic interactions in marine organisms (Prince et al. 2007, Yang et al. 2008, Raymond and Ralston 2009). The available literature on the effects of selenium on marine life is limited. A search of the ERED database revealed that none of the over 5,000 individual aquatic fauna endpoints were for selenium toxicity in bivalves or other marine invertebrates (there are several NOAELs applicable for various sea turtles only). A comparison to selenium concentrations measured in tissues of wild northern quahog (*Mercenaria mercenaria*) collected from Indian River Lagoon, Florida during the early 1990s and the mid-2000s suggests that the selenium concentrations observed in *N. virens* tissue in the present study are within the range of concentrations found in wild populations of marine bivalves (Exhibit 3-31). The selenium concentration in *A. virens* tissue exposed to project sediments CDP-02 (0.250 mg/kg) and CDP-03 (0.219 mg/kg) were also less than the concentrations of selenium analyzed from tissues of wild mantis shrimp (*Gibbesia neglecta*) and wild penaeid shrimp caught off Jacksonville, Florida in 2010 by ANAMAR (2011) (Exhibit 3-32).

Exhibit 3-31. Selenium Mean Concentration in Project Tissue That Statistically Significantly Exceeded That of the Reference Compared to Concentrations in Wild *Mercenaria mercenaria* (Northern Quahog) from Indian River Lagoon, Florida

Mean Concentration in Project Tissue Sample that Exceeded the Reference (mg/kg)	Concentrations in Project Tissue Exceed Concentrations in Wild Clams?	2006–2007 Concentrations in Wild Clams (mg/kg)	1992 Concentrations in Wild Clams (mg/kg)
0.250 and 0.219 (*N. virens*)	No	0.96 ± 0.41 (mean ± SD) 0.10–1.9 (range) (*n* = 22)	0.75 ± 0.44 (mean ± SD) 0.04–1.5 (range) (*n* = 22)

Sources: Table 13; concentrations in wild clams from Trefry and Trocine (2011)

Exhibit 3-32. Mean Selenium Concentrations in Project Tissue Samples Compared to Concentrations in Wild Aquatic Species Caught off Jacksonville, Florida

Mean Concentration in Project Tissue That Exceeded the Reference (mg/kg)	Does Mean Concentration in Project Tissue Exceed Concentrations in Wild Taxa?	2010 Concentrations in the Edible Tissues of Species Caught off Jacksonville, Florida	
		Wild Mantis Shrimp (*Gibbesia neglecta*) (mg/kg)	Wild Penaeid Shrimp (mg/kg)
0.250 and 0.219 (*N. virens*)	No (mantis shrimp) No (penaeid shrimp)	0.410–0.494 (composited samples)	0.387–1.070 (*n* = 6 samples)

Source: Concentrations in wild populations from Subsection 4.10 and Tables 58 and 59a through 59c of ANAMAR (2011)

Thallium

Thallium is a naturally occurring metal with several important industrial uses. The available literature on the effects of thallium on marine life is limited. A search of the ERED database revealed that none of the over 5,000 individual aquatic fauna endpoints were for thallium toxicity in bivalves or other marine invertebrates. There are several NOAELs and LOAELs applicable for population-level effects in fishes and crustaceans in the ERED database, ranging in tissue concentrations from 12.06 for a LOAEL for reproduction in a freshwater amphipod to 82.78 for a LOAEL for mortality in a freshwater amphipod. *Element Concentrations Toxic to Plants, Animals, and Man* (Gough et al. 1979 [https://pubs.usgs.gov/bul/1466/report.pdf]) suggests that the limit for animals is 0.003 mg/kg body weight. The mean concentration for thallium in CDP-01 was 0.00036 mg/kg which is 12% of the body weight limit for animals.

Zinc

The mobility of zinc is limited in most aquatic habitats. Tissue residue-toxicity relationships can also be variable because organisms sequester metals in different forms that are measurable as tissue residue but that can instead be stored in unavailable forms within the organism, possibly as a form of detoxification. Whole-body residues also might not be indicative of effects concentrations at the organ level because concentrations in target organs, such as the kidneys and liver, can be 20 times greater than whole-body residues (EPA 2000). After evaluating the effects of sample preparation techniques on measured concentrations of metals in the edible tissue of fish, Schmitt and Finger (1987) concluded that there was little direct value in measuring zinc (or copper, iron or manganese) tissue residues in fish because they do not bioaccumulate to any appreciable extent. It has also been suggested that there is no compelling evidence to support any significant concern about zinc as a putative toxin in the environment. Further, there is considerable evidence that zinc deficiency is a serious, worldwide human health problem that outweighs the potential problems associated with accidental, self-imposed or environmental exposure to excess zinc (EPA 2000).

The only sample value to significantly exceed the levels found in the Reference sample for *M. mercenaria* tissue from CDP-02 (19.6 mg/kg) was less than the 12 NOAELs and LOAELs reported to produce population-level impacts in bivalves, with one exception (Exhibit 3-33). Mortality in the bivalve *Mysella anomala* was reported to begin above 5 mg/kg of zinc. The *M. mercenaria* tissue sample for CDP-02 that exceeded the Reference had a concentration 392% greater than the NOAEL for *Mysella anomala* (Exhibit 3-33). The mean concentration of zinc found in the Reference (13.9 mg/kg) and the Pre-exposure tests (14.9 mg/kg) also exceeded the NOAEL for *Mysella anomala*, amounting to 278% and 298%, respectively, of this endpoint value. A search of over 5,100 toxicity endpoints in ERED produced the results shown in Exhibit 3-33 below.

Exhibit 3-33. Zinc Concentrations in Project Tissues That Statistically Significantly Exceeded Those of the Reference Compared to Toxicity Values from Literature Review

Mean Concentrations in Project Tissue Samples that Exceeded the Reference (mg/kg)	Toxicity Measure & Value (mg/kg)	Percent Sample Result Greater than Toxicity Value	Relevant Species & Reference
NOAEL			
19.6 (*M. mercenaria*)	5	392%	Mortality in adult *Mysella anomala* (a bivalve) King et al. (2004) in ERED
	26	(does not exceed)	Mortality in *Mytilus edulis* (blue mussel) St Jean et al. (2003) in ERED
	26	(does not exceed)	Growth in *Mytilus edulis* (blue mussel) St Jean et al. (2003) in ERED
	55.8	(does not exceed)	Survival in *Mytilus edulis* (blue mussel) Kaitala (1988) in ERED
	120	(does not exceed)	Mortality in *Dreissena polymorpha* (zebra mussel) Kraak et al. (1994) in ERED
	160	(does not exceed)	Lesions in *Scrobicularia plana* (peppery furrow shell) Riba et al. (2005) in ERED
	621	(does not exceed)	Growth in *Dreissena polymorpha* (zebra mussel) Kraak et al. (1994) in ERED
	1720.6	(does not exceed)	Lesions in *Crassostrea angulata* (Portuguese oyster) Riba et al. (2005) in ERED
LOAEL			
19.6 (*M. mercenaria*)	25	(does not exceed)	Growth in *Mytilus edulis* (blue mussel) Grout and Levings (2001) in ERED
	26	(does not exceed)	Mortality in *Mytilus edulis* (blue mussel) Grout and Levings (2001) in ERED
	26	(does not exceed)	Development in *Mytilus edulis* (blue mussel) Grout and Levings (2001) in ERED
	621	(does not exceed)	Mortality in *Dreissena polymorpha* (zebra mussel) Kraak et al. (1994) in ERED

Only population-level effects (growth, reproduction, mortality) are included. (Biochemical and behavioral effects are excluded since they do not necessarily equate to population-level effects.)

Sources: Table 14 and as listed above from ERED

Bis(2-ethylhexyl) phthalate

Bis(2-ethylhexyl) phthalate is the primary synonym for substance Di(2-ethylhexyl) phthalate and commonly referred to as DEHP. DEHP is not found naturally in the environment and was widely used as a plasticizer to help make polyvinyl chloride products soft and flexible (CPSC 2010a). DEHP enters the environment predominantly through disposal of wastes into landfills. To a much lesser extent, it is volatized into air (from industrial and end uses of DEHP), carried in wastewater from industrial sources, and in effluent from municipal wastewater treatment plants (Bauer and Herrmann 1997; Clara et al. 2010; EPA 1981). It tends to absorb strongly to soils and sediments and to bioconcentrate in aquatic organisms (Staples et al. 1997; Wolfe et al. 1980); however, potential for DEHP to biomagnify in the food chain is expected to be minimized by metabolism (EPA 1979; Johnson et al. 1977; Mackintosh et al. 2004; Staples et al. 1997; Wofford et al. 1981). Biodegradation can occur under aerobic conditions (Sugatt et al. 1984). Sorption, bioaccumulation, and biodegradation are likely to be competing processes, with the dominant fate determined by local environmental conditions. The available data on toxicity effects are limited to rodents, primates and human exposure and do not include population-level effects on marine life.

Bioconcentration of DEHP has been observed in invertebrates, fish and terrestrial organisms. Mean bioconcentration factors have been reported for algae (3,173±3,149, two species), mollusks (1,469±949, five species), crustacea (1,164±1,182, four species), insects (1,058±772, three species), polychaetes (422, one species), fish (280±230, five species), and amphibians (605, one species) have been compiled by Staples et al. (1997). Residues of DEHP have been found in the organs of terrestrial animals such as rats, rabbits, dogs, cows, and humans (EPA 1979). Uptake of DEHP from soil by plants has also been reported (EPA 1986; O'Connor 1996). There is no biomagnification factor given by the EPA or applicable to DEHP.

Di-n-butyl Phthalate

Di-n-butyl phthalate is an oily liquid that is odorless and can be clear to faintly yellow. This manmade compound is added to hard plastics to make them soft, especially in polyvinyl chloride plastics and nitrocellulose lacquers (ATSDR 2001). Di-n-butyl phthalate enters the air or sticks to dust particles from new carpets, drying paints and nail polish. When the compound enters surface waters or soils, it tends to get broken down by bacteria and this process may take up to a month to complete, depending on temperature and other factors. Di-n-butyl phthalate appears to have a relatively low toxicity. Large amounts are needed to cause injury (ATSDR 2001).

A search of the online database ERED found di-n-butyl phthalate endpoint data only for crustaceans. A whole-body concentration of 0.5 mg/kg caused mortality in juvenile daggernose grass shrimp (*Palaemonetes pugio*) in a study by Laughlin et al. (1978). The mean concentration of di-n-butyl phthalate in *M. mercenaria* tissue sample from CDP-01 (9.65 ug/kg [= 0.00965 mg/kg]) is a fraction of the tissue concentration that caused negative effects in the grass shrimp as discussed above.

Di-n-butyl phthalates and other butyl phthalates are used as a plasticizer in industry, a solvent for organic compounds, an antifoaming agent, a textile fiber lubricant, a fixative for fragrances, and an insect repellent (ATSDR 2001). Di-n-butyl phthalate has been reported to biologically degrade in fresh and marine water, with 50% to 100% degradation within 28 days in aerobic conditions and over 90% degradation within 30 days in anaerobic freshwater conditions (ATSDR 2001).

Data indicate that di-n-butyl phthalate can partition from food and water into a variety of organisms (ATSDR 2001). Studies using radioactively labeled di-n-butyl phthalate have shown accumulation of radioactivity in aquatic invertebrates and fishes. Numerous experiments have shown that the accumulation of di-n-butyl phthalate in the aquatic and terrestrial food chain is limited by biotransformation (i.e., transformation of chemical compounds within a living system), which progressively increases with trophic level (Staples et al. 1997, ATSDR 2001). In general, bioconcentration factors decrease for organisms that possess more advanced metabolic systems. Examples of mean bioconcentration factors (mg/g wet weight) include 3,399 for algae, 662 (±229 SD) for crustaceans, 624 (±144 SD) for insects, and 167 for fishes (Staples et al. 1997, ATSDR 2001).

Relevant NOAELs or LOAELs could not be found for comparison to the mean concentration of di-n-butyl phthalate in *M. mercenaria* tissue.

TPHs

Factors that determine health effects from exposure to TPHs involve the form of compounds in the TPH, the duration of exposure (acute versus chronic) and the number of chemical substances in contact with the organism (Farrington 2014). In severe cases, TPHs can coat the body of an organism, causing suffocation. Other types of damage to organisms involve cancerous tumors. The presence of smaller compounds within TPHs, such as benzene, toluene and xylene, can affect the central nervous system (Farrington 2014). Exposure to TPHs can lead to decreased resistance in a marine organism's ability to deal with other environmental stressors, such as variations in temperature or water quality. This has been well documented in corals that have been found to be damaged or have died following petroleum hydrocarbon exposure (Farrington 2014).

Mean concentrations for TPHs in *A. virens* tissue samples CDP-03 (1,126 mg/kg) and CDP-04 (956 mg/kg) statistically significantly exceeded that of the Reference (510 mg/kg). Relevant NOAELs or LOAELs could not be found for comparison to the mean concentration of TPHs in *M. mercenaria* and *A. virens* tissues.

Factor 6. Phylogenetic diversity of the species in which bioaccumulation in organisms exposed to sediment from the dredging site statistically exceeds bioaccumulation in organisms exposed to the Reference sediment.

This factor addresses and discusses the phylogenetic diversity of the species in which bioaccumulation from the dredged material statistically exceeds bioaccumulation from the Reference material.

The species tested, *M. mercenaria* and *A. virens*, are recommended in Section 12 of the Green Book and labeled as "examples of appropriate test species for determining potential bioaccumulation from whole sediment tests." The basic recommendations require that a deposit-feeding bivalve mollusk and a burrowing polychaete worm be tested. *A. virens* is an ecologically important infaunal member of the western North Atlantic region, provides adequate biomass for tissue analysis, and is a detritivore. *M. mercenaria* inhabits the western North and Central Atlantic including the Gulf of Mexico (Abbott 1968, Turgeon et al. 2009) and therefore represents a native species in and around the project area. Although *M. mercenaria* and other members of the genus feed using a siphon (as with most bivalves), it is possible that the proximity of the incurrent siphon to the sediment surface allows some fine particulates and contaminants associated with sediment to be ingested. Regardless, the use of *M. mercenaria* for bioaccumulation testing conforms to recommendations in the Green Book regarding the use of a deposit-feeder.

Factor 7. Propensity for the contaminants with statistically significant bioaccumulation to biomagnify within aquatic food webs.

Biomagnification, the ability of a compound to accumulate in upper-level consumers, is dependent on the propensity of a given compound to biomagnify in lower-level organisms. Compounds in project tissues having mean values less than or equal to two times the Reference values have a low magnitude of difference in bioaccumulation levels, which suggests that the toxicological relevance of the measured statistically significant difference is negligible and may not warrant further examination of the ecological significance (Lotufo et al. 2011). Analyte concentrations in project tissue samples that exceeded those of the Reference by more than a factor of two are evaluated against the ecological effects thresholds, which are regionally specific thresholds formulated to evaluate potential bioaccumulation-related adverse effects of sediments proposed for ocean disposal. The thresholds are concentrations of given compounds in tissues that are not expected to have unacceptable effects in marine organisms (EPA and USACE 2008).

Mean concentrations of arsenic, beryllium, lead, selenium, thallium, zinc, and di-n-butyl phthalate in *M. mercenaria* tissue from project samples listed below were detected at levels that were statistically significantly greater than the Reference mean value.

- Arsenic, beryllium, thallium, and di-n-butyl phthalate in project sample CDP-01
- Selenium and zinc in project sample CDP-02
- Lead and selenium in project sample CDP-03

Mean concentrations of beryllium, lead, nickel, TPH, and Bis(2-ethylhexyl) phthalate in *A. virens* tissue from project samples listed below were detected at levels that were statistically significantly greater than the Reference mean value.

- Beryllium in project sample CDP-03
- Lead and nickel in project samples CDP-01, CDP-02, and CDP-03
- TPH in project samples CDP-03 and CDP-04
- Bis(2-ethylhexyl) phthalate in project samples CDP-01, CDP-02, and CDP-03

The analyte concentrations in project tissues did not exceed the applicable ecological effects threshold or the northern Gulf of Mexico background concentration except for the following:

- Lead in *M. mercenaria* tissue in project sample CDP-03
- Lead in *A. virens* tissue in project samples CDP-01, CDP-02, and CDP-03
- Zinc in *M. mercenaria* tissue in project sample CDP-02

Arsenic, Beryllium, Lead, Nickel, Thallium, and Zinc

Arsenic, beryllium, lead, nickel, thallium, and zinc were given a biomagnification risk factor of 1 by Battelle (2005) for use in bioaccumulation risk assessment modeling for EPA Region 1 projects and has since been adopted by EPA Region 4 (ANAMAR 2015). This risk factor may also be applicable to this EPA Region 6 project as no region-specific alternative risk factor could be found during a literature search.

Selenium

The results of studies by Hermanutz et al. (1992) and Coyle et al. (1993) were evaluated by EPA (2000), and it was concluded that selenium can biomagnify within aquatic ecosystems (EPA

2000). However, selenium was not given a biomagnification risk factor by EPA Region 4 for use in bioaccumulation risk assessment modeling (Battelle 2005, ANAMAR 2015). It is possible that selenium has similar biomagnification risk as other metals. If this is the case, then the biomagnification risk factor of 1 may be appropriate here as this value was given by EPA Region 4 for 11 other metal analytes (Battelle 2005, ANAMAR 2015).

Di-n-butyl phthalate

Available data indicate that di-n-butyl phthalate tends to be taken up and metabolized by invertebrates and fishes. Numerous studies have shown that the accumulation of di-n-butyl phthalate in the aquatic and terrestrial food chain is limited by biotransformation, which progressively increases with trophic level (Staples et al. 1997). Therefore, di-n-butyl phthalate will not biomagnify through the food chain (ATSDR 2001).

Di-n-butyl phthalate was not given a biomagnification risk factor by EPA Region 1 for use in bioaccumulation risk assessment modeling (Battelle 2005, ANAMAR 2015). There is not a published biomagnification risk factor for this compound applicable to EPA Region 6.

Bis(2-ethylhexyl) phthalate

No biomagnification risk could be found for this analyte.

TPHs

No biomagnification risk could be found for this analyte.

Factor 8. Magnitude of toxicity and number and phylogenetic diversity of species exhibiting greater mortality in the sediment from the dredging site than in the Reference sediment.

Significant toxicity was not observed in the bioaccumulation tests performed on the PCCA CDP sediments.

The mean percent survival in the 100% elutriate concentration of the 96-hour water column bioassays with *A. bahia* ranged from 96% to 98% among the project elutriates, was 96% in the Reference and was not significantly different from that of the control (96% to 100%). The estimated LC_{50} was >100% for all project samples.

The mean percent survival in the 100% elutriate concentration of the 96-hour water column bioassays with *M. beryllina* ranged from 92% to 98% among the project elutriates CDP-01 through CDP-05, was 98% in the Reference and was not significantly different from that of the control (94% to 100%). The estimated LC_{50} values were >100% for all project samples.

The mean percent survival in the 100% elutriate concentration of the 48-hour water column bioassays with planktonic *A. bahia* ranged from 94% to 98% among the project elutriates, was 94% in the Reference and was not significantly different from that of the control (96% to 100%). The estimated LC_{50} values were >100% for all project samples.

Mean survival in the 10-day solid phase test for project sediments using *L. plumulosus* ranged from 85% to 94% and was not statistically different from that of the Reference (93%). Mean survival across all project samples was either greater than the Reference or less than 20% below the Reference, indicating that all samples met the LPC for benthic toxicity as defined in the RIA.

Mean survival in the 10-day solid phase test for project sediments using *A. bahia* ranged from 87% to 98% and was 99% in the Reference. The project samples did not result in mean survival that was greater than 10% different from that of the Reference, indicating that all samples met the LPC for benthic toxicity as defined in the RIA except for CDP-03 which has a percent difference from the Reference of 12.12%. Based on the re-sample test conducted at CDP-03 in February 2023, mean survival in the 10-day solid phase test for project sediment CDP-03 Re-Sample was 96% and was 90% in the Reference. Mean survival in CDP-03 Re-Sample was less than 10% different from that of the Reference, indicating this sample met the LPC for benthic toxicity as defined in the RIA. Based on the re-sample test results none of the project samples resulted in mean survival that was significantly different or greater than 10% different from that of the reference, indicating that the rest of the samples met the LPC for benthic toxicity as defined in the RIA.

Mean survival in the 28-day bioaccumulation test for project sediment samples ranged from 70% to 87% in *M. mercenaria* and from 67% to 81% for *A. virens*.

Summary

The bioaccumulation potentials of contaminants were evaluated through 28-day whole sediment exposure testing using *M. mercenaria* and *A. virens* followed by chemical analysis of the tissues. Sample results did not exceed any applicable FDA action level in FDA (2001, 2020). Mean concentrations of analytes in project tissue samples found to be statistically significantly greater than those of the Reference (August 2022) were further evaluated. Project samples having all replicate results below the MDL (U-qualified) did not require assessment and were not compared against the Reference or screening criteria.

Contaminant mean concentrations in *M. mercenaria* tissues in project samples CDP-01, CDP-02 and CDP-03 that were statistically significantly greater than those of the Reference did not exceed any applicable screening benchmarks with the exception of lead in CDP-03 and zinc in CDP-02. Each mean concentration exceeded the applicable EET. Nonetheless, such contaminant mean concentrations were further compared to toxicity endpoint values relevant to populations if appropriate endpoint values were available. NOAEL and LOAEL endpoint data that were found to be relevant to comparisons with the tissue concentrations in the test species, *M. mercenaria*, were greater than the mean concentrations in the project samples in all instances except for zinc in CDP-02 (19.6 mg/kg) as compared to the NOAEL of 5 mg/kg in *Mysella anomala*.

Contaminant mean concentrations in *A. virens* tissues in project samples CDP-01, CDP-02, CDP-03, and CDP-04 that were statistically significantly greater than those of the Reference did not exceed any applicable screening benchmarks with the exception of lead in CDP-01, CDP-02 and CDP-03, which exceeded the EET. Nonetheless, such contaminant mean concentrations were further compared to toxicity endpoint values relevant to populations, if appropriate endpoint values were available. NOAEL and LOAEL endpoint data that were found to be relevant to comparisons with the tissue concentrations in the test species, *A. virens*, were greater than the mean concentrations in the project samples in all instances.

A final step in the evaluative process goes beyond assessing the individual test results to look at the complete set of results to provide an opportunity for an integrated assessment of the contaminants.

Although some of the contaminants that bioaccumulated in the tests are toxicologically important, in no case did they accumulate to toxicologically important concentrations. The materials tested met the minimum acceptable levels for bioaccumulation criteria. Thus, considering the factors in the Green Book, an evaluation of the solid phase bioaccumulation test results for the dredge material taken as a whole would not indicate a different outcome from that shown by the individual test results, i.e., the material does not have the potential for significant undesirable effects due to bioaccumulation.

Accounting for all the above information, it is determined that there is no potential for significant undesirable effects due to bioaccumulation as a result of the presence of individual chemicals or of the solid phase of the dredged material as a whole. Therefore, it is concluded that the solid phase of the material from the outer channel proposed for disposal meets the ocean disposal requirements of 40 CFR §227.6(c)(3) and §227.27(b), and the LPC for bioaccumulation is met in accordance with RIA Subsection 10.2.3.

4 ADDAMS MODEL

Elutriate chemistry results and SPP tests are used to determine if Short-Term Fate [of Dredged Material Disposal in Open-Water Models] (STFATE) modeling is required.

Based on the elutriate chemistry results, the analytes tested (metals, pesticides, or ammonia) did not exceed the corresponding CMC; therefore, Tier II STFATE modeling was not required for the project samples.

Based on the toxicology results, the tested species for suspended particulate phase analysis did not statistically significantly exceed the control; therefore, Tier III STFATE modeling was not required for the project samples.

Since neither Tier II nor Tier III STFATE modeling is required, the dredge material from DMMU's CDP-01 through CDP-05 may be disposed in the Corpus Christi New Work ODMDS without restriction with respect to disposal location or volume per load.

5 REFERENCES

Abbott, R.T. 1968. A Guide to Field Identification. Seashells of North America. Golden Press, Western Publishing Co., Inc., Racine, WI.

ANAMAR Environmental Consulting, Inc. 2011. Site Designation Studies for a New Ocean Dredged Material Disposal Site off Jacksonville, Florida: Spring and Fall 2010 Survey Results. Submitted to USACE Jacksonville District, Jacksonville, FL.

ANAMAR Environmental Consulting, Inc. 2012. *Final Report, Site Designation Study for the Port Everglades Harbor Ocean Dredged Material Disposal Site Expansion: May 2011 Survey Results*. Submitted to USACE Jacksonville District, Jacksonville, FL.

ANAMAR Environmental Consulting, Inc. 2015. A Guide to Regional Input Values for the BRAMS Program Modules BEST and Trophic Trace, Final Report. Submitted to USACE Wilmington District, Wilmington, NC, and EPA Region 4, Atlanta, GA.

Agency for Toxic Substances and Disease Registry (ATSDR). 2001. *Toxicological Profile for Di-n-butyl Phthalate*. AGSDR, Division of Toxicology/Toxicology Information Branch, Atlanta, GA. Accessible online at https://www.atsdr.cdc.gov/toxprofiles/tp135.pdf.

ATSDR. 2002. Toxicological Profile for Beryllium. Agency for Toxic Substances and Disease Registry, Division of Toxicology and Human Health Sciences, Environmental Toxicology Branch, Atlanta, GA. Available online at https://www.atsdr.cdc.gov/toxprofiles/tp4.pdf.

ATSDR. 2012. *Toxicological Profile for Cadmium*. ATSDR, Division of Toxicology/Toxicology Information Branch, Atlanta, GA. Available online at https://www.atsdr.cdc.gov/toxprofiles/tp5.pdf.

Barrows, M.E., S.R. Petrocelli, K.J. Macek, and J.J. Carroll. 1980. Bioconcentration and elimination of selected water pollutants by bluegill sunfish (Lepomis macrochirus). Pp. 379-392. In: R. Haque (ed.) Dynamic Exposure and Hazard Assessment of Toxic Chemicals. Ann Arbor Science, Ann Arbor, MI.

Battelle. 2005. Final Evaluation of EPA Region 1 Bioaccumulation Risk Assessment Model. Submitted to EPA, Oceans and Coastal Protection Division, Washington, DC.

Bauer MJ, Herrmann R. 1997. Estimation of the environmental contamination by phthalic acid esters leaching from household wastes. Sci Total Environ 208:49-57.

Buchman, M.F. 2008. NOAA Screening Quick Reference Tables. NOAA, OR&R Report 08-1, Office of Response and Restoration Division, Seattle, WA.

Clara M, Windhofer G, Hartl W, et al. 2010. Occurrence of phthalates in surface runoff, untreated and treated wastewater and fate during wastewater treatment. Chemosphere 78(9):1078-1084. http://doi.org/10.1016/j.chemosphere.2009.12.052.

Coyle, J.J., D.R. Buckler, C.G. Ingersoll, J.F. Fairchild, and T.W. May. 1993. Effects of dietary selenium on the reproductive success of bluegills (Lepomis macrochirus). Environmental Toxicology and Chemistry 12:551–565.

CPSC. 2010a. Memorandum to Michael Babich from Kent Carlson regarding the toxicity review of di(2-ethylhexyl) phthalate (DEHP). Bethesda, MD: U.S. Consumer Product Safety Commission.

Dulka, J.J. and T.H. Risby. 1976. Ultratrace metals in some environmental and biological systems. Analytical Chemistry 48(8):640–653.

EPA. 1979. Water-related environmental fate of 129 priority pollutants. Vol. II. Halogenated aliphatic hydrocarbons, halogenated ethers, monocyclic aromatics, phthalate esters, polycyclic aromatic hydrocarbons, nitrosamines, and miscellaneous compounds. Washington, DC: U.S. Environmental Protection Agency. EPA440479029a. PB80204373.

EPA. 1981. An exposure and risk assessment for phthalate esters: Di(2-ethylhexyl) phthalate, di-n-butyl phthalate, dimethyl phthalate, diethyl phthalate, di-n-octyl phthalate, butyl benzyl phthalate. Washington, DC: U.S. Environmental Protection Agency. EPA440481020. PB85211936.

EPA. 1986. Method 8060: Phthalate esters. Test methods for evaluating solid waste. U.S. Environmental Protection Agency. SW-846.

EPA. 1994. Methods for Measuring the Toxicity and Bioaccumulation of Sediment-associated Contaminants with Freshwater Invertebrates. EPA 600/R-99/064. US Environmental Protection Agency, Washington, DC.

EPA. 2000. Bioaccumulation Testing and Interpretation for the Purpose of Sediment Quality Assessment, Status and Needs. EPA-823-R-00-002, EPA Bioaccumulation Analysis Workshop, Washington, DC.

EPA and USACE. 2003. *Ocean Dredged Material Disposal Program, Regional Implementation Agreement for Testing and Reporting Requirements for Ocean Disposal of Dredged Material off the Louisiana and Texas Coasts under Section 103 of the Marine Protection, Research, and Sanctuaries Act*. EPA Region 6, Dallas, TX; USACE Galveston District, Galveston, TX; and USACE New Orleans District, New Orleans, LA.

EPA. 2006. National Recommended Water Quality Criteria. EPA Region 4, Water Management Division, Wetlands, Coastal & Nonpoint Source Branch, Atlanta, GA.

EPA. 2012. Guidelines establishing test procedures for the analysis of pollutants under the Clean Water Act; analysis and sampling procedures: Final rule. Federal Register 77(97):29785–29846. Available online at https://www.gpo.gov/fdsys/pkg/FR-2012-05-18/pdf/2012-10210.pdf .

EPA. 2015. National Recommended Water Quality Criteria [online resource]. Available online at http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm#altable.

EPA and USACE. 1991. Evaluation of Dredged Material Proposed for Ocean Disposal, Testing Manual [Green Book]. EPA 503-8-91-001. EPA Office of Marine and Estuarine Protection, Washington, DC, and Department of the Army, USACE, Washington, DC.

EPA and USACE. 1998. Evaluation of Dredged Material for Discharge in Waters of the U.S. – Testing Manual [ITM]. EPA 823-B-98-004. EPA Office of Water and Office of Science and Technology, Washington, DC, and Department of the Army, USACE, Operations, Construction, and Readiness Division, Washington, DC.

EPA and USACE. 2008. Southeast Regional Implementation Manual (SERIM), Requirements and Procedures for Evaluation of the Ocean Disposal of Dredged Material in Southeast U.S. Atlantic and Gulf Coast Waters. EPA 904-B-08-001. EPA Region 4, Atlanta, GA, and USACE South Atlantic Division, Atlanta, GA.

Fattorini, D., Notti, A., & Regoli, F. 2006. Characterization of arsenic content in marine organisms from temperate, tropical, and polar environments. *Chemistry and Ecology, 22*, 405 - 414.

Farrington, J.W. 2014. Oil pollution in the marine environment II: fates and effects of oil spills. *Environment: Science and Policy for Sustainable Development* 2014(56):16–31.

FDA. 2001. Chapter 9: Environmental Chemical Contaminants and Pesticides. In: U.S. Department of Health and Human Services (ed.), Fish and Fishery Products Hazards and Controls Guidance, Third Edition.

FDA. 2020. Chapter 9: Environmental Chemical Contaminants and Pesticides. In: U.S. Department of Health and Human Services (ed.), Fish and Fishery Products Hazards and Controls Guidance, Fourth Edition [online document]. Available online at https://www.fda.gov/downloads/food/guidanceregulation/ucm251970.pdf.

Gough, L.P., H.T. Shacklette, and A.A. Case. 1979. Element Concentrations Toxic to Plants, Animals, and Man. Geological Survey Bulletin 1466, U.S. Department of the Interior, U.S. Government Printing Office, Washington, DC. Available online at http://pubs.usgs.gov/bul/1466/report.pdf.

Hermanutz, R.O., K.N. Allen, T.H. Roush, and S.F. Hedtke. 1992. Effects of elevated selenium concentrations on bluegills (Lepomis macrochirus) in outdoor experimental streams. Environmental Toxicology and Chemistry 11:217–224.

Johnson BT, Heitkamp MA, Jones JR. 1977. Dynamics of phthalic acid esters in aquatic organisms. Fate of pollutants in the air and water environments: Part 2. Chemical and biological fate of pollutants in the environment. New York, NY: John Wiley & Sons. 283-300.

Laughlin, R.B. Jr., J.M. Neff, Y.C. Hrung, T.C. Goodwin, and C.S. Giam. 1978. The effects of three phthalate esters on the larval development of the grass shrimp Palaemonetes pugio (Holthuis). Water, Air, & Soil Pollution 9:323–336.

Lee, D.R. 1980. Reference Toxicants in Quality Control of Aquatic Bioassays. Pp. 188–199. In: A.L. Buikema and J. Cairns (Eds.), Aquatic Invertebrate Bioassays. ASTM Special Technical Publication 715, American Society for Testing and Materials, Philadelphia, PA.

Lotufo, G.R., T.J. Estes, P.R. Schroeder, J.M. Corbino, E.J. Glisch, and R.F. Mach. 2011. Water Quality and Sediment Evaluation for Inner Harbor Navigation Canal Lock replacement Project, New Orleans, Louisiana. Environmental Laboratory ERDC/EL TR-11-8, prepared for U.S. Army Corps of Engineers, Washington, DC.

Mackintosh CE, Maldonado J, Hongwu J, et al. 2004. Distribution of phthalate esters in a marine aquatic food web: Comparison to polychlorinated biphenyls. Environ Sci Technol 38(7):2011-2020.

O'Connor GA. 1996. Organic compounds in sludge-amended soils and their potential for uptake by crop plants. Sci Total Environ 185(1-3):71-81. http://doi.org/10.1016/0048-9697(95)05043-4.

Plumb, R.H. 1981. Procedures for Handling and Chemical Analysis of Sediment and Water Samples. Great Lakes Laboratory, State University College at Buffalo, Buffalo, NY. Submitted to EPA and USACE Technical Committee on Criteria for Dredged and Fill Material, EPA, Grosse Ile, MI, and U.S. Army Engineer Waterways Experiment Substation, Vicksburg, MS.

Prince, R.C., J. Gailer, D.E. Gunson, R.J. Turner, G.N. George, and I.J. Pickering. 2007. Strong poison revisited. Journal of Inorganic Biochemistry 101:1891–1893.

Raymond, L.J. and N.V.C. Ralston. 2009. Selenium's importance in regulatory issues regarding mercury. Fuel Processing Technology 90:1333–1338.

Schmitt, C.J. and S.E. Finger. 1987. The effects of sample preparation on measured concentrations of eight elements in edible tissues of fish from streams contaminated by lead mining. *Archives of Environmental Contamination and Toxicology* 16:185–207.

Staples, C., D. Peterson, T. Parkerton, and W.J. Adams. 1997. The environmental fate of phthalate esters: a literature review. *Chemosphere* 35(4):667–749.

Subcommittee on Nutrient and Toxic Elements in Water. 1974. Nutrients and Toxic Substances in Water for Livestock and Poultry. National Research Council, Committee on Animal Nutrition, Subcommittee on Nutrient and Toxic Elements in Water, Washington, D.C.

Sugatt RH, O'Grady DP, Banerjee S, et al. 1984. Shake flask biodegradation of 14 commercial phthalate esters. Appl Environ Microbiol 47(4):601-606.

Texas Commission on Environmental Quality. 2018. Chapter 307. Texas Surface Water Quality Standards Rule Project No. 2016-002-307-OW [online resource]. Available online at https://www.tceq.texas.gov/assets/public/waterquality/standards/tswqs2018/2018swqs_allsections_nopreamble.pdf .

Trefry, J.H. and R.P. Trocine. 2011. Metals in sediments and clams from the Indian River Lagoon, Florida: 2006–7 versus 1992. *Florida Scientist* 74:43–62.

Turgeon, D.D., W.G. Lyons, P. Mikkelsen, G. Rosenberg, and F. Moretzsohn. 2009. Bivalvia (Mollusca) of the Gulf of Mexico. 711-744 pp. In: D.L. Felder and D.K. Camp (eds.) *Gulf* *of Mexico, Origin, Waters, and Biota. Volume 1, Biodiversity.* Texas A&M University Press, College Substation, TX.

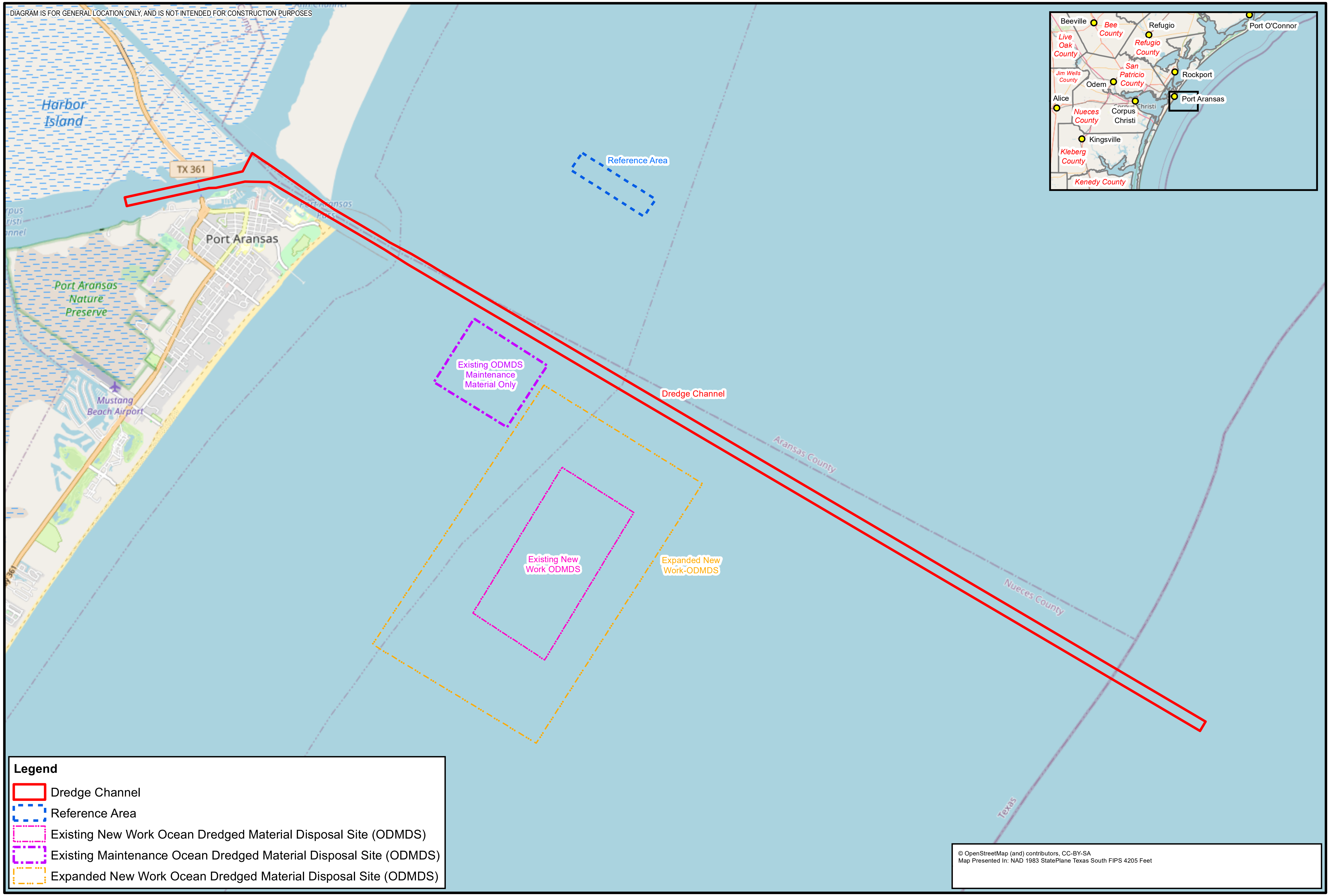
U.S. Army Engineer Research and Development Center. 2021. ERED, Environmental Residue-Effects Database [online database]. Environmental Laboratory, U.S. Army Engineer Research and Development Center, Vicksburg, MS. Accessed 02/08/23 at https://ered.el.erdc.dren.mil/index.cfm. (References from ERED can be found at https://ered.el.erdc.dren.mil/references.cfm.)

Wofford HW, Wilsey CD, Neff GS. 1981. Bioaccumulation and metabolism of phthalate esters of oysters, brown shrimp, and sheepshead minnows. Ecotoxicol Environ Saf 5:202-210.

Wolfe NL, Burns LA, Steen WC. 1980. Use of linear free energy relationships and an evaluative model to assess the fate and transport of phthalate esters in the aquatic environment. Chemosphere 9:393-402.

Yang, D.-Y., Y.-W. Chen, J.M. Gunn, and N. Belzile. 2008. Selenium and mercury in organisms: interactions and mechanisms. Environmental Review 16:71–92.

FIGURES



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APPROXIMATE SCALE: 1" = 1 Mile

Project Mngr:	PM
Drawn By:	DB
Checked By:	CB
Approved By:	AB

Project No.	92217C03
Scale:	1" = 1 mile
Report:	LSI
Date:	02-20-2023

Terracon
11555 CLAY ROAD, SUITE. 100 HOUSTON, TX 77043
PH. (713) 690-8989 FAX. (713) 690-8787

Site Vicinity Map

Port of Corpus Christi Authority
Channel Deepening Project
Port Aransas, Aransas County, Texas

FIGURE 1

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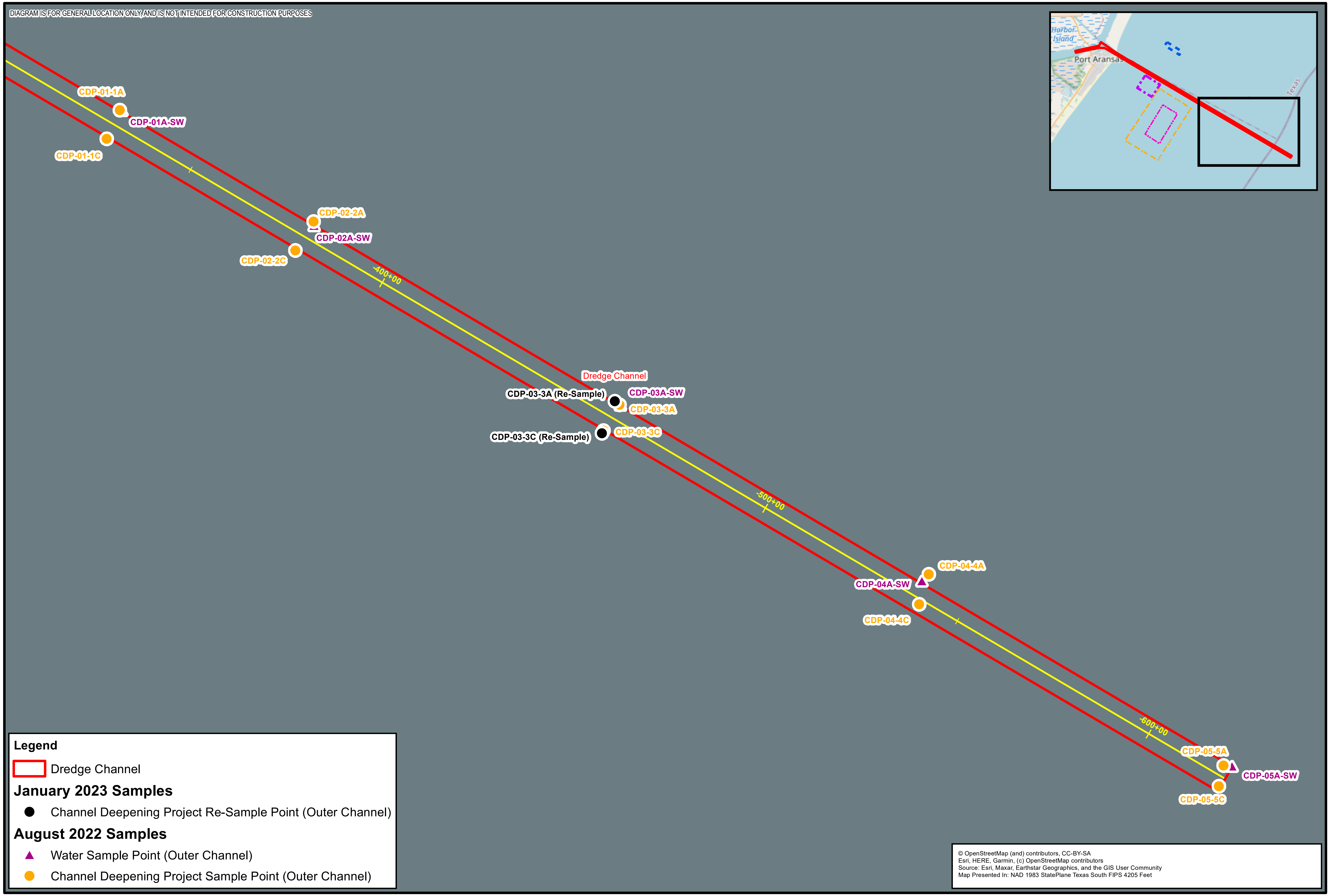

Legend

🟥 Dredge Channel

January 2023 Samples

● Channel Deepening Project Re-Sample Point (Outer Channel)

August 2022 Samples

▲ Water Sample Point (Outer Channel)

● Channel Deepening Project Sample Point (Outer Channel)

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FIGURE
2.1

Sample Location Map (Outer Channel)

New Work Ocean Dredged Material Disposal Site
Port of Corpus Christi Authority
Channel Deepening Project
Port Aransas, Aransas County, Texas

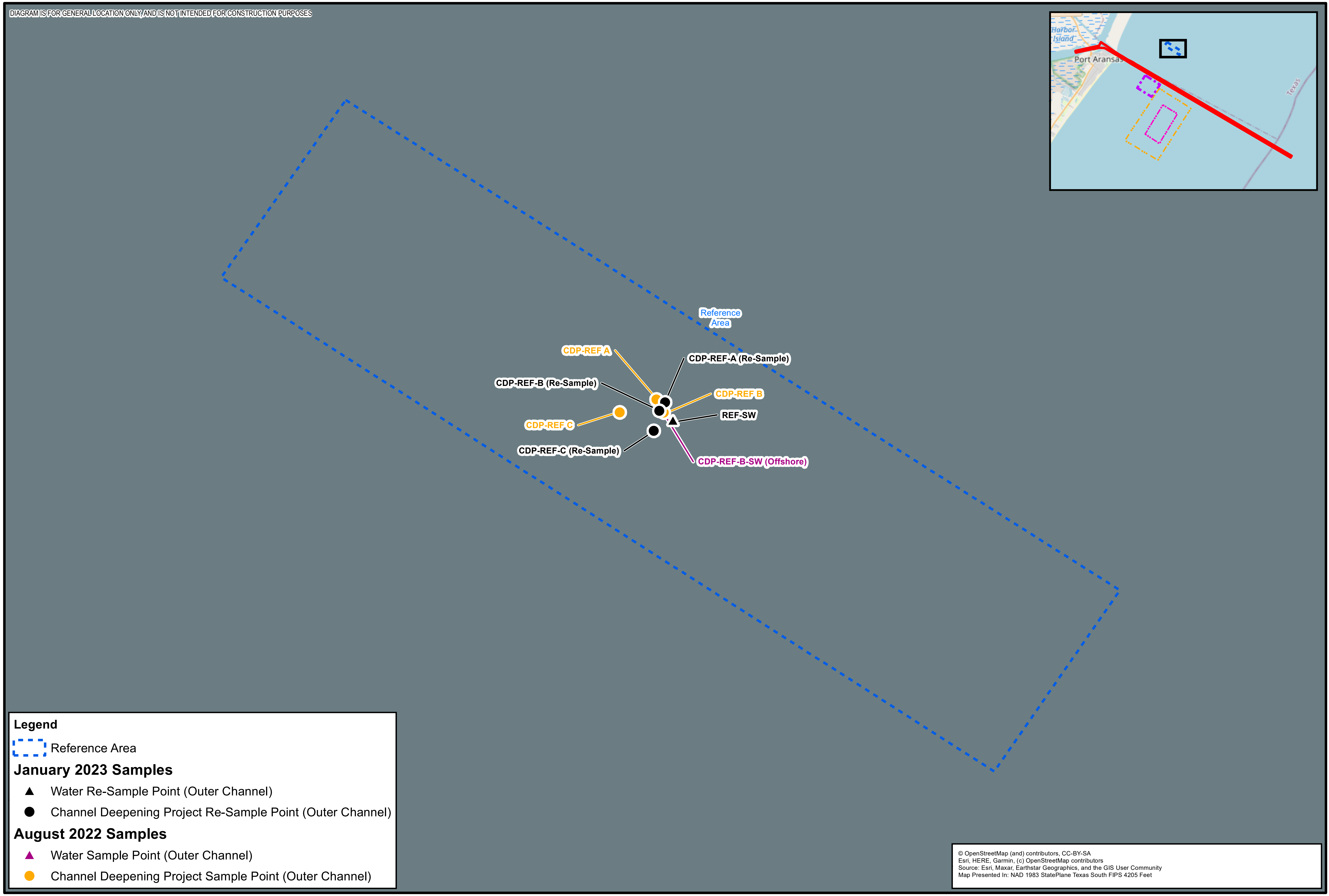
Terracon
11555 CLAY ROAD, SUITE. 100 HOUSTON, TX 77043
PH. (713) 690-8989 FAX. (713) 690-8787

N

Project Mngr:	PM	Project No.	92217C03
Drawn By:	DB	Scale:	1" = 2,000'
Checked By:	CB	Report:	LSI
Approved By:	AB	Date:	02-23-2023

0' 1,000' 2,000' 4,000'
APPROXIMATE SCALE: 1" = 2,000'

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES



Legend

- ▭ Reference Area

January 2023 Samples

- ▲ Water Re-Sample Point (Outer Channel)
- ● Channel Deepening Project Re-Sample Point (Outer Channel)

August 2022 Samples

- ▲ Water Sample Point (Outer Channel)
- ● Channel Deepening Project Sample Point (Outer Channel)

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FIGURE 2.2

Reference Area Sample Location Map
Reference Area
Port of Corpus Christi Authority
Channel Deepening Project
Port Aransas, Aransas County, Texas

Terracon
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N

Project Mngr:	PM	Project No.	92217C03
Drawn By:	DB	Scale:	1" = 500'
Checked By:	CB	Report:	LSI
Approved By:	AB	Date:	02-23-2023

0' 250' 500' 1,000'
APPROXIMATE SCALE: 1" = 500'

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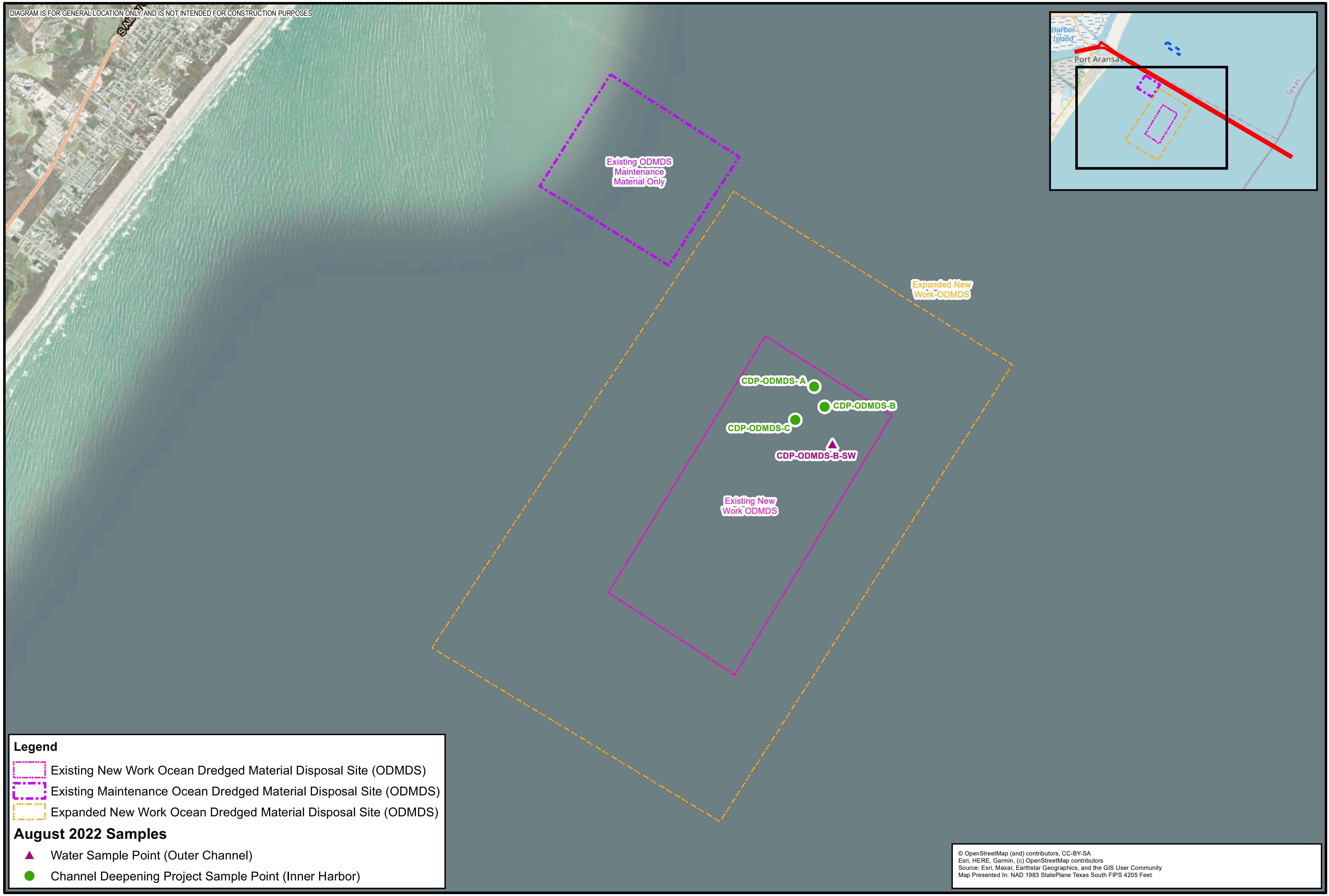

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

Legend

- ⬚ Existing New Work Ocean Dredged Material Disposal Site (ODMDS)
- ⬚ Existing Maintenance Ocean Dredged Material Disposal Site (ODMDS)
- ⬚ Expanded New Work Ocean Dredged Material Disposal Site (ODMDS)

August 2022 Samples

- ▲ Water Sample Point (Outer Channel)
- ● Channel Deepening Project Sample Point (Inner Harbor)

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Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
Map Presented In: NAD 1983 StatePlane Texas South FIPS 4205 Feet

0' 1,500' 3,000' 6,000'
APPROXIMATE SCALE: 1" = 3,000'

Project Mngr:	PM
Drawn By:	DB
Checked By:	CB
Approved By:	AB

Project No.	92217C03
Scale:	1" = 3,000'
Report:	LSI
Date:	02-23-2023

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New Work ODMDS Sample Location Map

Dredge Material Management Unit (DMMU) Area
Port of Corpus Christi Authority
Channel Deepening Project
Port Aransas, Aransas County, Texas

FIGURE
2.3

N:\ENV\2021\Drafting\92217C03\Task 2\202301\92217C03.2 Dredge Areas_202301.mxd, Revised: 02-23-2023, 8:04:03 AM

TABLES

Table 18 – Analytical Results for Wet Weight SVOCs in *Alitta virens* Tissues

Table 19 – Analytical Results for Dry Weight SVOCs in *Mercenaria mercenaria* Tissues

Table 20 - Analytical Results for Dry Weight SVOCs in *Alitta virens* Tissues

TABLE 1

Core and Grab Sample Summary

								Metrics Per Core/Sample								
DMMU/ Sample ID	**Composite ID**	**Subsample ID**	**Date**	**Sampling Start & End (CST)**	**Latitude[1] (°N, NAD 83)**	**Longitude[1] (°W, NAD 83)**	**Project Depth (feet, MLLW)**	**Water Depth (feet)**	**Water Surface Elevation[2] (feet, MLLW)**	**Top of Sediment Elevation[3] (feet, MLLW)**	**Bottom of Core Elevation (feet, MLLW)**	**Core Number**	**Core Penetration (feet)**	**Recovery Length (feet)**	**Average Recovery per Core (%)**	**Description/ Notes**
CDP-01	**CDP-01**	**CDP-01-1A**	8/16/2022	1330-1630	27.79396	-96.96286	-81	60.5	1.0	-59.5	-82.4	1	23.0	17.0	74	Low and incoming tide with 10-15 knot winds from the SE, 2-3 ft. seas, sunny. 1st push-penetrated 14 ft with 11 ft of recovery, silty clay, soft, wet, gray, 0-2'; clayey sand, soft, wet, gray 2'-3'; clay, soft, wet, gray 3' -14' with sand lense 7'-8'; 2nd push-no recovery-sample washed out, no sample was retained. 3rd push penetrated 14' to 23' to reach project depth. Low recovery 4 ft. silty clay, unconsolidated, soft, wet, gray. Retained all of recovery from the 3rd penetration attempted.
		CDP-01-1C	8/17/2022	0640-0915	27.79220	-96.96380		62.0	1.2	-60.8	-82.8	1	22.0	22.0	100	Mid to high outgoing tide with 10-15 knot winds from the SE, 2-3 ft seas, sunny. Penetrated 22 ft with 100% recovery. 0-7' silty clay, soft, wet, unconsolidated; 7'-10', clayey sand, soft, wet, gray; 10'-14.5' silty clay, soft, wet, gray; 14.5'-15' clayey sand, soft, wet, gray; 15'-21' silty clay, soft, wet, gray with sand lenses at 16' and 18'-20'. Over-penetrated to retain material to project depth, discarded 1.8' below the project depth.
CDP-02	**CDP-02**	**CDP-02-2A**	8/17/2022	1245-1500	27.78693	-96.94949	-81	64.5	0.6	-63.9	-87.5	1	23.5	23.5	100	Outgoing low to slack tide with 10-15 knot winds from the SE, 2'-3' seas, sunny. Penetrated 23 ft with 100% recovery. 0 -2.5' silty clay, soft, wet, unconsolidated, gray; 2.5'-3' sandy clay, soft, moist, gray; 3'-4.5' silty clay, soft, wet, gray; 4.5'-6.5' sandy clay, soft, wet, gray; 6.5'-23.5' slity clay, soft, wet, gray. Over-penetrated to retain sample, discarded 6.5' below the project depth.
		CDP-02-2C	8/18/2022	0655-0830	27.78515	-96.95078		63.9	1.1	-63.9	-87.4	1	23.5	23.5	100	Mid-outgoing tide with 10-15 knot winds from the SE, 2'-3' seas, sunny. Penetrated 23.5 ft with 100% recovery. 0 -1.5' silty clay, soft, wet, unconsolidated, gray; 1.5'-14.5' siltyy clay, soft, moist, gray; 14.5'-16' sand lense, gray; 16-16.5' clayey sand, wet, soft, gray; 16.5'-23.5' silty clay, wet, soft, gray. Over-penetrated to retain sample, discarded 6.5' below the project depth.
CDP-03	**CDP-03**	**CDP-03-3A**	8/18/2022	1215-1345	27.77536	-96.92837	-81	69.5	0.6	-68.9	-93.9	1	25.0	25.0	100	Mid to low outgoing tide with 10-15 knot wids from the SE, sunny. Penetrated 25 ft with 100% recovery. 0-2' silty clay, soft, wet, unconsolidaed; 2'-2.5' sandy clay, soft, wet, gray; 2.5'-12' silty clay, soft, wet, gray with a sand lense 6'-8'. Over-penetrated to retain sample to the project depth. Discarded 13' below the project depth.
		CDP-03-3A (Duplicate)	8/18/2022	1600-1700	27.77538	-96.92839		69.0	0.4	-68.6	-92.6	2	24.0	23.0	96	Slack and incoming tide with 5-10 knot winds from the SE, 2-3 ft. seas, sunny. Silty clay, soft, wet, unconsolidated, gray, 0 to 6'; silty clay, soft, wet, gray, 6' to 12'. Gypsum flakes at 10'. Very soft, unconsolidated at surface. Over penetrated to retain material to project depth. Discarded 11.5 feet.
		CDP-03-3C	8/19/2022	0705-0810	27.77377	-96.92951		70.0	1.1	-68.9	-94.9	1	26.0	26.0	100	High to mid outgoing tide with 5-10 knot winds from the SE, 2-3 ft. seas, partly cloudy. Silty clay, soft, wet, unconsolidated, gray, 0 to 6'; silty clay, soft, wet, gray, 6' to 12'. Gypsum flakes at 10'. Very soft, unconsolidated at surface. Over penetrated to retain material to project depth. Discarded 14 feet below the project depth.
		CDP-03-3C (Duplicate)	8/19/2022	1145-1320	27.77379	-96.92945		70.0	0.6	-69.4	-93.4	2	24.0	24.0	100	Mid to low outgoing tide with 5-10 knot winds from the SE, 2-3 ft. seas, partly cloudy. Silty clay, gray, soft, wet, unconsolidated 0 to 5'; silty clay, soft, wet, gray 5' to 11.5'. Very soft, unconsolidated at surface. Over penetrated to retain material to project depth. Discarded 12.5 feet.
CDP-03	**CDP-03 (Re-sample Benthic Test Only)**	**CDP-03-3A (Re-Sample)**	1/22/2023	1050-1150	27.77559	-96.92870	-81	66.5	0.35	-66.2	-81.2	1	15.0	12.0	80	Low, incoming tide with 15 knot winds from the N, 2-4 ft. seas, sunny. Due to very wet, unconsolidated sediment, ~3-feet from the top of core flushed out of the core barrel and onto the deck of the lift boat (not collected). Silty soft, wet, gray, 0-3'; silty clay, soft, sticky, olive gray 3' to 8; clay, stiff, olive gray 8' -15'. Re-sample is for 10-day Mysid benthic test only.
		CDP-03-3C (Re-Sample)	1/22/2023	1400-1500	27.77362	-96.92962		71.7	1.25	-70.5	86.5	1	16.0	16.0	100	Mid to high incoming tide with 10-15 knot winds from the N, 1-2 ft. seas, sunny. Very soft, unconsolidated at surface with silty clay, gray, 0 to 5'; silty clay, soft, sticky, olive gray 5' to 16'. Over penetrated to retain material to project depth. Discarded 5.5 feet. Re-sample is for 10-day Mysid benthic test only.
CDP-04	**CDP-04**	**CDP-04-4A**	8/24/2022	1438-1458	27.76465	-96.90705	-81	74.0	0.9	-73.1						Surface grab samples collected using double van veen. Mid to low outgoing tide with 5-10 knot winds from the SE, 2-3 ft seas, partly coudy. ~20 gallons collected in buckets.
		CDP-04-4C		1529-1552	27.7627923	-96.90774		74.0	0.73	-73.3						Surface grab samples collected using double van veen. Low outgoing tide with 5-10 knot winds from the SE, 2-3 ft seas, partly coudy. ~20 gallons collected in buckets.
CDP-05	**CDP-05**	**CDP-05-5A**	8/24/2022	1615-1635	27.75259	-96.88672	-81	77.0	0.52	-76.5						Surface grab samples collected using double van veen. Low outgoing tide with 5-10 knot winds from the SE, 2-3 ft seas, partly coudy. ~20 gallons collected in buckets.
		CDP-05-5C		1647-1715	27.75131	-96.88706		77.0	0.40	-76.6						Surface grab samples collected using double van veen. Low outgoing tide with 5-10 knot winds from the SE, 2-3 ft seas, partly coudy. ~20 gallons collected in buckets.

TABLE 1 (*continued*)

Vibracore and Grab Sample Summary

DMMU/ Sample ID	Composite ID	Subsample ID	Date	Sampling Start & End (CST)	Latitude[1] (°N, NAD 83)	Longitude[1] (°W, NAD 83)	Project Depth (feet, MLLW)	Metrics Per Core/Sample								
								Water Depth (feet)	Water Surface Elevation[2] (feet, MLLW)	Top of Sediment Elevation[3] (feet, MLLW)	Bottom of Core Elevation (feet, MLLW)	Core Number	Core Penetration (feet)	Recovery Length (feet)	Average Recovery per Core (%)	Description/ Notes
CDP-REF	**CDP-REF**	**CDP-REF A**	8/24/22	1035-1115	27.84193	-96.99385		45.0	1.3	-43.7						Surface grab samples collected using double van veen. Low outgoing tide with 5-10 knot winds from the SE, 2-3 ft seas, partly coudy. Worm castings observed. ~15 gallons collected in buckets.
		CDP-REF B		0930-0948	27.84172	-96.99372		45.0	1.3	-43.7						Surface grab samples collected using double van veen. Low outgoing tide with 5-10 knot winds from the SE, 2-3 ft seas, partly coudy. Worm castings observed. ~15 gallons collected in buckets.
		CDP-REF C		0910-0928	27.84173	-96.99449		45.0	1.2	-43.8						Surface grab samples collected using double van veen. Low outgoing tide with 5-10 knot winds from the SE, 2-3 ft seas, partly coudy. Worm castings observed. ~15 gallons collected in buckets.
CDP-REF	**CDP-REF (CDP-03 Re-sample Benthic Test Only)**	**CDP-REF A**	1/27/23	0920-1000	27.84198	-96.99379		45.0	0.8	-44.2						Surface grab samples collected with a double van Veen. High-outgoing tide with 5-10 knot winds from the NE, 2-3 ft seas, cloudy skes. Silty-clay with fine sand, light brown and olive gray in color with shells; sand crab, worms/worm castings observed. ~15 gallons collected in buckets.
		CDP-REF B		1053-1125	27.84171	-96.99360		45.0	0.8	-44.2						Surface grab samples collected with a double van Veen. Mid-outgoing tide; 5-10 knot winds from the NE, 2-3 ft seas, cloudy skies. Silty-clay with fine sand and shells; light brown and olive gray in color. ~15 gallons collected in buckets.
		CDP-REF C		1003-1050	27.84148	-96.99395		45.0	0.7	-44.3						Surface grab samples collected with a double van Veen. Multiple drops required, sample was washing out from bottom (shells). Mid-outgoing tide, 5-10 knot winds from the NE, 2-3 ft seas, cloudy skies. Silty-clay with fine sand and shells, light brown and olive gray in color; small conch, sand crab, and worms observed. ~15 gallons collected in buckets.
CDP-ODMDS	**CDP-ODMDS**	**CDP-ODMDS- A**	3/3/22	1100-1105	27.79060	-96.99857		45.0	0.18	-44.8						Sample collected with a double van Veen; sand fine to coarse and silt, shell fragments, light brown and tan in color; 5-10 knot winds from the SE, 1-2 ft seas, sunny skies, mid-outgoing tide. Composite in field for sample collection
		CDP-ODMDS-B		1121-1138	27.78870	-96.99750		45.0	0.22	-44.8						Sample collected with a double van Veen; sand fine to coarse and silt, shell fragments, light brown and tan in color; 5-10 knot winds from the SE, 1-2 ft seas, sunny skies, mid-outgoing tide. Composite in field for sample collection.
		CDP-ODMDS-C		1109-1114	27.78752	-97.00059		45.0	0.17	-44.8						Sample collected with a double van Veen; sand fine to coarse and silt, shell fragments, light brown and tan in color; 5-10 knot winds from the SE, 1-2 ft seas, sunny skies, mid-outgoing tide. Composite in field for sample collection
Notes	[1] Coordinates were recorded in the field with a Trimble GeoXH 6000 (Terracon Trimble) and were referenced to North American Datum of 1983, Texas South Central State Plane, US Survey Feet. [2] Feet mean lower low water calculated from water depth (measured by leadline) and tide height using real-time data/National Oceanic and Atmospheric Administration (NOAA) Tide Station # 8775237 in Port Aransas, Texas. [3] Sediment elevation data was calculated as water surface elevation minus water depth. * Unless otherwise noted, no living organisms or organic debris observed, no oil present, no odor detected. ft = feet, (cells shaded grey) = Not applicable DMMU as listed in Table 1 in the SAP. Sources: ANAMAR																

TABLE 2

Site Water Sample Summary Including Water Column Measurements

DMMU:	CDP-01	CDP-02	CDP-03	CDP-04	CDP-05	Reference	ODMDS
Sample ID:	**CDP-01A-SW**	**CDP-02A-SW**	**CDP-03A-SW**	**CDP-04A-SW**	**CDP-05A-SW**	**CDP-REF-B-SW (Offshore)**	**CDP-ODMDS-B-SW**
Date	08/25/22	08/25/22	08/25/22	08/25/22	08/25/22	08/25/22	3/3/22
Sampling Start/End Times (CST)	1903-1940	1825-1855	1736-1813	1650-1725	0925-1635	2000-2015	1144-1202
Depth of Water (feet)	62	65	69	74	77	45	46
Time of Measurement (CST)	1907	1828	1740	1655	930	2005	1150
Depth of Measurement (feet)	32	33	35	37	40	24	23
Water Temperature (°C)	29.41	29.46	29.48	29.69	28.55	29.26	13.68
pH (units)	8.22	8.22	8.25	8.26	8.22	8.2	8.64
Salinity (ppt)							28.0
Sp. Conductivity (mS/cm)	50.7	50.7	50.4	50.5	50.3	50.7	43.1
Dissolved Oxygen (mg/L)	5.54	6.88	5.9	5.91	5.33	4.92	12.64
Dissolved Oxygen (%)	--	--	--	--	--	--	146.5
Turbidity (NTU)	1.9	1.8	1.0	1.2	0.0	0.0	0.0
Oxidation Reduction Potential (mV)	--	--	--	--	--	--	175
Total Dissolved Solids (g/L)							26.2
Latitude (°N, NAD 83)	27.793934	27.786670	27.775336	27.764220	27.752520	27.841597	27.785238
Longitude (°W, NAD 83)	-96.962711	-96.949461	-96.928322	-96.907524	-96.886144	-96.993566	-96.996742
Sampling Method	Submersible pump	Submersible pump	Submersible pump	Submersible pump	Submersible pump	Submersible pump	Submersible pump
Field Description of Sample	Clear in color, no suspended materials or odor observed	Clear in color, no suspended materials or odor observed	Clear in color, no suspended materials or odor observed	Clear in color, no suspended materials or odor observed	Clear in color, no suspended materials or odor observed	Clear in color, no suspended materials or odor observed	Clear in color; no suspended materials or odor observed
Weather/Tidal Cycle	Low-outgoing tide with 0-5 knot winds from the SE, calm seas, sunny skies	Low-outgoing tide with 0-5 knot winds from the SE, calm seas, sunny skies	Low-outgoing tide with 0-5 knot winds from the SSE, calm seas, sunny skies	Mid to low-outgoing tide with 0 to 5 knot winds from the SSE, calm seas, sunny skies	0930 High-slack tide at with 10-15 knot winds from the SSE, 2-3 ft seas, pouring rain. Returned at 1610, mid-outgoing tide with 0-5 knot winds from the SE, calm, sunny skies	Low-outgoing tide with 0-5 knot winds from the SE, calm seas, sunny skies	Low-incoming tide with 5-10 knot winds from the S, 1-2 ft seas, sunny skies
General Conditions and Observations	MLLW 0.13 @ 1906	MLLW 0.24 @ 1824	MLLW 0.39 @ 1736	MLLW 0.54 @ 1648	MLLW 0.99 @ 0930. Controller for submersible pump stopped working. Returned to dock, received new controller and pump. Returned to station location and completed sampling.	MLLW 0.05 @ 2000	MLLW 0.26 @ 1136

Salinity calculated using the formula: (Sp. Conductivity (ms/cm)^1.0878)*0.4665

(--) or (cells shaded grey) = no reading taken

Source: ANAMAR Environmental Consulting, Inc.

TABLE 3
Results of Physical Analyses for Sediment Samples

DMMU Location:*		CDP-01 Stations -330+00 (open bay, channel extension)			CDP-02 Stations -380+00 (open bay, channel extension)			CDP-03 Stations -460+00 (open bay, channel extension)			
Sample ID:		**CDP-01-COMP (Composite)**	**1A**	**1C**	**CDP-02-COMP (Composite)**	**2A**	**2C**	**CDP-03-COMP (Composite)**	**CDP-03 Duplicate (Core # 2, Composite)**	**3A**	**3C**
Sediment Description		Silt, some clay, little fine-grained quartz sand, brown	Fat clay, little silt, little fine-grained quartz sand, brown	Silt, some clay, little fine-grained quartz sand, brown	Silt, some clay, little fine-grained quartz sand, brown	Silt, some clay, little fine-grained quartz sand, brown	Silt, some clay, few fine-grained quartz sand, brown	Lean clay, some silt, few fine-grained quartz sand, brown	Fat clay, little silt, little fine-grained quartz sand, brown	Lean clay, some silt, few fine-grained quartz sand, brown	Silt, some clay, few fine-grained quartz sand, brown
% Gravel (Particles ≥4.750 mm)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% Coarse Sand		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% Medium Sand		0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
% Fine Sand		20.3	19.8	25.8	14.5	20.2	10.0	10.6	9.2	9.6	9.4
% Sand (total) (Particles 0.075-4.749 mm)		20.3	19.8	25.9	14.6	20.2	10.0	10.6	9.2	9.6	9.4
% Silt (Particles 0.005-0.074 mm)		43.8	23.7	41.6	47.2	41.1	47.0	43.8	40.6	43.9	46.6
% Clay (Particles <0.005 mm)		35.9	56.5	32.5	38.2	38.7	43.0	45.6	50.2	46.5	44.0
% Silt & Clay (combined)		79.7	80.2	74.1	85.4	79.8	90.0	89.4	90.8	90.4	90.6
USCS Classification		ML	CH	ML	ML	ML	ML	CL	CH	CL	ML
% Passing Sieve Size	**Metric Equivalent (mm)**										
#4	**4.75**	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
#10	**2.00**	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
#20	**0.85**	100.0	100.0	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
#40	**0.425**	100.0	100.0	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0
#50	**0.297**	100.0	100.0	99.9	99.9	100.0	100.0	100.0	99.9	100.0	100.0
#70	**0.210**	99.9	99.9	99.8	99.8	100.0	100.0	100.0	99.9	100.0	100.0
#100	**0.149**	99.3	99.4	99.3	99.5	99.9	99.7	99.9	99.8	99.9	100.0
#140	**0.105**	96.1	94.8	95.2	97.6	97.0	98.7	98.5	99.3	99.0	99.5
#200	**0.075**	79.7	80.2	74.1	85.4	79.8	90.0	89.4	90.8	90.4	90.6
Hydrometer Readings (% less than the following sizes)		58.7 @ 0.0414 mm	75.3 @ 0.0381 mm.	54.4 @ 0.0422 mm	68.5 @ 0.0393 mm	66.3 @ 0.0394 mm	76.3 @ 0.0375 mm	75.0 @ 0.0375 mm	79.5 @ 0.0369 mm	73.0 @ 0.0383 mm	68.5 @ 0.0390 mm
		53.1 @ 0.0301 mm	72.6 @ 0.0273 mm.	47.5 @ 0.0308 mm	60.2 @ 0.0290 mm	58.7 @ 0.0290 mm	65.9 @ 0.0281 mm	68.2 @ 0.0276 mm	71.7 @ 0.0273 mm	65.2 @ 0.0282 mm	64.3 @ 0.0282 mm
		49.2 @ 0.0217 mm	69.1 @ 0.0197 mm.	44.9 @ 0.0220 mm	53.8 @ 0.0212 mm	51.1 @ 0.0213 mm	58.2 @ 0.0207 mm	61.9 @ 0.0202 mm	65.6 @ 0.0200 mm	60.1 @ 0.0205 mm	58.4 @ 0.0206 mm
		42.2 @ 0.0115 mm	62.1 @ 0.0105 mm.	38.8 @ 0.0117 mm	46.0 @ 0.0113 mm	44.4 @ 0.0113 mm	48.7 @ 0.0112 mm	53.5 @ 0.0109 mm	56.9 @ 0.0108 mm	52.3 @ 0.0110 mm	50.0 @ 0.0111 mm
		39.6 @ 0.0082 mm	58.6 @ 0.0076 mm.	37.0 @ 0.0083 mm	42.9 @ 0.0081 mm	41.0 @ 0.0081 mm	45.3 @ 0.0080 mm	50.0 @ 0.0078 mm	54.3 @ 0.0077 mm	48.9 @ 0.0079 mm	46.6 @ 0.0080 mm
		37.0 @ 0.0059 mm	56.8 @ 0.0054 mm.	34.4 @ 0.0059 mm	39.5 @ 0.0058 mm	39.3 @ 0.0058 mm	43.6 @ 0.0057 mm	46.6 @ 0.0056 mm	50.9 @ 0.0055 mm	47.1 @ 0.0056 mm	44.9 @ 0.0057 mm
		32.7 @ 0.0030 mm	53.3 @ 0.0027 mm.	26.6 @ 0.0031 mm	35.6 @ 0.0030 mm	35.9 @ 0.0029 mm	40.1 @ 0.0029 mm	41.6 @ 0.0029 mm	47.4 @ 0.0028 mm	42.0 @ 0.0029 mm	38.3 @ 0.0029 mm
		25.7 @ 0.0013 mm	44.1 @ 0.0012 mm.	23.1 @ 0.0013 mm	30.0 @ 0.0012 mm	28.3 @ 0.0012 mm	32.8 @ 0.0012 mm	34.8 @ 0.0012 mm	28.3 @ 0.0012 mm	33.3 @ 0.0012 mm	32.1 @ 0.0012 mm

TABLE 3 (*continued*)
Results of Physical Analyses for Sediment Samples

DMMU Location:*		CDP-04 Stations -540+00 (open bay, channel extension)			CDP-05 Stations -620+00 (open bay, channel extension)			CDP-REF (Reference Area) Offshore Event	CDP-ODMDS (Placement Area [New Work ODMDS])
Sample ID:		**CDP-04-COMP (Composite)**	**4A**	**4C**	**CDP-05-COMP (Composite)**	**5A**	**5C**	**CDP-REF (Composite)**	**CDP-ODMDS (Composite)**
Sediment Description		Lean clay, some silt, little fine-grained quartz sand, brown	Fat clay, little silt, little fine-grained quartz sand, brown	Fat clay, little silt, little fine-grained quartz sand, brown	Fat clay, some silt, few fine-grained quartz sand, brown	Fat clay, some silt, few fine-grained quartz sand, brown	Fat clay, some silt, few fine-grained quartz sand, brown	Lean clay, some fine-grained quartz sand, some silt, brown	Sand, poorly graded, mostly fine-grained quartz sand, trace clay, trace fine gravel-size shell fragments, brown
% Gravel (Particles ≥4.750 mm)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4
% Coarse Sand		0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7
% Medium Sand		0.0	0.0	0.0	0.0	0.0	0.0	0.2	5.9
% Fine Sand		18.8	18.9	20.0	10.4	10.4	11.7	44.0	79.7
% Sand (total) (Particles 0.075-4.749 mm)		18.8	18.9	20.0	10.4	10.4	11.7	44.2	90.3
% Silt (Particles 0.005-0.074 mm)		34.4	22.9	24.9	32.1	35.2	33.4	27.8	1.4
% Clay (Particles <0.005 mm)		46.8	58.2	55.1	57.5	54.4	54.9	28.0	5.9
% Silt & Clay (combined)		81.2	81.1	80.0	89.6	89.6	88.3	55.8	7.3
USCS Classification		CL	CH	CH	CH	CH	CH	CL	SP
% Passing Sieve Size	**Metric Equivalent (mm)**								
#4	**4.75**	100.0	100.0	100.0	100.0	100.0	100.0	100.0	97.6
#10	**2.00**	100.0	100.0	100.0	100.0	100.0	100.0	100.0	92.9
#20	**0.85**	100.0	100.0	100.0	100.0	100.0	100.0	100.0	88.5
#40	**0.425**	100.0	100.0	100.0	100.0	100.0	100.0	99.8	87.0
#50	**0.297**	100.0	100.0	100.0	100.0	100.0	100.0	99.7	85.7
#70	**0.210**	100.0	100.0	100.0	100.0	100.0	100.0	99.6	74.8
#100	**0.149**	99.4	99.5	99.4	99.9	99.9	99.8	99.2	44.2
#140	**0.105**	90.2	89.9	91.3	97.5	96.6	97.0	92.8	18.2
#200	**0.075**	81.2	81.1	80.0	89.6	89.6	88.3	55.8	7.3
Hydrometer Readings (% less than the following sizes)		68.9 @ 0.0394 mm	79.2 @ 0.0373 mm	76.0 @ 0.0373 mm	78.2 @ 0.0367 mm	76.1 @ 0.0379 mm	77.7 @ 0.0373 mm	45.4 @ 0.0439 mm	7.1 @ 0.0490 mm
		64.5 @ 0.0285 mm	74.4 @ 0.0271 mm	72.7 @ 0.0269 mm	74.9 @ '0.0265 mm	71.7 @ 0.0275 mm	71.6 @ 0.0274 mm	41.1 @ 0.0316 mm	6.9 @ 0.0347 mm
		60.6 @ 0.0205 mm	71.8 @ 0.0195 mm	69.3 @ 0.0194 mm	70.6 @ 0.0192 mm	68.2 @ 0.0198 mm	69.1 @ 0.0196 mm	38.5 @ 0.0226 mm	6.7 @ 0.0246 mm
		54.0 @ 0.0109 mm	64.8 @ 0.0104 mm	62.6 @ 0.0104 mm	66.4 @ 0.0102 mm	61.3 @ 0.0106 mm	63.1 @ 0.0105 mm	33.7 @ '0.0119 mm	6.7 @ 0.0127 mm
		50.9 @ 0.0079 mm	61.3 @ 0.0075 mm	59.2 @ 0.0075 mm	61.3 @ 0.0074 mm	58.2 @ 0.0076 mm	59.7 @ 0.0075 mm	31.6 @ '0.0085 mm	6.7 @ 0.0090 mm
		47.9 @ 0.0056 mm	58.8 @ 0.0054 mm	55.9 @ 0.0054 mm	58.0 @ 0.0053 mm	55.2 @ 0.0055 mm	55.7 @ 0.0054 mm	29.0 @ 0.0061 mm	6.0 @ 0.0064 mm
		41.7 @ 0.0029 mm	53.6 @ 0.0027 mm	49.2 @ 0.0028 mm	51.2 @ 0.0028 mm	49.2 @ 0.0028 mm	50.2 @ 0.0028 mm	26.4 @ 0.0031 mm	5.7 @ 0.0032 mm
		31.2 @ 0.0012 mm	45.9 @ 0.0012 mm	39.2 @ 0.0012 mm	42.7 @ 0.0012 mm	39.7 @ 0.0012 mm	38.8 @ 0.0012 mm	19.5 @ 0.0013 mm	5.6 @ 0.0013 mm

*DMMU and sample locations are in State Plane NAD 83. Note: DMMUs CDP-01 through CDP-05 did not have sub-samples collected for B stations.
Note: Total distribution does not necessarily add up to 100% for each sample due to rounding. Some sieve openings differ slightly from phi mm scale.
Unified Soil Classification System (USCS) classes:
CH = Clay of high plasticity, elastic silt. CL = Clay. SC = Clayey sand. SM = Silty sand. SP = Poorly graded sand. ML = Silt of low plasticity.
Source: Results from Taylor Engineering, Inc.
Compiled by: ANAMAR Environmental Consulting, Inc.

TABLE 4

Analytical Results for Dry Weight Metals, Ammonia, Total Cyanide, TPHs, Total Solids, TOCs, and pH in Sediment Samples

			DMMU:	CDP-01				CDP-02				CDP-03				CDP-03 Duplicate (Core #2)			
			Sample ID:	CDP-01 Composite				CDP-02 Composite				CDP-03 Composite				CDP-03 Duplicate Composite			
Analyte	Maximum Conc. mg/kg	TEL mg/kg	ERL mg/kg	Result mg/kg	Qualifier	MDL	LRL	Result mg/kg	Qualifier	MDL	LRL	Result mg/kg	Qualifier	MDL	LRL	Result mg/kg	Qualifier	MDL	LRL
Metals																			
Antimony	<0.421	x	x	<0.0307	U	0.0307	0.0615	<0.0277	U	0.0277	0.0555	<0.0293	U	0.0293	0.0588	<0.0302	U	0.0302	0.0606
Arsenic	7.31	7.24	8.2	5.61	--	0.00307	0.0307	4.53	--	0.00277	0.0277	6.95	--	0.0147	0.147	7.31	--	0.0151	0.151
Beryllium	0.693	x	x	0.490	--	0.000615	0.0123	0.409	--	0.000555	0.0111	0.542	--	0.000588	0.0117	0.554	--	0.000606	0.0121
Cadmium	0.107	0.676	1.2	0.0383	J	0.00307	0.0615	0.0324	J	0.00277	0.0555	0.0507	J	0.00293	0.0588	0.0492	J	0.00302	0.0606
Chromium	12.1	52.3	81	8.21	--	0.00920	0.184	7.18	--	0.00830	0.166	8.75	--	0.00880	0.176	9.30	--	0.00907	0.181
Chromium (III)	12.1	x	x	8.21	--	2.61	7.53	7.18	--	2.38	6.86	8.75	--	2.67	7.69	9.30	--	2.52	7.27
Chromium (VI)	<3.48	x	x	<2.60	U	2.60	7.35	<2.37	U	2.37	6.69	<2.66	U	2.66	7.52	<2.51	U	2.51	7.09
Copper	7.62	18.7	34	5.58	V	0.0123	0.0615	4.79	V	0.0111	0.0555	7.33	V	0.0117	0.0588	7.38	V	0.0121	0.0606
Lead	13.2	30.24	46.7	9.12	--	0.0153	0.153	7.90	--	0.0138	0.138	9.88	--	0.0147	0.147	10.2	--	0.0151	0.151
Mercury	0.0397	0.13	0.15	0.0146	J	0.00963	0.0193	0.0161	J	0.00971	0.0194	0.0194	--	0.00915	0.0183	0.0196	J	0.0116	0.0232
Nickel	13.2	15.9	20.9	9.57	--	0.0615	0.0615	8.41	--	0.0555	0.0555	11.0	--	0.0588	0.0588	11.3	--	0.0606	0.0606
Selenium	2.13	x	x	1.82	--	0.0615	0.307	1.59	--	0.0555	0.277	1.91	--	0.0588	0.293	1.86	--	0.0606	0.302
Silver	0.0336	0.73	1	0.0211	J	0.00153	0.0307	0.0189	J	0.00138	0.0277	0.0236	J	0.00147	0.0293	0.0269	J	0.00151	0.0302
Thallium	0.0991	x	x	0.0829	--	0.00153	0.0307	0.0742	--	0.00138	0.0277	0.0902	--	0.00147	0.0293	0.0960	--	0.00151	0.0302
Zinc	49.4	124	150	33.0	--	0.307	0.613	30.3	--	0.277	0.553	38.2	--	0.294	0.586	36.1	--	0.303	0.604
Others																			
Ammonia (as nitrogen)	111	x	x	111	--	14.9	29.9	24.9	J	13.9	27.8	38.1	--	14.8	29.6	37.3	--	14.5	29.0
Cyanide, Total	<0.0467	x	x	<0.0352	U	0.0352	0.0704	<0.0351	U	0.0351	0.0703	<0.0363	U	0.0363	0.0725	<0.0350	U	0.0350	0.0699
Petroleum Hydrocarbons, Total	26.1	x	x	<6.88	--	6.88	25	<6.88	--	6.88	25	<6.88	--	6.88	25	<6.88	--	6.88	25
Analyte	**Maximum Conc. %**	**TEL %**	**ERL %**	**Result %**	**Qualifier**	**MDL**	**LRL**	**Result %**	**Qualifier**	**MDL**	**LRL**	**Result %**	**Qualifier**	**MDL**	**LRL**	**Result %**	**Qualifier**	**MDL**	**LRL**
Solids, Total	89.0	x	x	67.0	--	0.100	0.100	71.9	--	0.100	0.100	67.6	--	0.100	0.100	68.1	--	0.100	0.100
Carbon, Total Organic	0.64	x	x	0.31	--	0.02	0.1	0.22	--	0.02	0.1	0.27	--	0.02	0.1	0.27	--	0.02	0.1
Analyte	**pH units Range**	**TEL pH units**	**ERL pH units**	**Result pH units**	**Qualifier**	**MDL**	**LRL**	**Result pH units**	**Qualifier**	**MDL**	**LRL**	**Result pH units**	**Qualifier**	**MDL**	**LRL**	**Result pH units**	**Qualifier**	**MDL**	**LRL**
pH	8.13 - 9.47	x	x	9.27	H		0.100	9.47	H		0.100	9.37	H		0.100	9.35	H		0.100

TABLE 4 (*continued*)

Analytical Results for Dry Weight Metals, Ammonia, Total Cyanide, TPHs, Total Solids, Lipids, TOCs, and pH in Sediment Samples

			DMMU:	CDP-04				CDP-05				Reference (Offshore)				ODMDS			
			Sample ID:	CDP-04 Composite				CDP-05 Composite				CDP-REF				CDP-ODMDS			
Analyte	**Maximum Conc. mg/kg**	**TEL mg/kg**	**ERL mg/kg**	**Result mg/kg**	**Qualifier**	**MDL**	**LRL**	**Result mg/kg**	**Qualifier**	**MDL**	**LRL**	**Result mg/kg**	**Qualifier**	**MDL**	**LRL**	**Result mg/kg**	**Qualifier**	**MDL**	**LRL**
Metals																			
Antimony	<0.421	x	x	<0.0360	U	0.0360	0.0721	<0.0427	U	0.0427	0.0855	<0.0397	U	0.0397	0.0796	<0.268	U, A	0.268	0.538
Arsenic	7.31	7.24	8.2	5.78	--	0.00360	0.0360	6.62	--	0.00427	0.0427	2.80	--	0.00397	0.0397	<0.0268	U, A	0.0268	0.268
Beryllium	0.693	x	x	0.623	--	0.000721	0.0144	0.693	--	0.000855	0.0171	0.380	--	0.000796	0.0159	<0.00538	U, A	0.00538	0.107
Cadmium	0.107	0.676	1.2	0.0418	J	0.00360	0.0721	0.0410	J	0.00427	0.0855	0.0346	J	0.00397	0.0796	<0.0268	A, U	0.0268	0.538
Chromium	12.1	52.3	81	10.9	--	0.0108	0.216	12.1	--	0.0128	0.256	6.47	--	0.0119	0.238	<0.0805	A, B, U	0.0805	1.61
Chromium (III)	12.1	x	x	10.9	--	3.06	8.84	12.1	--	3.46	9.98	6.47	J	3.50	10.1	<2.22	U	2.22	7.66
Chromium (VI)	<3.48	x	x	<3.05	U	3.05	8.63	<3.44	U	3.44	9.72	<3.48	U	3.48	9.84	<2.14	U	2.14	6.05
Copper	7.62	18.7	34	6.70	V	0.0144	0.0721	7.62	V	0.0171	0.0855	4.18	V	0.0159	0.0796	<0.107	U, A	0.107	0.538
Lead	13.2	30.24	46.7	12.4	--	0.0180	0.180	13.2	--	0.0213	0.213	6.72	--	0.00397	0.0397	<0.0268	A, U	0.0268	0.268
Mercury	0.0397	0.13	0.15	0.0328	--	0.00953	0.0191	0.0382	--	0.00970	0.0194	0.0175	J	0.0113	0.0227	0.00526	J	0.00506	0.0101
Nickel	13.2	15.9	20.9	11.7	--	0.0721	0.0721	13.2	--	0.0855	0.0855	6.92	--	0.0796	0.0796	<0.538	U, A	0.538	0.538
Selenium	2.13	x	x	1.97	--	0.0721	0.360	2.13	--	0.0855	0.427	1.36	--	0.0796	0.397	<0.538	A, U	0.538	2.68
Silver	0.0336	0.73	1	0.0307	J	0.00180	0.0360	0.0336	J	0.00214	0.0427	0.0203	J	0.00199	0.0397	<0.0134	A, U	0.0134	0.268
Thallium	0.0991	x	x	0.0991	--	0.00180	0.0360	0.112	--	0.00214	0.0427	0.0638	--	0.00199	0.0397	<0.0134	A, U	0.0134	0.268
Zinc	49.4	124	150	46.6	--	0.360	0.719	49.4	--	0.428	0.853	24.4	--	0.0796	0.159	<0.538	U	0.538	1.07
Others																			
Ammonia (as nitrogen)	111	x	x	39.2	--	17.9	35.9	46.0	--	20.5	41.1	35.5	J	19.2	38.4	<12.6	U	12.6	25.2
Cyanide, Total	<0.0467	x	x	<0.0449	U	0.0449	0.0897	<0.0467	U	0.0467	0.0933	<0.0439	U	0.0439	0.0877	<0.0347	U	0.0347	0.0694
Petroleum Hydrocarbons, Total	26.1	x	x	<6.88	--	6.88	25	26.1	--	6.88	25	<6.88	--	6.88	25	<3.74	U	3.74	11.2
Analyte	**Maximum Conc. %**	**TEL %**	**ERL %**	**Result %**	**Qualifier**	**MDL**	**LRL**	**Result %**	**Qualifier**	**MDL**	**LRL**					**Result %**	**Qualifier**	**MDL**	**LRL**
Solids, Total	89.0	x	x	55.7	--	0.100	0.100	48.7	--	0.100	0.100	51.8	--	0.100	0.100	79.2	HR	0.100	0.100
Carbon, Total Organic	0.64	x	x	0.61	--	0.02	0.1	0.64	--	0.02	0.1	0.51	--	0.02	0.10	0.10	J	0.02	0.10
Analyte	**pH units Range**	**TEL pH units**	**ERL pH units**	**Result pH units**	**Qualifier**	**MDL**	**LRL**	**Result pH units**	**Qualifier**	**MDL**	**LRL**					**Result pH units**	**Qualifier**	**MDL**	**LRL**
pH	8.13 - 9.47	x	x	8.93	H		0.100	8.96	H		0.100	8.75	H		0.100	8.43	H		0.100

< #.## = The analyte was not detected (ND) at or above the MDL. The value indicates the MDL.

Qualifiers: A = Detection limit elevated due to abundance of non-target analyte. B = Analyte was found in the associated method blank. H = The parameter was analyzed outside the method specified holding time. J = Estimated value - The reported value is between the detection limit and reporting limit. U = Indicates that the compound was analyzed for but not detected. V = Analyte was detected in both sample and method blank.

Sources: All results from NWDLS with the exception of the organotins, cyanide, and TOC results which came from ALS; TEL and ERL values from Buchman (2008). Compiled by: ANAMAR Environmental Consulting, Inc.

TABLE 5

Analytical Results for Dry Weight Pesticides and Total PCBs in Sediment Samples

			DMMU:	CDP-01				CDP-02				CDP-03				CDP-03 Duplicate			
			Sample ID:	CDP-01 Composite				CDP-02 Compposite				CDP-03 Composite				CDP-03 Duplicate Composite			
Analyte	Maximum Conc. µg/kg	TEL µg/kg	ERL µg/kg	Result µg/kg	Qualifier	MDL	LRL	Result µg/kg	Qualifier	MDL	LRL	Result µg/kg	Qualifier	MDL	LRL	Result µg/kg	Qualifier	MDL	LRL
Aldrin	<0.616	x	x	<0.432	U	0.432	1.44	<0.410	U	0.410	1.37	<0.429	U	0.429	1.43	<0.416	U	0.416	1.39
Chlordane (technical)	**<0.616**	2.26	0.5	<0.432	U	0.432	1.44	<0.410	U	0.410	1.37	<0.429	U	0.429	1.43	<0.416	U	0.416	1.39
α (cis)-Chlordane	<0.616	x	x	<0.432	U	0.432	1.44	<0.410	U	0.410	1.37	<0.429	U	0.429	1.43	<0.416	U	0.416	1.39
γ (trans)-Chlordane	<0.616	x	x	<0.432	U	0.432	1.44	<0.410	U	0.410	1.37	<0.429	U	0.429	1.43	<0.416	U	0.416	1.39
p,p' (4,4')-DDD	<0.616	1.22	2	<0.432	U	0.432	1.44	<0.410	U	0.410	1.37	<0.429	U	0.429	1.43	<0.416	U	0.416	1.39
p,p' (4,4')-DDE	<0.616	2.07	2.2	<0.432	U	0.432	1.44	<0.410	U	0.410	1.37	<0.429	U	0.429	1.43	<0.416	U	0.416	1.39
p,p' (4,4')-DDT	<0.616	1.19	1	<0.432	U	0.432	1.44	<0.410	U	0.410	1.37	<0.429	U	0.429	1.43	<0.416	U	0.416	1.39
Dieldrin	**<0.616**	0.72	0.02	**<0.432**	U	0.432	1.44	**<0.410**	U	0.410	1.37	**<0.429**	U	0.429	1.43	**<0.416**	U	0.416	1.39
Endosulfan I	<0.616	x	x	<0.432	U	0.432	1.44	<0.410	U	0.410	1.37	<0.429	U	0.429	1.43	<0.416	U	0.416	1.39
Endosulfan II	<0.616	x	x	<0.432	U	0.432	1.44	<0.410	U	0.410	1.37	<0.429	U	0.429	1.43	<0.416	U	0.416	1.39
Endosulfan Sulfate	<0.616	x	x	<0.432	U	0.432	1.44	<0.410	U	0.410	1.37	<0.429	U	0.429	1.43	<0.416	U	0.416	1.39
Endrin	<0.616	x	x	<0.432	U	0.432	1.44	<0.410	U	0.410	1.37	<0.429	U	0.429	1.43	<0.416	U	0.416	1.39
Endrin Aldehyde	<0.616	x	x	<0.432	U	0.432	1.44	<0.410	U	0.410	1.37	<0.429	U	0.429	1.43	<0.416	U	0.416	1.39
Endrin Ketone	<0.616	x	x	<0.432	U	0.432	1.44	<0.410	U	0.410	1.37	<0.429	U	0.429	1.43	<0.416	U	0.416	1.39
Heptachlor	<0.616	x	x	<0.432	U	0.432	1.44	<0.410	U	0.410	1.37	<0.429	U	0.429	1.43	<0.416	U	0.416	1.39
Heptachlor Epoxide	<0.616	x	x	<0.432	U	0.432	1.44	<0.410	U	0.410	1.37	<0.429	U	0.429	1.43	<0.416	U	0.416	1.39
α-BHC	<0.616	x	x	<0.432	U	0.432	1.44	<0.410	U	0.410	1.37	<0.429	U	0.429	1.43	<0.416	U	0.416	1.39
β-BHC	<0.616	x	x	<0.432	U	0.432	1.44	<0.410	U	0.410	1.37	<0.429	U	0.429	1.43	<0.416	U	0.416	1.39
δ-BHC	0.585	x	x	<0.432	C+, U	0.432	1.44	<0.410	C+, U	0.410	1.37	<0.429	C+, U	0.429	1.43	<0.416	C+, U	0.416	1.39
γ-BHC (Lindane)	**<0.616**	0.32	x	**<0.432**	U	0.432	1.44	**<0.410**	U	0.410	1.37	**<0.429**	U	0.429	1.43	**<0.416**	U	0.416	1.39
Methoxychlor	<0.616	x	x	<0.432	C+, U	0.432	1.44	<0.410	C+, U	0.410	1.37	<0.429	C+, U	0.429	1.43	<0.416	C+, U	0.416	1.39
Toxaphene	**<30.8**	0.1	x	**<21.6**	U	21.6	21.6	**<20.5**	U	20.5	20.5	**<21.4**	U	21.4	21.4	**<20.8**	U	20.8	20.8
PCBs, Total	<2.05	21.6	22.7	<1.45	U	1.45	2.91	<1.34	U	1.34	2.69	<1.45	U	1.45	2.90	<1.41	U	1.41	2.83

TABLE 5 (*continued)*
Analytical Results for Dry Weight Pesticides and Total PCBs in Sediment Samples

DMMU:	DMMU:			CDP-04				CDP-05				Reference (Offshore)				ODMDS			
Sample ID:	Sample ID:			CDP-04 Composite				CDP-05 Composite				CDP-REF				CDP-ODMDS			
Analyte	Maximum Conc. µg/kg	TEL µg/kg	ERL µg/kg	Result µg/kg	Qualifier	MDL	LRL	Result µg/kg	Qualifier	MDL	LRL	Result µg/kg	Qualifier	MDL	LRL	Result µg/kg	Qualifier	MDL	LRL
Aldrin	<0.616	x	x	<0.538	U	0.538	1.79	<0.616	U	0.616	2.05	<0.579	U	0.579	1.93	<0.369	U	0.369	1.23
Chlordane (technical)	**<0.616**	2.26	0.5	**<0.538**	U	0.538	1.79	**<0.616**	U	0.616	2.05	**<0.579**	U	0.579	1.93	<0.369	U	0.369	1.23
α (cis)-Chlordane	<0.616	x	x	<0.538	U	0.538	1.79	<0.616	U	0.616	2.05	<0.579	U	0.579	1.93	<0.369	U	0.369	1.23
γ (trans)-Chlordane	<0.616	x	x	<0.538	U	0.538	1.79	<0.616	U	0.616	2.05	<0.579	U	0.579	1.93	<0.369	U	0.369	1.23
p,p' (4,4')-DDD	<0.616	1.22	2	<0.538	U	0.538	1.79	<0.616	U	0.616	2.05	<0.579	U	0.579	1.93	<0.369	U	0.369	1.23
p,p' (4,4')-DDE	<0.616	2.07	2.2	<0.538	C+, U	0.538	1.79	<0.616	C+, U	0.616	2.05	<0.579	C+, U	0.579	1.93	<0.369	U	0.369	1.23
p,p' (4,4')-DDT	<0.616	1.19	1	<0.538	U	0.538	1.79	<0.616	U	0.616	2.05	<0.579	U	0.579	1.93	<0.369	U	0.369	1.23
Dieldrin	**<0.616**	0.72	0.02	**<0.538**	U	0.538	1.79	**<0.616**	U	0.616	2.05	**<0.579**	U	0.579	1.93	**<0.369**	U	0.369	1.23
Endosulfan I	<0.616	x	x	<0.538	U	0.538	1.79	<0.616	U	0.616	2.05	<0.579	U	0.579	1.93	<0.369	U	0.369	1.23
Endosulfan II	<0.616	x	x	<0.538	U	0.538	1.79	<0.616	U	0.616	2.05	<0.579	U	0.579	1.93	<0.369	U	0.369	1.23
Endosulfan Sulfate	<0.616	x	x	<0.538	U	0.538	1.79	<0.616	U	0.616	2.05	<0.579	U	0.579	1.93	<0.369	U	0.369	1.23
Endrin	<0.616	x	x	<0.538	U	0.538	1.79	<0.616	U	0.616	2.05	<0.579	U	0.579	1.93	<0.369	U	0.369	1.23
Endrin Aldehyde	<0.616	x	x	<0.538	U	0.538	1.79	<0.616	U	0.616	2.05	<0.579	U	0.579	1.93	<0.369	U	0.369	1.23
Endrin Ketone	<0.616	x	x	<0.538	U	0.538	1.79	<0.616	U	0.616	2.05	<0.579	U	0.579	1.93	<0.369	U	0.369	1.23
Heptachlor	<0.616	x	x	<0.538	U	0.538	1.79	<0.616	U	0.616	2.05	<0.579	U	0.579	1.93	<0.369	U	0.369	1.23
Heptachlor Epoxide	<0.616	x	x	<0.538	U	0.538	1.79	<0.616	U	0.616	2.05	<0.579	U	0.579	1.93	<0.369	U	0.369	1.23
α-BHC	<0.616	x	x	<0.538	C+, U	0.538	1.79	<0.616	C+, U	0.616	2.05	<0.579	C+, U	0.579	1.93	<0.369	U	0.369	1.23
β-BHC	<0.616	x	x	<0.538	U	0.538	1.79	<0.616	U	0.616	2.05	<0.579	U	0.579	1.93	<0.369	U	0.369	1.23
δ-BHC	0.585	x	x	<0.538	U	0.538	1.79	<0.616	U	0.616	2.05	<0.579	U	0.579	1.93	<0.369	U	0.369	1.23
γ-BHC (Lindane)	**<0.616**	0.32	x	**<0.538**	U	0.538	1.79	**<0.616**	U	0.616	2.05	**<0.579**	U	0.579	1.93	**<0.369**	U	0.369	1.23
Methoxychlor	<0.616	x	x	<0.538	U	0.538	1.79	<0.616	U	0.616	2.05	<0.579	U	0.579	1.93	<0.369	U	0.369	1.23
Toxaphene	**<30.8**	0.1	x	**<26.9**	U	26.9	26.9	**<30.8**	U	30.8	30.8	**<28.9**	U	28.9	28.9	**<18.5**	U	18.5	18.5
PCBs, Total	<2.05	21.6	22.7	<1.79	U	1.79	3.59	<2.05	U	2.05	4.11	<1.93	U	1.93	3.86	<1.24	U	1.24	2.47

Bolded values meet or exceed the TEL and (or) ERL.

< #.## = The analyte was not detected (ND) at or above the MDL. The value indicates the MDL.

Qualifier definitions: C+ = The associated calibration QC is higher than the established quality control criteria for accuracy - no hit in sample; data not affected and acceptable to report.
U = Indicates that the compound was analyzed for but not detected.

Sources: Results from NWDLS; TEL and ERL values from Buchman (2008). Compiled by: ANAMAR Environmental Consulting, Inc.

TABLE 6
Analytical Results for Dry Weight PAHs in Sediment Samples

			DMMU:	CDP-01				CDP-02				CDP-03				CDP-03 Duplicate				CDP-04				CDP-05				Reference (Offshore)				ODMDS			
			Sample ID:	CDP-01 Composite				CDP-02 Composite				CDP-03 Composite				CDP-03 Duplicate Composite				CDP-04 Composite				CDP-05 Composite				CDP-REF				CDP-ODMDS			
Analyte	Maximum Conc. µg/kg	TEL µg/kg	ERL µg/kg	Result µg/kg	Qualifier	MDL	LRL	Result µg/kg	Qualifier	MDL	LRL	Result µg/kg	Qualifier	MDL	LRL	Result µg/kg	Qualifier	MDL	LRL	Result µg/kg	Qualifier	MDL	LRL	Result µg/kg	Qualifier	MDL	LRL	Result µg/kg	Qualifier	MDL	LRL	Result µg/kg	Qualifier	MDL	LRL
Acenaphthene^{LPAH}	<2.57	6.71	16	<1.83	U	1.83	3.66	<1.67	U	1.67	3.33	<1.77	U	1.77	3.54	<1.77	U	1.77	3.54	<2.24	U	2.24	4.49	<2.57	U	2.57	5.13	<2.41	U	2.41	4.82	<1.56	U	1.56	3.12
Acenaphthylene^{LPAH}	<2.57	5.87	44	<1.83	U	1.83	3.66	<1.67	U	1.67	3.33	<1.77	U	1.77	3.54	<1.77	U	1.77	3.54	<2.24	U	2.24	4.49	<2.57	U	2.57	5.13	<2.41	U	2.41	4.82	<1.56	U	1.56	3.12
Anthracene^{LPAH}	<2.57	46.9	85.3	<1.83	U	1.83	3.66	<1.67	U	1.67	3.33	<1.77	U	1.77	3.54	<1.77	U	1.77	3.54	<2.24	U	2.24	4.49	<2.57	U	2.57	5.13	<2.41	U	2.41	4.82	<1.56	U	1.56	3.12
Benzo(a)anthracene^{HPAH}	<2.57	74.8	261	<1.83	U	1.83	3.66	<1.67	U	1.67	3.33	<1.77	U	1.77	3.54	<1.77	U	1.77	3.54	<2.24	U	2.24	4.49	<2.57	U	2.57	5.13	<2.41	U	2.41	4.82	<1.56	U	1.56	3.12
Benzo(a)pyrene^{HPAH}	<2.57	88.8	430	<1.83	U	1.83	3.66	<1.67	U	1.67	3.33	<1.77	U	1.77	3.54	<1.77	U	1.77	3.54	<2.24	U	2.24	4.49	<2.57	U	2.57	5.13	<2.41	U	2.41	4.82	<1.56	U	1.56	3.12
Benzo(b&k)fluoranthene^{HPAH}	<5.14	x	x	<3.66	U	3.66	7.32	<3.34	U	3.34	3.34	<3.54	U	3.54	7.08	<3.54	U	3.54	7.08	<4.48	U	4.48	8.96	<5.14	U	5.14	10.26	<4.82	U	4.82	9.64	<1.56	U	1.56	3.12
Benzo(g,h,i)perylene^{HPAH}	<2.57	x	x	<1.83	U	1.83	3.66	<1.67	U	1.67	3.33	<1.77	U	1.77	3.54	<1.77	U	1.77	3.54	<2.24	U	2.24	4.49	<2.57	U	2.57	5.13	<2.41	U	2.41	4.82	<1.56	U	1.56	3.12
Chrysene^{HPAH}	<2.57	108	384	<1.83	U	1.83	3.66	<1.67	U	1.67	3.33	<1.77	U	1.77	3.54	<1.77	U	1.77	3.54	<2.24	U	2.24	4.49	<2.57	U	2.57	5.13	<2.41	U	2.41	4.82	<1.56	U	1.56	3.12
Dibenzo(a,h)anthracene^{HPAH}	<2.57	6.22	63.4	<1.83	U	1.83	3.66	<1.67	U	1.67	3.33	<1.77	U	1.77	3.54	<1.77	U	1.77	3.54	<2.24	U	2.24	4.49	<2.57	U	2.57	5.13	<2.41	U	2.41	4.82	<1.56	U	1.56	3.12
Fluoranthene^{HPAH}	<2.57	113	600	<1.83	U	1.83	3.66	<1.67	U	1.67	3.33	<1.77	U	1.77	3.54	<1.77	U	1.77	3.54	<2.24	U	2.24	4.49	<2.57	U	2.57	5.13	<2.41	U	2.41	4.82	<1.56	U	1.56	3.12
Fluorene^{LPAH}	<2.57	21.2	19	<1.83	U	1.83	3.66	<1.67	U	1.67	3.33	<1.77	U	1.77	3.54	<1.77	U	1.77	3.54	<2.24	U	2.24	4.49	<2.57	U	2.57	5.13	<2.41	U	2.41	4.82	<1.56	U	1.56	3.12
Indeno(1,2,3-cd)pyrene^{HPAH}	<2.57	x	x	<1.83	U	1.83	3.66	<1.67	U	1.67	3.33	<1.77	U	1.77	3.54	<1.77	U	1.77	3.54	<2.24	U	2.24	4.49	<2.57	U	2.57	5.13	<2.41	U	2.41	4.82	<1.56	U	1.56	3.12
Naphthalene^{LPAH}	<2.57	34.6	160	<1.83	U	1.83	3.66	<1.67	U	1.67	3.33	<1.77	U	1.77	3.54	<1.77	U	1.77	3.54	<2.24	U	2.24	4.49	<2.57	U	2.57	5.13	<2.41	U	2.41	4.82	<1.56	U	1.56	3.12
Phenanthrene^{LPAH}	<2.57	86.7	240	<1.83	U	1.83	3.66	<1.67	U	1.67	3.33	<1.77	U	1.77	3.54	<1.77	U	1.77	3.54	<2.24	U	2.24	4.49	<2.57	U	2.57	5.13	<2.41	U	2.41	4.82	<1.56	U	1.56	3.12
Pyrene^{HPAH}	<2.57	153	665	<1.83	U	1.83	3.66	<1.67	U	1.67	3.33	<1.77	U	1.77	3.54	<1.77	U	1.77	3.54	<2.24	U	2.24	4.49	<2.57	U	2.57	5.13	<2.41	U	2.41	4.82	<1.56	U	1.56	3.12
Total LPAHs	15.4	312	552	11.0				10.0				10.6				10.6				13.4				15.4				14.5				9.36			
Total HPAHs	25.7	655	1700	18.3				16.7				17.7				17.7				22.4				25.7				24.1				14.0			
Total PAHs	41.1	1684	4022	29.3				26.7				28.3				28.3				35.8				41.1				38.6				23.4			

LPAH = Low molecular weight PAH as defined in the *Regional Implementation Agreement* by USEPA/USACE (2003).

HPAH = High molecular weight PAH as defined in the *Regional Implementation Agreement* by USEPA/USACE (2003).

< #.## = The analyte was not detected (ND) at or above the MDL. The value indicates the MDL.

For calculating total PAHs, U-qualified results use the MDL and J-qualified results use the value reported by the laboratory.

Qualifiers: U = Indicates that the compound was analyzed for but not detected.

Sources: Results from NWDLS; TEL and ERL values from Buchman (2008).

Compiled by: ANAMAR Environmental Consulting, Inc.

TABLE 7

Analytical Results for Dry Weight SVOCs in Sediment Samples

			DMMU:	CDP-01				CDP-02				CDP-03				CDP-03			
			Sample ID:	CDP-01 Composite				CDP-02 Composite				CDP-03 Composite				CDP-03 Duplicate Composite			
Analyte	Maximum Conc. µg/kg	TEL µg/kg	ERL µg/kg	Result µg/kg	Qualifier	MDL	LRL	Result µg/kg	Qualifier	MDL	LRL	Result µg/kg	Qualifier	MDL	LRL	Result µg/kg	Qualifier	MDL	LRL
1,2,4-Trichlorobenzene	<2.57	x	x	<1.83	U	1.83	3.66	<1.67	U	1.67	3.33	<1.77	U	1.77	3.54	<1.77	U	1.77	3.54
1,2-Dichlorobenzene	<2.57	x	x	<1.83	U	1.83	3.66	<1.67	U	1.67	3.33	<1.77	U	1.77	3.54	<1.77	U	1.77	3.54
1,2-Diphenylhydrazine	<2.57	x	x	<1.83	U	1.83	3.66	<1.67	U	1.67	3.33	<1.77	U	1.77	3.54	<1.77	U	1.77	3.54
1,3-Dichlorobenzene	<2.57	x	x	<1.83	U	1.83	3.66	<1.67	U	1.67	3.33	<1.77	U	1.77	3.54	<1.77	U	1.77	3.54
1,4-Dichlorobenzene	<2.57	x	x	<1.83	U	1.83	3.66	<1.67	U	1.67	3.33	<1.77	U	1.77	3.54	<1.77	U	1.77	3.54
2,4,6-Trichlorophenol	<5.13	x	x	<3.66	U	3.66	7.32	<3.33	U	3.33	6.67	<3.54	U	3.54	7.08	<3.54	U	3.54	7.09
2,4-Dichlorophenol	<5.13	x	x	<3.66	U	3.66	7.32	<3.33	U	3.33	6.67	<3.54	U	3.54	7.08	<3.54	U	3.54	7.09
2,4-Dimethylphenol	<5.13	x	x	<3.66	U	3.66	7.32	<3.33	U	3.33	6.67	<3.54	U	3.54	7.08	<3.54	U	3.54	7.09
2,4-Dinitrophenol	<5.13	x	x	<3.66	U	3.66	7.32	<3.33	U	3.33	6.67	<3.54	U	3.54	7.08	<3.54	U	3.54	7.09
2,4-Dinitrotoluene (2,4-DNT)	<2.57	x	x	<1.83	U	1.83	3.66	<1.67	U	1.67	3.33	<1.77	U	1.77	3.54	<1.77	U	1.77	3.54
2,6-Dinitrotoluene (2,6-DNT)	<2.57	x	x	<1.83	U	1.83	3.66	<1.67	U	1.67	3.33	<1.77	U	1.77	3.54	<1.77	U	1.77	3.54
2-Chloronaphthalene	<2.57	x	x	<1.83	U	1.83	3.66	<1.67	U	1.67	3.33	<1.77	U	1.77	3.54	<1.77	U	1.77	3.54
2-Chlorophenol	<5.13	x	x	<3.66	U	3.66	7.32	<3.33	U	3.33	6.67	<3.54	U	3.54	7.08	<3.54	U	3.54	7.09
2-Nitrophenol	<5.13	x	x	<3.66	U	3.66	7.32	<3.33	U	3.33	6.67	<3.54	U	3.54	7.08	<3.54	U	3.54	7.09
3,3'-Dichlorobenzidine	<2.57	x	x	<1.83	U	1.83	3.66	<1.67	U	1.67	3.33	<1.77	U	1.77	3.54	<1.77	U	1.77	3.54
4,6-Dinitro-o-Cresol	<20.5	x	x	<14.6	U	14.6	29.3	<13.3	U	13.3	26.7	<14.2	U	14.2	28.3	<14.2	U	14.2	28.3
4-Bromophenyl phenyl ether (BDE-3)	<2.57	x	x	<1.83	U	1.83	3.66	<1.67	U	1.67	3.33	<1.77	U	1.77	3.54	<1.77	U	1.77	3.54
4-Chlorophenyl phenyl ether	<2.57	x	x	<1.83	U	1.83	3.66	<1.67	U	1.67	3.33	<1.77	U	1.77	3.54	<1.77	U	1.77	3.54
4-Nitrophenol	<2.57	x	x	<1.83	U	1.83	3.66	<1.67	U	1.67	3.33	<1.77	U	1.77	3.54	<1.77	U	1.77	3.54
Benzidine	<2.57	x	x	<1.83	U	1.83	3.66	<1.67	U	1.67	3.33	<1.77	U	1.77	3.54	<1.77	U	1.77	3.54
Bis(2-Chloroethoxy) methane	<2.57	x	x	<1.83	U	1.83	3.66	<1.67	U	1.67	3.33	<1.77	U	1.77	3.54	<1.77	U	1.77	3.54
Bis(2-Chloroethyl) ether	<2.57	x	x	<1.83	U	1.83	3.66	<1.67	U	1.67	3.33	<1.77	U	1.77	3.54	<1.77	U	1.77	3.54
Bis(2-chloroisopropyl) ether	<2.57	x	x	<1.83	U	1.83	3.66	<1.67	U	1.67	3.33	<1.77	U	1.77	3.54	<1.77	U	1.77	3.54
Bis(2-ethylhexyl) phthalate	6.15	182	x	6.15	V	1.83	3.66	6.02	V	1.67	3.33	5.57	V	1.77	3.54	6.09	V	1.77	3.54
Butyl benzyl phthalate	<2.57	x	x	<1.83	U	1.83	3.66	<1.67	U	1.67	3.33	<1.77	U	1.77	3.54	<1.77	U	1.77	3.54
Diethyl phthalate	<2.57	x	x	<1.83	U	1.83	3.66	<1.67	U	1.67	3.33	<1.77	U	1.77	3.54	<1.77	U	1.77	3.54
Dimethyl phthalate	<2.57	x	x	<1.83	U	1.83	3.66	<1.67	U	1.67	3.33	<1.77	U	1.77	3.54	<1.77	U	1.77	3.54
Di-n-butyl phthalate	9.13	x	x	9.13	V	1.83	3.66	8.27	V	1.67	3.33	7.10	V	1.77	3.54	8.50	V	1.77	3.54
Di-n-octyl phthalate	<2.57	x	x	<1.83	U	1.83	3.66	<1.67	U	1.67	3.33	<1.77	U	1.77	3.54	<1.77	U	1.77	3.54
Hexachlorobenzene	<2.57	x	x	<1.83	U	1.83	3.66	<1.67	U	1.67	3.33	<1.77	U	1.77	3.54	<1.77	U	1.77	3.54
Hexachlorobutadiene	<2.57	x	x	<1.83	U	1.83	3.66	<1.67	U	1.67	3.33	<1.77	U	1.77	3.54	<1.77	U	1.77	3.54
Hexachlorocyclopentadiene	<2.57	x	x	<1.83	U	1.83	3.66	<1.67	U	1.67	3.33	<1.77	U	1.77	3.54	<1.77	U	1.77	3.54
Hexachloroethane	<2.57	x	x	<1.83	U	1.83	3.66	<1.67	U	1.67	3.33	<1.77	U	1.77	3.54	<1.77	U	1.77	3.54
Isophorone	<2.57	x	x	<1.83	U	1.83	3.66	<1.67	U	1.67	3.33	<1.77	U	1.77	3.54	<1.77	U	1.77	3.54
Nitrobenzene	<2.57	x	x	<1.83	U	1.83	3.66	<1.67	U	1.67	3.33	<1.77	U	1.77	3.54	<1.77	U	1.77	3.54
N-Nitrosodimethylamine	<2.57	x	x	<1.83	U	1.83	36.6	<1.67	U	1.67	33.3	<1.77	U	1.77	35.4	<1.77	U	1.77	35.4
N-Nitrosodi-n-propylamine	<2.57	x	x	<1.83	U	1.83	3.66	<1.67	U	1.67	3.33	<1.77	U	1.77	3.54	<1.77	U	1.77	3.54
N-Nitrosodiphenylamine	<2.57	x	x	<1.83	U	1.83	3.66	<1.67	U	1.67	3.33	<1.77	U	1.77	3.54	<1.77	U	1.77	3.54
P-Chloro-m-Cresol	<5.13	x	x	<3.66	U	3.66	7.32	<3.33	U	3.33	6.67	<3.54	U	3.54	7.08	<3.54	U	3.54	7.09
Pentachlorophenol	<5.13	x	x	<3.66	U	3.66	7.32	<3.33	U	3.33	6.67	<3.54	U	3.54	7.08	<3.54	U	3.54	7.09
Phenol, Total	6.29	x	x	4.77	J	3.66	7.32	4.19	J	3.33	6.67	4.48	J	3.54	7.08	5.54	J	3.54	7.09

TABLE 7 (*continued*)
Analytical Results for Dry Weight SVOCs in Sediment Samples

DMMU:	CDP-04				CDP-05				Reference (Offshore)				ODMDS			
Sample ID:	CDP-04 Composite				CDP-05 Composite				CDP-REF				CDP-ODMDS			
Analyte	Result µg/kg	Qualifier	MDL	LRL	Result µg/kg	Qualifier	MDL	LRL	Result µg/kg	Qualifier	MDL	LRL	Result µg/kg	Qualifier	MDL	LRL
1,2,4-Trichlorobenzene	<2.24	U	2.24	4.49	<2.57	U	2.57	5.13	<2.41	U	2.41	4.82	<1.56	U	1.56	3.12
1,2-Dichlorobenzene	<2.24	U	2.24	4.49	<2.57	U	2.57	5.13	<2.41	U	2.41	4.82	<1.56	U	1.56	3.12
1,2-Diphenylhydrazine	<2.24	U	2.24	4.49	<2.57	U	2.57	5.13	<2.41	U	2.41	4.82	<1.56	U	1.56	3.12
1,3-Dichlorobenzene	<2.24	U	2.24	4.49	<2.57	U	2.57	5.13	<2.41	U	2.41	4.82	<1.56	U	1.56	3.12
1,4-Dichlorobenzene	<2.24	U	2.24	4.49	<2.57	U	2.57	5.13	<2.41	U	2.41	4.82	<1.56	U	1.56	3.12
2,4,6-Trichlorophenol	<4.49	U	4.49	8.97	<5.13	U	5.13	10.3	<4.82	U	4.82	9.65	<3.12	U	3.12	6.24
2,4-Dichlorophenol	<4.49	U	4.49	8.97	<5.13	U	5.13	10.3	<4.82	U	4.82	9.65	<3.12	U	3.12	6.24
2,4-Dimethylphenol	<4.49	U	4.49	8.97	<5.13	U	5.13	10.3	<4.82	U	4.82	9.65	<3.12	U	3.12	6.24
2,4-Dinitrophenol	<4.49	U	4.49	8.97	<5.13	U	5.13	10.3	<4.82	U	4.82	9.65	<3.12	U	3.12	6.24
2,4-Dinitrotoluene (2,4-DNT)	<2.24	U	2.24	4.49	<2.57	U	2.57	5.13	<2.41	U	2.41	4.82	<1.56	U	1.56	3.12
2,6-Dinitrotoluene (2,6-DNT)	<2.24	U	2.24	4.49	<2.57	U	2.57	5.13	<2.41	U	2.41	4.82	<1.56	U	1.56	3.12
2-Chloronaphthalene	<2.24	U	2.24	4.49	<2.57	U	2.57	5.13	<2.41	U	2.41	4.82	<1.56	U	1.56	3.12
2-Chlorophenol	<4.49	U	4.49	8.97	<5.13	U	5.13	10.3	<4.82	U	4.82	9.65	<3.12	U	3.12	6.24
2-Nitrophenol	<4.49	U	4.49	8.97	<5.13	U	5.13	10.3	<4.82	U	4.82	9.65	<3.12	U	3.12	6.24
3,3'-Dichlorobenzidine	<2.24	U	2.24	4.49	<2.57	U	2.57	5.13	<2.41	U	2.41	4.82	<1.56	U	1.56	3.12
4,6-Dinitro-o-Cresol	<17.9	U	17.9	35.9	<20.5	U	20.5	41.1	<19.3	U	19.3	38.6	<12.5	U	12.5	25.0
4-Bromophenyl phenyl ether (BDE-3)	<2.24	U	2.24	4.49	<2.57	U	2.57	5.13	<2.41	U	2.41	4.82	<1.56	U	1.56	3.12
4-Chlorophenyl phenyl ether	<2.24	U	2.24	4.49	<2.57	U	2.57	5.13	<2.41	U	2.41	4.82	<1.56	U	1.56	3.12
4-Nitrophenol	<2.24	U	2.24	4.49	<2.57	U	2.57	5.13	<2.41	U	2.41	4.82	<1.56	U	1.56	3.12
Benzidine	<2.24	U	2.24	4.49	<2.57	U	2.57	5.13	<2.41	U	2.41	4.82	<1.56	U	1.56	3.12
Bis(2-Chloroethoxy) methane	<2.24	U	2.24	4.49	<2.57	U	2.57	5.13	<2.41	U	2.41	4.82	<1.56	U	1.56	3.12
Bis(2-Chloroethyl) ether	<2.24	U	2.24	4.49	<2.57	U	2.57	5.13	<2.41	U	2.41	4.82	<1.56	U	1.56	3.12
Bis(2-chloroisopropyl) ether	<2.24	U	2.24	4.49	<2.57	U	2.57	5.13	<2.41	U	2.41	4.82	<1.56	U	1.56	3.12
Bis(2-ethylhexyl) phthalate	3.74	V, J	2.24	4.49	3.48	V, J	2.57	5.13	5.37	V	2.41	4.82	2.49	V, J	1.56	3.12
Butyl benzyl phthalate	<2.24	U	2.24	4.49	<2.57	U	2.57	5.13	<2.41	U	2.41	4.82	<1.56	U	1.56	3.12
Diethyl phthalate	<2.24	U	2.24	4.49	<2.57	U	2.57	5.13	2.43	J	2.41	4.82	<1.56	U	1.56	3.12
Dimethyl phthalate	<2.24	U	2.24	4.49	<2.57	U	2.57	5.13	<2.41	U	2.41	4.82	<1.56	U	1.56	3.12
Di-n-butyl phthalate	3.55	V, J	2.24	4.49	<2.57	B, U	2.57	5.13	<2.41	B, U	2.41	4.82	5.69	V	1.56	3.12
Di-n-octyl phthalate	<2.24	U	2.24	4.49	<2.57	U	2.57	5.13	<2.41	U	2.41	4.82	<1.56	U	1.56	3.12
Hexachlorobenzene	<2.24	U	2.24	4.49	<2.57	U	2.57	5.13	<2.41	U	2.41	4.82	<1.56	U	1.56	3.12
Hexachlorobutadiene	<2.24	U	2.24	4.49	<2.57	U	2.57	5.13	<2.41	U	2.41	4.82	<1.56	U	1.56	3.12
Hexachlorocyclopentadiene	<2.24	U	2.24	4.49	<2.57	U	2.57	5.13	<2.41	U	2.41	4.82	<1.56	U	1.56	3.12
Hexachloroethane	<2.24	U	2.24	4.49	<2.57	U	2.57	5.13	<2.41	U	2.41	4.82	<1.56	U	1.56	3.12
Isophorone	<2.24	U	2.24	4.49	<2.57	U	2.57	5.13	<2.41	U	2.41	4.82	<1.56	U	1.56	3.12
Nitrobenzene	<2.24	U	2.24	4.49	<2.57	U	2.57	5.13	<2.41	U	2.41	4.82	<1.56	U	1.56	3.12
N-Nitrosodimethylamine	<2.24	U	2.24	44.9	<2.57	U	2.57	51.3	<2.41	U	2.41	48.2	<1.56	U	1.56	3.12
N-Nitrosodi-n-propylamine	<2.24	U	2.24	4.49	<2.57	U	2.57	5.13	<2.41	U	2.41	4.82	<1.56	U	1.56	3.12
N-Nitrosodiphenylamine	<2.24	U	2.24	4.49	<2.57	U	2.57	5.13	<2.41	U	2.41	4.82	<1.56	U	1.56	3.12
P-Chloro-m-Cresol	<4.49	U	4.49	8.97	<5.13	U	5.13	10.3	<4.82	U	4.82	9.65	<3.12	U	3.12	6.24
Pentachlorophenol	<4.49	U	4.49	8.97	<5.13	U	5.13	10.3	<4.82	U	4.82	9.65	<3.12	U	3.12	6.24
Phenol, Total	5.80	J	4.49	8.97	6.29	J	5.13	10.3	6.19	J	4.82	9.65	3.20	J	3.12	6.24

< #.## = The analyte was not detected (ND) at or above the MDL. The value indicates the MDL. DMMUs CDP-07, CDP-08, CDP-09 did not have sub-samples collected for B stations
Qualifiers: B = Analyte was found in the associated method blank. CQb = CCV out of control high, no hits in samples, data not affected. J = Estimated value - The reported value is between the detection limit and reporting limit.
U = Indicates that the compound was analyzed for but not detected. V = Analyte was detected in both sample and method blank.
Sources: Results from NWDLS; TEL and ERL values from Buchman (2008). Compiled by: ANAMAR Environmental Consulting, Inc.

TABLE 8

Analytical Results for Metals, Organotins, Ammonia, TOCs, Total Cyanide, TSSs, TPHs, and Salinity in Site Water and Elutriates Generated from Sediment

			Sample ID:	CDP-01-W				CDP-01-E				CDP-02-W				CDP-02-E				CDP-03-W				CDP-03-E			
Analyte	Maximum Conc. µg/L	CMC µg/L	TWQS Acute µg/L	Result µg/L	Qualifier	MDL	LRL	Result µg/L	Qualifier	MDL	LRL	Result µg/L	Qualifier	MDL	LRL	Result µg/L	Qualifier	MDL	LRL	Result µg/L	Qualifier	MDL	LRL	Result µg/L	Qualifier	MDL	LRL
Metals																											
Antimony	3.87	x	x	<1.00	U	1.00	5.00	3.86	J	1.00	5.00	<1.00	U	1.00	5.00	3.70	J	1.00	5.00	<1.00	U	1.00	5.00	3.87	J	1.00	5.00
Arsenic	14.9	69	149	1.91	J	0.500	2.50	14.9	CQe	0.500	2.50	2.12	J	0.500	2.50	14.4	CQe	0.500	2.50	1.96	J	0.500	2.50	14.1	CQe	0.500	2.50
Beryllium	<0.100	x	x	<0.0500	U	0.0500	1.00	<0.0500	CQd, U	0.0500	1.00	<0.0500	U	0.0500	1.00	<0.0500	CQd, U	0.0500	1.00	<0.0500	U	0.0500	1.00	<0.0500	CQd, U	0.0500	1.00
Cadmium	<0.500	40	40.0	<0.250	U	0.250	5.00	<0.250	U	0.250	5.00	<0.250	U	0.250	5.00	<0.250	U	0.250	5.00	<0.250	U	0.250	5.00	<0.250	U	0.250	5.00
Chromium	1.48	x	x	0.570	V, J	0.400	15.0	1.48	CQb, J	0.400	15.0	0.635	V, J	0.400	15.0	<0.400	CQf, U	0.400	15.0	0.659	J	0.400	15.0	<0.400	CQf, U	0.400	15.0
Chromium (III)	<2.30	x	x	<2.28	U	2.28	18.8	<1.90	U	1.90	18.0	<1.90	U	1.90	18.0	<1.90	U	1.90	18.0	<2.28	U	2.28	18.8	<1.90	U	1.90	18.0
Chromium (VI)	10.8	1100	1090	7.05	--	1.88	3.75	<0.00150	U	0.00150	0.00300	10.8	--	1.50	3.00	0.00228	J	0.00150	0.00300	9.00	--	1.88	3.75	0.00160	J	0.00150	0.00300
Copper	**15.7**	4.8	13.5	**6.03**	--	1.00	5.00	<1.00	B, CQf, U	1.00	5.00	<1.00	U	1.00	5.00	<1.00	B, CQf, U	1.00	5.00	<1.00	B, U	1.00	5.00	<1.00	B, CQf, U	1.00	5.00
Lead	1.87	210	133	<0.500	U	0.500	2.50	<0.500	CQf, U	0.500	2.50	<0.500	U	0.500	2.50	1.87	CQg, J	0.500	2.50	<0.500	U	0.500	2.50	<0.500	CQf, U	0.500	2.50
Mercury	<0.150	1.8	2.1	<0.150	U	0.150	0.200	<0.150	U	0.150	0.200	<0.150	U	0.150	0.200	<0.150	U	0.150	0.200	<0.150	U	0.150	0.200	<0.150	U	0.150	0.200
Nickel	15.9	74	118	0.436	B, J	0.250	5.00	3.11	CQe, J	0.250	5.00	0.419	B, J	0.250	5.00	15.9	CQe	0.250	5.00	0.431	J	0.250	5.00	1.41	J	0.250	5.00
Selenium	<3.30	290	564	<1.65	U	1.65	25.0	2.16	J	1.65	25.0	<1.65	U	1.65	25.0	2.12	J	1.65	25.0	<1.65	U	1.65	25.0	2.37	J	1.65	25.0
Silver	<0.300	1.9	2	<0.150	U	0.150	2.50	<0.150	U	0.150	2.50	<0.150	U	0.150	2.50	<0.150	U	0.150	2.50	<0.150	U	0.150	2.50	<0.150	U	0.150	2.50
Thallium	<0.300	x	x	<0.150	U	0.150	2.50	<0.150	U	0.150	2.50	<0.150	U	0.150	2.50	<0.150	U	0.150	2.50	<0.150	U	0.150	2.50	<0.150	U	0.150	2.50
Zinc	4.38	90	92.7	<1.00	B, U	1.00	10.0	<1.00	B, CQd, U	1.00	10.0	3.34	V, J	1.00	10.0	3.75	CQe, V, J	1.00	10.0	<1.00	U	1.00	10.0	<1.00	B, CQd, U	1.00	10.0
Others																											
Analyte	**Maximum Conc. mg/L**	**CMC mg/L**	**TWQS Acute mg/L**	**Result mg/L**	**Qualifier**	**MDL**	**LRL**	**Result mg/L**	**Qualifier**	**MDL**	**LRL**	**Result mg/L**	**Qualifier**	**MDL**	**LRL**	**Result mg/L**	**Qualifier**	**MDL**	**LRL**	**Result mg/L**	**Qualifier**	**MDL**	**LRL**	**Result mg/L**	**Qualifier**	**MDL**	**LRL**
Ammonia (as nitrogen)	2.14	x	x	0.0932	--	0.0200	0.0500	1.89	--	0.100	0.250	0.551	--	0.0200	0.0500	1.88	--	0.100	0.250	0.480	--	0.0200	0.0500	2.07	--	0.100	0.250
Carbon, Total Organic	3.1	x	x	1.4	--	0.35	1	3.1	--	0.35	1	1.1	--	0.35	1	2.2	--	0.35	1	<0.35	--	0.35	1	2.0	--	0.35	1
Cyanide, Total	0.001	0.001	0.0056	0.001	J	0.0005	0.02	0.001	J	0.0005	0.02	0.001	J	0.0005	0.02	0.001	J	0.0005	0.02	0.001	J	0.0005	0.02	0.001	J	0.0005	0.02
Residual-nonfilterable (TSS)	28.6	x	x	3.79	--	1.00	1.00	28.6	CQc	1.00	1.00	3.58	B1	1.00	1.00	4.10	CQc	1.00	1.00	2.63	--	1.00	1.00	3.03	CQc	1.00	1.00
Petroleum Hydrocarbons, Total (TPHs)	2.82	x	x	<0.18	--	0.18	6.45	<0.18	--	0.18	6.45	2.25	--	0.18	6.45	<0.18	--	0.18	6.45	<0.18	--	0.18	6.45	0.507	--	0.18	6.45

TABLE 8 (*continued*)

Analytical Results for Metals, Organotins, Ammonia, TOCs, Total Cyanide, TSSs, TPHs, and Salinity in Site Water and Elutriates

Sample ID:	CDP-DUP-E (Offshore)*				CDP-04-W				CDP-04-E				CDP-05-W				CDP-05-E				CDP-REF-W (Offshore)				CDP-ODMDS-W			
Analyte	Result µg/L	Qualifier	MDL	LRL	Result µg/L	Qualifier	MDL	LRL	Result µg/L	Qualifier	MDL	LRL	Result µg/L	Qualifier	MDL	LRL	Result µg/L	Qualifier	MDL	LRL	Result µg/L	Qualifier	MDL	LRL	Result µg/L	Qualifier	MDL	LRL
Metals																												
Antimony	2.64	J	1.00	5.00	<1.00	U	1.00	5.00	1.99	J	1.00	5.00	<1.00	U	1.00	5.00	1.52	J	1.00	5.00	<1.00	U	1.00	5.00	<2.00	A, U	2.00	10.0
Arsenic	12.2	CQe	0.500	2.50	2.12	J	0.500	2.50	9.72	CQe	0.500	2.50	1.92	J	0.500	2.50	7.34	CQe	0.500	2.50	1.89	J	0.500	2.50	6.65	--	1.00	5.00
Beryllium	<0.0500	CQd, U	0.0500	1.00	<0.0500	U	0.0500	1.00	<0.0500	CQd, U	0.0500	1.00	<0.0500	U	0.0500	1.00	<0.0500	CQd, U	0.0500	1.00	<0.0500	U	0.0500	1.00	<0.100	A, U	0.100	2.00
Cadmium	<0.250	U	0.250	5.00	<0.250	U	0.250	5.00	<0.250	U	0.250	5.00	<0.250	U	0.250	5.00	<0.250	U	0.250	5.00	<0.250	U	0.250	5.00	<0.500	A, U	0.500	10.0
Chromium	<0.400	CQf, U	0.400	15.0	0.835	V, J	0.400	15.0	<0.400	CQf, U	0.400	15.0	0.653	V, J	0.400	15.0	<0.400	CQf, U	0.400	15.0	1.34	V, J	0.400	15.0	<0.800	A, U	0.800	30.0
Chromium (III)	<1.90	U	1.90	18.0	<1.90	U	1.90	18.0	<1.90	U	1.90	18.0	<1.90	U	1.90	18.0	<1.90	U	1.90	18.0	<1.90	U	1.90	18.0	<2.30	U	2.30	33.0
Chromium (VI)	<0.00150	U	0.00150	0.00300	<1.50	U	1.50	3.00	0.00211	J	0.00150	0.00300	2.90	J	1.50	3.00	<0.00150	U	0.00150	0.00300	<1.50	U	1.50	3.00	6.34	--	1.50	3.00
Copper	<1.00	B, CQf, U	1.00	5.00	3.49	J	1.00	5.00	<1.00	B, CQf, U	1.00	5.00	<1.00	U	1.00	5.00	<1.00	B, CQf, U	1.00	5.00	**15.7**	--	1.00	5.00	<2.00	A, B, U	2.00	10.0
Lead	<0.500	CQf, U	0.500	2.50	<0.500	U	0.500	2.50	<0.500	CQf, U	0.500	2.50	<0.500	U	0.500	2.50	<0.500	CQf, U	0.500	2.50	<0.500	U	0.500	2.50	<1.00	A, U	1.00	5.00
Mercury	<0.150	U	0.150	0.200	<0.150	U	0.150	0.200	<0.150	U	0.150	0.200	<0.150	U	0.150	0.200	<0.150	U	0.150	0.200	<0.150	U	0.150	0.200	<0.150	U	0.150	0.200
Nickel	4.56	CQe, J	0.250	5.00	1.26	B, J	0.250	5.00	0.791	CQe, J	0.250	5.00	0.534	B, J	0.250	5.00	0.969	CQe, J	0.250	5.00	1.52	B, J	0.250	5.00	1.20	V, J	0.500	10.0
Selenium	2.44	J	1.65	25.0	<1.65	U	1.65	25.0	<1.65	U	1.65	25.0	<1.65	U	1.65	25.0	<1.65	U	1.65	25.0	<1.65	U	1.65	25.0	<3.30	A, U	3.30	50.0
Silver	<0.150	U	0.150	2.50	<0.150	U	0.150	2.50	<0.150	U	0.150	2.50	<0.150	U	0.150	2.50	<0.150	U	0.150	2.50	<0.150	U	0.150	2.50	<0.300	U	0.300	5.00
Thallium	<0.150	U	0.150	2.50	<0.150	U	0.150	2.50	<0.150	U	0.150	2.50	<0.150	U	0.150	2.50	<0.150	U	0.150	2.50	<0.150	U	0.150	2.50	<0.300	A, U	0.300	5.00
Zinc	1.12	CQe, V, J	1.00	10.0	1.58	V, J	1.00	10.0	<1.00	B, CQd, U	1.00	10.0	4.38	V, J	1.00	10.0	1.34	CQe, V, J	1.00	10.0	1.65	V, J	1.00	10.0	<2.00	A, U	2.00	20.0
Others																												
Analyte	Result mg/L	Qualifier	MDL	LRL	Result mg/L	Qualifier	MDL	LRL	Result mg/L	Qualifier	MDL	LRL	Result mg/L	Qualifier	MDL	LRL	Result mg/L	Qualifier	MDL	LRL					Result mg/L	Qualifier	MDL	LRL
Ammonia (as nitrogen)	2.14	--	0.100	0.250	0.210	--	0.0200	0.0500	1.05	--	0.100	0.250	0.322	--	0.0200	0.0500	1.18	--	0.100	0.250	0.355	--	0.0200	0.0500	0.480	--	0.0200	0.0500
Carbon, Total Organic	2.0	--	0.35	1.00	1.1	--	0.35	1	2.0	--	0.35	1	<0.35	--	0.35	1.00	2.0	--	0.35	1.00	1.3	--	0.35	1.00	0.16	J	0.07	0.50
Cyanide, Total	0.001	J	0.0005	0.020	0.001	J	0.0005	0.02	0.001	J	0.0005	0.02	0.001	J	0.0005	0.020	0.001	J	0.0005	0.020	0.001	J	0.0005	0.020	<0.0005	U	0.0005	0.020
Residual-nonfilterable (TSS)	7.37	CQc	1.00	1.00	2.95	--	1.00	1.00	14.3	CQc	1.00	1.00	3.26	--	1.00	1.00	9.89	CQc	1.00	1.00	2.84	B1	1.00	1.00	3.05	--	1.00	1.00
Petroleum Hydrocarbons, Total	<0.18	--	0.18	6.45	2.82	--	0.18	6.45	<0.18	--	0.18	6.45	<0.18	--	0.18	6.45	<0.18	--	0.18	6.45	<0.18	--	0.18	6.45	<0.442	U	0.442	4.42

Bolded values meet or exceed the CMC and (or) Texas surface water quality (acute) standard.

< #.## = The analyte was not detected (ND) at or above the MDL (U-qualified). The value indicates the MDL.

* = The sediment for the offshore duplicate elutriate sample (CDP-DUP-E) was collected from CDP-03 (Core #2).

Qualifiers: A = Detection limit elevated due to abundance of non-target analyte. B = Analyte was found in the associated method blank. CQd = The analyte was detected in both sample and leach blank. CQe = The analyte was found in the associated leach blank. CQf = The analyte was found in the associated leach blank. CQg = The analyte was found in the associated leach blank. J = Estimated value - The reported value is between the detection limit and reporting limit. V = Analyte was detected in both sample and method blank.

Sources: All results from NWDLS with the exception of the organotin, cyanide, and TOC results which came from ALS; CMC values from EPA (2015); Texas surface water quality (acute) standards from Texas Commission on Environmental Quality (2018).

Compiled by: ANAMAR Environmental Consulting, Inc.

TABLE 9

Analytical Results for Pesticides and Total PCBs in Site Water and Elutriates Generated from Sediment

			Sample ID:	CDP-01-W				CDP-01-E				CDP-02-W				CDP-02-E				CDP-03-W				CDP-03-E				CDP-DUP-E (Offshore)			
Analyte	**Maximum Conc. µg/L**	**CMC µg/L**	**TWQS Acute µg/L**	**Result µg/L**	**Qualifier**	**MDL**	**LRL**	**Result µg/L**	**Qualifier**	**MDL**	**LRL**	**Result µg/L**	**Qualifier**	**MDL**	**LRL**	**Result µg/L**	**Qualifier**	**MDL**	**LRL**	**Result µg/L**	**Qualifier**	**MDL**	**LRL**	**Result µg/L**	**Qualifier**	**MDL**	**LRL**	**Result µg/L**	**Qualifier**	**MDL**	**LRL**
Aldrin	<0.00600	1.3	1.3	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	U	0.00600	0.00600
Chlordane (technical)	<0.00600	0.09	0.09	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	U	0.00600	0.00600
α (cis)-Chlordane	<0.00600	x	x	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	U	0.00600	0.00600
γ (trans)-Chlordane	<0.00600	x	x	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	U	0.00600	0.00600
p,p' (4,4')-DDD	<0.00600	x	x	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	U	0.00600	0.00600
p,p' (4,4')-DDE	<0.00600	x	x	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	U	0.00600	0.00600
p,p' (4,4')-DDT	<0.00600	0.13	0.13	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	U	0.00600	0.00600
Dieldrin	<0.00600	0.71	0.71	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	U	0.00600	0.00600
Endosulfan I	<0.00600	0.034	0.034	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	U	0.00600	0.00600
Endosulfan II	<0.00600	0.034	0.034	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	U	0.00600	0.00600
Endosulfan Sulfate	<0.00600	x	0.034	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	U	0.00600	0.00600
Endrin	<0.00600	0.037	0.037	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	U	0.00600	0.00600
Endrin Aldehyde	<0.00600	x	x	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	U	0.00600	0.00600
Endrin Ketone	<0.00600	x	x	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	U	0.00600	0.00600
Heptachlor	<0.00600	0.053	0.053	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	U	0.00600	0.00600
Heptachlor Epoxide	<0.00600	0.053	x	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	U	0.00600	0.00600
α-BHC	<0.00600	x	x	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	U	0.00600	0.00600
β-BHC	<0.00600	x	x	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	U	0.00600	0.00600
δ-BHC	<0.00600	x	x	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	U	0.00600	0.00600
γ-BHC (Lindane)	<0.00600	0.16	0.16	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	U	0.00600	0.00600
Methoxychlor	<0.00600	x	x	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	U	0.00600	0.00600
Toxaphene	**<0.300**	0.21	0.21	**<0.300**	C+, U	0.300	0.300	**<0.300**	U	0.300	0.300	**<0.300**	C+, U	0.300	0.300	**<0.300**	U	0.300	0.300	**<0.300**	C+, U	0.300	0.300	**<0.300**	U	0.300	0.300	**<0.300**	U	0.300	0.300
PCBs, Total	<0.00600	x	10	<0.00600	U	0.00600	0.120	<0.00600	U	0.00600	0.120	<0.00600	U	0.00600	0.120	<0.00600	U	0.00600	0.120	<0.00600	U	0.00600	0.120	<0.00600	U	0.00600	0.120	<0.00600	U	0.00600	0.120

TABLE 9 (*continued*)
Analytical Results for Pesticides and Total PCBs in Site Water and Elutriates Generated from Sediment

Sample ID:	CDP-04-W				CDP-04-E				CDP-05-W				CDP-05-E				CDP-REF-W (Offshore)				CDP-ODMDS-W			
Analyte	**Result µg/L**	**Qualifier**	**MDL**	**LRL**	**Result µg/L**	**Qualifier**	**MDL**	**LRL**	**Result µg/L**	**Qualifier**	**MDL**	**LRL**	**Result µg/L**	**Qualifier**	**MDL**	**LRL**	**Result µg/L**	**Qualifier**	**MDL**	**LRL**	**Result µg/L**	**Qualifier**	**MDL**	**LRL**
Aldrin	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00597	U	0.00597	0.00597
Chlordane (technical)	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00597	U	0.00597	0.00597
α (cis)-Chlordane	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00597	U	0.00597	0.00597
γ (trans)-Chlordane	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00597	CQ, U	0.00597	0.00597
p,p' (4,4')-DDD	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00597	CQ, U	0.00597	0.00597
p,p' (4,4')-DDE	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00597	U	0.00597	0.00597
p,p' (4,4')-DDT	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00597	U	0.00597	0.00597
Dieldrin	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00597	U	0.00597	0.00597
Endosulfan I	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00597	U	0.00597	0.00597
Endosulfan II	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00597	U	0.00597	0.00597
Endosulfan Sulfate	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00597	U	0.00597	0.00597
Endrin	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00597	U	0.00597	0.00597
Endrin Aldehyde	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00597	U	0.00597	0.00597
Endrin Ketone	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00597	U	0.00597	0.00597
Heptachlor	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00597	U	0.00597	0.00597
Heptachlor Epoxide	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00597	U	0.00597	0.00597
α-BHC	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00597	U	0.00597	0.00597
β-BHC	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00597	CQ, U	0.00597	0.00597
δ-BHC	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00597	U	0.00597	0.00597
γ-BHC (Lindane)	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00597	U	0.00597	0.00597
Methoxychlor	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00600	U	0.00600	0.00600	<0.00600	C+, U	0.00600	0.00600	<0.00597	U	0.00597	0.00597
Toxaphene	**<0.300**	C+, U	0.300	0.300	**<0.300**	U	0.300	0.300	**<0.300**	C+, U	0.300	0.300	**<0.300**	U	0.300	0.300	**<0.300**	C+, U	0.300	0.300	**<0.298**	U	0.298	0.298
PCBs, Total	<0.00600	U	0.00600	0.120	<0.00600	U	0.00600	0.120	<0.00600	U	0.00600	0.120	<0.00600	U	0.00600	0.120	<0.00600	U	0.00600	0.120	<0.00599	U	0.00599	0.120

Bolded values meet or exceed the CMC and (or) Texas surface water quality (acute) standard. < #.## = The analyte was not detected (ND) at or above the MDL (U-qualified). The value indicates the MDL.

* = The sediment for the offshore duplicate elutriate sample (CDP-DUP-E) was collected from CDP-03 (Core #2).

Qualifiers: CQ = Associated calibration blank QC is outside the established quality control criteria. C+ = The associated calibration QC is higher than the established quality control criteria for accuracy - no hit in sample; data not affected and acceptable to report.

Sources: Results from NWDLS; CMC values from EPA (2015); Texas surface water quality (acute) standards from Texas Commission on Environmental Quality (2018). Compiled by: ANAMAR Environmental Consulting, Inc.

TABLE 10

Analytical Results for PAHs in Site Water and Elutriates Generated from Sediment

			Sample ID:	CDP-01-W				CDP-01-E				CDP-02-W				CDP-02-E				CDP-03-W				CDP-03-E				CDP-DUP-E (Offshore)			
Analyte	**Maximum Conc. µg/L**	**CMC µg/L**	**TWQS Acute µg/L**	**Result µg/L**	**Qualifier**	**MDL**	**LRL**	**Result µg/L**	**Qualifier**	**MDL**	**LRL**	**Result µg/L**	**Qualifier**	**MDL**	**LRL**	**Result µg/L**	**Qualifier**	**MDL**	**LRL**	**Result µg/L**	**Qualifier**	**MDL**	**LRL**	**Result µg/L**	**Qualifier**	**MDL**	**LRL**	**Result µg/L**	**Qualifier**	**MDL**	**LRL**
Acenaphthene^{LPAH}	<0.281	x	x	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562
Acenaphthylene^{LPAH}	<0.281	x	x	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562
Anthracene^{LPAH}	<0.281	x	x	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562
Benzo(a)anthracene^{HPAH}	<0.281	x	x	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562
Benzo(a)pyrene^{HPAH}	<0.281	x	x	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562
Benzo(b&k)fluoranthene^{HPAH}	<0.562	x	x	<0.281	U	0.281	0.562	<0.562	U	0.562	1.124	<0.562	U	0.562	1.124	<0.562	U	0.562	1.124	<0.562	U	0.562	1.124	<0.562	U	0.562	1.124	<0.562	U	0.562	1.124
Benzo(g,h,i)perylene^{HPAH}	<0.281	x	x	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562
Chrysene^{HPAH}	<0.281	x	x	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562
Dibenzo(a,h)anthracene^{HPAH}	<0.281	x	x	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562
Fluoranthene^{HPAH}	<0.281	x	x	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562
Fluorene^{LPAH}	<0.281	x	x	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562
Indeno(1,2,3-cd)pyrene^{HPAH}	<0.281	x	x	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562
Naphthalene^{LPAH}	<0.281	x	x	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562
Phenanthrene^{LPAH}	<0.281	x	7.7	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562
Pyrene^{HPAH}	<0.281	x	x	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562
Total LPAHs	1.69	x	x	1.69				1.69				1.69				1.69				1.69				1.69				1.69			
Total HPAHs	2.81	x	x	2.81				2.81				2.81				2.81				2.81				2.81				2.81			
Total PAHs	4.50	x	x	4.50				4.50				4.50				4.50				4.50				4.50				4.50			

TABLE 10 (*continued*)

Analytical Results for PAHs in Site Water and Elutriates Generated from Sediment

Sample ID:	**CDP-04-W**				**CDP-04-E**				**CDP-05-W**				**CDP-05-E**				**CDP-REF-W (Offshore)**				**CDP-ODMDS-W**			
Analyte	**Result µg/L**	**Qualifier**	**MDL**	**LRL**	**Result µg/L**	**Qualifier**	**MDL**	**LRL**	**Result µg/L**	**Qualifier**	**MDL**	**LRL**	**Result µg/L**	**Qualifier**	**MDL**	**LRL**	**Result µg/L**	**Qualifier**	**MDL**	**LRL**	**Result µg/L**	**Qualifier**	**MDL**	**LRL**
Acenaphthene^{LPAH}	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.275	U	0.275	0.551	<0.278	U	0.278	0.557
Acenaphthylene^{LPAH}	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.275	U	0.275	0.551	<0.278	U	0.278	0.557
Anthracene^{LPAH}	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.275	U	0.275	0.551	<0.278	U	0.278	0.557
Benzo(a)anthracene^{HPAH}	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.275	U	0.275	0.551	<0.278	U	0.278	0.557
Benzo(a)pyrene^{HPAH}	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.275	U	0.275	0.551	<0.278	U	0.278	0.557
Benzo(b&k)fluoranthene^{HPAH}	<0.562	U	0.562	1.124	<0.562	U	0.562	1.124	<0.281	U	0.281	0.562	<0.562	U	0.562	1.124	<0.275	U	0.275	1.10	<0.278	U	0.278	1.11
Benzo(g,h,i)perylene^{HPAH}	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.275	U	0.275	0.551	<0.278	U	0.278	0.557
Chrysene^{HPAH}	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.275	U	0.275	0.551	<0.278	U	0.278	0.557
Dibenzo(a,h)anthracene^{HPAH}	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.275	U	0.275	0.551	<0.278	U	0.278	0.557
Fluoranthene^{HPAH}	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.275	U	0.275	0.551	<0.278	U	0.278	0.557
Fluorene^{LPAH}	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.275	U	0.275	0.551	<0.278	U	0.278	0.557
Indeno(1,2,3-cd)pyrene^{HPAH}	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.275	U	0.275	0.551	<0.278	U	0.278	0.557
Naphthalene^{LPAH}	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.275	U	0.275	0.551	<0.278	U	0.278	0.557
Phenanthrene^{LPAH}	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.275	U	0.275	0.551	<0.278	U	0.278	0.557
Pyrene^{HPAH}	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.275	U	0.275	0.551	<0.278	U	0.278	0.557
Total LPAHs	1.69				1.69				1.69				1.69				1.65				1.67			
Total HPAHs	2.81				2.81				2.81				2.81				2.48				2.50			
Total PAHs	4.50				4.50				4.50				4.50				4.13				4.17			

LPAH = Low molecular weight PAH as defined in the *Regional Implementation Agreement* by USEPA/USACE (2003).

HPAH = High molecular weight PAH as defined in the *Regional Implementation Agreement* by USEPA/USACE (2003).

< #.## = The analyte was not detected (ND) at or above the MDL. The value indicates the MDL. For calculating total PAHs, U-qualified results use the MDL and J-qualified results use the value reported by the laboratory.

* = The sediment for the offshore duplicate elutriate sample (CDP-DUP-E) was collected from CDP-03 (Core #2).

Qualifiers: U = Indicates that the compound was analyzed for but not detected.

Sources: Results from NWDLS; CMC values from EPA (2015); Texas surface water quality (acute) standards from Texas Commission on Environmental Quality (2018).

Compiled by: ANAMAR Environmental Consulting, Inc.

TABLE 11

Analytical Results for SVOCs in Site Water and Elutriates Generated from Sediment

			Sample ID:	CDP-01-W				CDP-01-E				CDP-02-W				CDP-02-E				CDP-03-W				CDP-03-E			
Analyte	Maximum Conc. µg/L	CMC µg/L	TWQS Acute µg/L	Result µg/L	Qualifier	MDL	LRL	Result µg/L	Qualifier	MDL	LRL	Result µg/L	Qualifier	MDL	LRL	Result µg/L	Qualifier	MDL	LRL	Result µg/L	Qualifier	MDL	LRL	Result µg/L	Qualifier	MDL	LRL
1,2,4-Trichlorobenzene	<0.281	x	x	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562
1,2-Dichlorobenzene	<0.281	x	x	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562
1,2-Diphenylhydrazine	<0.281	x	x	<0.281	U	0.281	0.562	<0.281	C+, U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	C+, U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	C+, U	0.281	0.562
1,3-Dichlorobenzene	<0.281	x	x	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562
1,4-Dichlorobenzene	<0.281	x	x	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562
2,4,6-Trichlorophenol	<0.560	x	x	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12
2,4-Dichlorophenol	<0.560	x	x	<0.560	U	0.560	1.12	<0.560	U	0.560	0.562	<0.560	U	0.560	1.12	<0.560	U	0.560	0.562	<0.560	U	0.560	1.12	<0.560	U	0.560	0.562
2,4-Dimethylphenol	<0.560	x	x	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12
2,4-Dinitrophenol	<4.50	x	x	<4.50	U	4.50	4.50	<4.50	U	4.50	4.50	<4.50	U	4.50	4.50	<4.50	U	4.50	4.50	<4.50	U	4.50	4.50	<4.50	U	4.50	4.50
2,4-Dinitrotoluene (2,4-DNT)	<0.281	x	x	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562
2,6-Dinitrotoluene (2,6-DNT)	<0.281	x	x	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562
2-Chloronaphthalene	<0.281	x	x	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562
2-Chlorophenol	<0.560	x	x	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12
2-Nitrophenol	<0.560	x	x	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12
3,3'-Dichlorobenzidine	<0.281	x	x	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562
4,6-Dinitro-o-Cresol	<0.560	x	x	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12
4-Bromophenyl phenyl ether (BDE-3)	<0.281	x	x	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562
4-Chlorophenyl phenyl ether	<0.281	x	x	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562
4-Nitrophenol	<4.50	x	x	<4.50	U	4.50	4.50	<4.50	U	4.50	4.50	<4.50	U	4.50	4.50	<4.50	U	4.50	4.50	<4.50	U	4.50	4.50	<4.50	U	4.50	4.50
Benzidine	<0.281	x	x	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562
Bis(2-Chloroethoxy) methane	<0.281	x	x	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562
Bis(2-Chloroethyl) ether	<0.281	x	x	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562
Bis(2-chloroisopropyl) ether	<0.281	x	x	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562
Bis(2-ethylhexyl) phthalate	0.553	x	x	<0.281	B, U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	B, U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	B, U	0.281	0.562	0.553	J	0.281	0.562
Butyl benzyl phthalate	<0.281	x	x	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562
Diethyl phthalate	3.08	x	x	<0.281	B, U	0.281	0.562	0.372	V, J	0.281	0.562	<0.281	B, U	0.281	0.562	<0.281	B, U	0.281	0.562	<0.281	B, U	0.281	0.562	3.08	V	0.281	0.562
Dimethyl phthalate	<0.281	x	x	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562
Di-n-butyl phthalate	3.96	x	x	<0.281	B, U	0.281	0.562	0.724	V, V2	0.281	0.562	<0.281	B, U	0.281	0.562	0.339	V, V2, J	0.281	0.562	<0.281	B, U	0.281	0.562	3.96	V, V2	0.281	0.562
Di-n-octyl phthalate	<0.281	x	x	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562
Hexachlorobenzene	<0.281	x	x	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562
Hexachlorobutadiene	<0.281	x	x	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562
Hexachlorocyclopentadiene	<0.281	x	x	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562
Hexachloroethane	<0.281	x	x	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562
Isophorone	<0.281	x	x	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562
Nitrobenzene	<0.281	x	x	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562
N-Nitrosodimethylamine	<0.281	x	x	<0.281	U	0.281	2.25	<0.281	U	0.281	2.25	<0.281	U	0.281	2.25	<0.281	U	0.281	2.25	<0.281	U	0.281	2.25	<0.281	U	0.281	2.25
N-Nitrosodi-n-propylamine	<0.281	x	x	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562
N-Nitrosodiphenylamine	<0.281	x	x	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562
P-Chloro-m-Cresol	<0.560	x	x	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12
Pentachlorophenol	<0.560	13	15.1	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12
Phenol, Total	2.00	x	x	1.57	V	0.560	1.12	1.36	V, V2	0.560	1.12	1.82	V	0.560	1.12	1.40	V, V2	0.560	1.12	1.89	V	0.560	1.12	1.51	V, V2	0.560	1.12

TABLE 11 (*continued*)
Analytical Results for SVOCs in Water and Elutriates Generated from Sediment

Sample ID:	CDP-04-W				CDP-04-E				CDP-05-W				CDP-05-E				CDP-REF-W				CDP-ODMDS-W			
Analyte	**Result µg/L**	**Qualifier**	**MDL**	**LRL**	**Result µg/L**	**Qualifier**	**MDL**	**LRL**	**Result µg/L**	**Qualifier**	**MDL**	**LRL**	**Result µg/L**	**Qualifier**	**MDL**	**LRL**	**Result µg/L**	**Qualifier**	**MDL**	**LRL**	**Result µg/L**	**Qualifier**	**MDL**	**LRL**
1,2,4-Trichlorobenzene	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.278	U	0.278	0.557
1,2-Dichlorobenzene	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.278	U	0.278	0.557
1,2-Diphenylhydrazine	<0.281	U	0.281	0.562	<0.281	C+, U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	C+, U	0.281	0.562	<0.281	U	0.281	0.562	<0.278	U	0.278	0.557
1,3-Dichlorobenzene	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.278	U	0.278	0.557
1,4-Dichlorobenzene	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.278	U	0.278	0.557
2,4,6-Trichlorophenol	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.555	U	0.555	1.11
2,4-Dichlorophenol	<0.560	U	0.560	1.12	<0.560	U	0.560	0.562	<0.560	U	0.560	1.12	<0.560	U	0.560	0.562	<0.560	U	0.560	1.12	<0.555	U	0.555	1.11
2,4-Dimethylphenol	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.555	U	0.555	1.11
2,4-Dinitrophenol	<4.50	U	4.50	4.50	<4.50	U	4.50	4.50	<4.50	U	4.50	4.50	<4.50	U	4.50	4.50	<4.50	U	4.50	4.50	<4.46	U	4.46	4.46
2,4-Dinitrotoluene (2,4-DNT)	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.278	U	0.278	0.557
2,6-Dinitrotoluene (2,6-DNT)	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.278	U	0.278	0.557
2-Chloronaphthalene	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.278	U	0.278	0.557
2-Chlorophenol	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.555	U	0.555	1.11
2-Nitrophenol	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.555	U	0.555	1.11
3,3'-Dichlorobenzidine	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.278	U	0.278	0.557
4,6-Dinitro-o-Cresol	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.555	U	0.555	1.11
4-Bromophenyl phenyl ether (BDE-3)	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.278	U	0.278	0.557
4-Chlorophenyl phenyl ether	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.278	U	0.278	0.557
4-Nitrophenol	<4.50	U	4.50	4.50	<4.50	U	4.50	4.50	<4.50	U	4.50	4.50	<4.50	U	4.50	4.50	<4.50	U	4.50	4.50	<4.46	U	4.46	4.46
Benzidine	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.278	U	0.278	0.557
Bis(2-Chloroethoxy) methane	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.278	U	0.278	0.557
Bis(2-Chloroethyl) ether	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.278	U	0.278	0.557
Bis(2-chloroisopropyl) ether	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.278	U	0.278	0.557
Bis(2-ethylhexyl) phthalate	<0.281	B, U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	B, U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	B, U	0.281	0.562	<0.278	U	0.278	0.557
Butyl benzyl phthalate	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.278	U	0.278	0.557
Diethyl phthalate	<0.281	B, U	0.281	0.562	<0.281	B, U	0.281	0.562	<0.281	B, U	0.281	0.562	0.289	V, J	0.281	0.562	<0.281	B, U	0.281	0.562	<0.278	B, U	0.278	0.557
Dimethyl phthalate	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.278	U	0.278	0.557
Di-n-butyl phthalate	<0.281	B, U	0.281	0.562	0.574	V, V2	0.281	0.562	<0.281	B, U	0.281	0.562	0.465	V, V2, J	0.281	0.562	<0.281	B, U	0.281	0.562	0.523	V, J	0.278	0.557
Di-n-octyl phthalate	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.278	U	0.278	0.557
Hexachlorobenzene	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.278	U	0.278	0.557
Hexachlorobutadiene	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.278	U	0.278	0.557
Hexachlorocyclopentadiene	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.278	U	0.278	0.557
Hexachloroethane	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.278	U	0.278	0.557
Isophorone	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.278	U	0.278	0.557
Nitrobenzene	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.278	U	0.278	0.557
N-Nitrosodimethylamine	<0.281	U	0.281	2.25	<0.281	U	0.281	2.25	<0.281	U	0.281	2.25	<0.281	U	0.281	2.25	<0.281	U	0.281	2.25	<0.278	U	0.278	2.23
N-Nitrosodi-n-propylamine	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.278	U	0.278	0.557
N-Nitrosodiphenylamine	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.281	U	0.281	0.562	<0.278	U	0.278	0.557
P-Chloro-m-Cresol	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.555	U	0.555	1.11
Pentachlorophenol	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.560	U	0.560	1.12	<0.555	U	0.555	1.11
Phenol, Total	2.00	V	0.560	1.12	1.07	V, V2, J	0.560	1.12	1.39	V	0.560	1.12	1.39	V, V2	0.560	1.12	1.46	V	0.560	1.12	0.814	J	0.555	1.11

< #.## = The analyte was not detected (ND) at or above the MDL. The value indicates the MDL.

* = The sediment for the offshore duplicate elutriate sample (CDP-DUP-E) was collected from CDP-03 (Core #2).

Qualifiers: B = Analyte was found in the associated method blank. J = Estimated value - The reported value is between the detection limit and reporting limit. U = Indicates that the compound was analyzed for but not detected.
V = Analyte was detected in both sample and method blank. V2 = The analyte was detected in the sample and the associated leach blank.

Sources: Results from NWDLS; CMC values from EPA (2015); Texas surface water quality (acute) standards from Texas Commission on Environmental Quality (2018).

Compiled by: ANAMAR Environmental Consulting, Inc.

TABLE 12

Analytical Results for Wet Weight Total Solids in M. mercenaria and A. virens Tissues

Analyte:	***Mercenaria mercenaria*** **Total Solids**				***Alitta virens*** **Total Solids**			
Sample-Replicate #	**Result %**	**Qualifier**	**MDL**	**MRL**	**Result %**	**Qualifier**	**MDL**	**MRL**
CDP-DMMU-01 Rep. 1	8.74	B	0.100	0.100	13.6	B	0.100	0.100
CDP-DMMU-01 Rep. 2	8.51	B	0.100	0.100	14.4	B	0.100	0.100
CDP-DMMU-01 Rep. 3	8.63	B	0.100	0.100	14.5	B	0.100	0.100
CDP-DMMU-01 Rep. 4	7.74	B	0.100	0.100	14.7	B	0.100	0.100
CDP-DMMU-01 Rep. 5	8.08	B	0.100	0.100	14.4	B	0.100	0.100
CDP-DMMU-02 Rep. 1	9.29	B	0.100	0.100	14.0	B	0.100	0.100
CDP-DMMU-02 Rep. 2	9.52	B	0.100	0.100	14.1	B	0.100	0.100
CDP-DMMU-02 Rep. 3	8.61	B	0.100	0.100	14.6	B	0.100	0.100
CDP-DMMU-02 Rep. 4	9.00	B	0.100	0.100	14.3	B	0.100	0.100
CDP-DMMU-02 Rep. 5	9.89	B	0.100	0.100	13.6	B	0.100	0.100
CDP-DMMU-03 Rep. 1	8.28	B	0.100	0.100	13.8	B	0.100	0.100
CDP-DMMU-03 Rep. 2	8.91	B	0.100	0.100	14.7	B	0.100	0.100
CDP-DMMU-03 Rep. 3	8.57	B	0.100	0.100	15.0	B	0.100	0.100
CDP-DMMU-03 Rep. 4	9.26	B	0.100	0.100	15.2	B	0.100	0.100
CDP-DMMU-03 Rep. 5	9.12	B	0.100	0.100	13.6	B	0.100	0.100
CDP-DMMU-04 Rep. 1	9.22	B	0.100	0.100	10.7	B	0.100	0.100
CDP-DMMU-04 Rep. 2	8.85	B	0.100	0.100	13.1	B	0.100	0.100
CDP-DMMU-04 Rep. 3	9.36	B	0.100	0.100	13.8	B	0.100	0.100
CDP-DMMU-04 Rep. 4	8.99	B	0.100	0.100	14.1	B	0.100	0.100
CDP-DMMU-04 Rep. 5	9.13	B	0.100	0.100	13.8	B	0.100	0.100
CDP-DMMU-05 Rep. 1	9.42	B	0.100	0.100	12.4	B	0.100	0.100
CDP-DMMU-05 Rep. 2	9.75	B	0.100	0.100	12.8	B	0.100	0.100
CDP-DMMU-05 Rep. 3	9.17	B	0.100	0.100	14.1	B	0.100	0.100
CDP-DMMU-05 Rep. 4	9.53	B	0.100	0.100	13.5	B	0.100	0.100
CDP-DMMU-05 Rep. 5	9.36	B	0.100	0.100	13.3	B	0.100	0.100
CDP-REF Rep. 1	8.75	B	0.100	0.100	13.3	B	0.100	0.100
CDP-REF Rep. 2	8.91	B	0.100	0.100	12.6	B	0.100	0.100
CDP-REF Rep. 3	8.69	B	0.100	0.100	13.8	B	0.100	0.100
CDP-REF Rep. 4	8.89	B	0.100	0.100	14.6	B	0.100	0.100
CDP-REF Rep. 5	8.37	B	0.100	0.100	11.7	B	0.100	0.100
Pre-exposure Rep. 1	9.78	B	0.100	0.100	14.3	B	0.100	0.100
Pre-exposure Rep. 2	9.83	B	0.100	0.100	15.1	B	0.100	0.100
Pre-exposure Rep. 3	10.6	B	0.100	0.100	15.8	B	0.100	0.100

Data qualifiers and acronyms are defined at the front of the tables section.

Source: Results from NWDLS
Compiled by: ANAMAR Environmental Consulting, Inc.

TABLE 13

Analytical Results for Wet Weight Metals in *Mercenaria mercenaria* Tissues

Analyte:	**Antimony**				**Arsenic**				**Beryllium**				**Cadmium**				**Chromium**				**Copper**				**Lead**			
Sample-Replicate #	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**
CDP-DMMU-01 Rep. 1	0.00181	J	0.00166	0.0206	1.37	--	0.00253	0.0103	0.00130	J	0.000206	0.00412	0.0596	--	0.000650	0.0206	0.0372	V, J	0.00151	0.0617	1.34	V	0.00179	0.0206	0.102	--	0.00155	0.0103
CDP-DMMU-01 Rep. 2	0.00187	J	0.00166	0.0206	1.45	--	0.00253	0.0103	0.00208	J	0.000206	0.00412	0.0538	--	0.000650	0.0206	0.0360	V, J	0.00151	0.0617	1.39	V	0.00179	0.0206	0.154	--	0.00155	0.0103
CDP-DMMU-01 Rep. 3	<0.00176	U	0.00176	0.0218	1.30	--	0.00269	0.0109	0.00162	J	0.000218	0.00437	0.0499	--	0.000690	0.0218	0.0286	V, J	0.00160	0.0655	1.17	V	0.00190	0.0218	0.0853	--	0.00165	0.0109
CDP-DMMU-01 Rep. 4	0.00167	J	0.00154	0.0192	1.45	--	0.00236	0.00958	0.00184	J	0.000192	0.00383	0.0548	--	0.000605	0.0192	0.0494	V, J	0.00141	0.0575	1.38	V	0.00167	0.0192	0.123	--	0.00145	0.00958
CDP-DMMU-01 Rep. 5	<0.00169	U	0.00169	0.0210	1.27	--	0.00258	0.0105	0.00168	J	0.000210	0.00420	0.0539	--	0.000664	0.0210	0.0357	V, J	0.00154	0.0630	1.24	V	0.00183	0.0210	0.116	--	0.00159	0.0105
CDP-01 Mean	0.00176				**1.37**				**0.00170**				0.0544				0.0374				1.30				0.116			
% of Reference	102				109				123				105				117				91				126			
CDP-DMMU-02 Rep. 1	<0.00150	U	0.00150	0.0186	1.45	--	0.00229	0.00929	0.00158	J	0.000186	0.00372	0.0530	--	0.000587	0.0186	0.0404	V, J	0.00137	0.0558	1.22	V	0.00162	0.0186	0.0938	--	0.00140	0.00929
CDP-DMMU-02 Rep. 2	<0.00152	U	0.00152	0.0189	1.48	--	0.00232	0.00943	0.00175	J	0.000189	0.00377	0.0564	--	0.000596	0.0189	0.0586	V	0.00139	0.0566	1.17	V	0.00164	0.0189	0.124	--	0.00142	0.00943
CDP-DMMU-02 Rep. 3	<0.00164	U	0.00164	0.0203	1.29	--	0.00250	0.0102	0.00150	J	0.000203	0.00407	0.0477	--	0.000642	0.0203	0.0402	V, J	0.00149	0.0610	1.51	V	0.00177	0.0203	0.167	--	0.00153	0.0102
CDP-DMMU-02 Rep. 4	<0.00161	U	0.00161	0.0200	1.29	--	0.00246	0.0100	0.00138	J	0.000200	0.00400	0.0520	--	0.000632	0.0200	0.0412	V, J	0.00147	0.0600	1.59	V	0.00174	0.0200	0.143	--	0.00151	0.0100
CDP-DMMU-02 Rep. 5	<0.00171	U	0.00171	0.0213	1.49	--	0.00262	0.0106	0.00162	J	0.000213	0.00426	0.0579	--	0.000672	0.0213	0.0370	V, J	0.00156	0.0638	1.32	V	0.00185	0.0213	0.0985	--	0.00161	0.0106
CDP-02 Mean	0.00160				1.40				0.00157				0.0534				0.0435				1.36				0.125			
% of Reference	92				111				113				103				136				95				136			
CDP-DMMU-03 Rep. 1	<0.00175	U	0.00175	0.0217	1.13	--	0.00267	0.0109	0.00172	J	0.000217	0.00435	0.0420	--	0.000687	0.0217	0.0375	V, J	0.00160	0.0652	1.55	V	0.00189	0.0217	0.144	--	0.00164	0.0109
CDP-DMMU-03 Rep. 2	0.00171	J	0.00166	0.0207	1.25	--	0.00254	0.0103	0.00161	J	0.000207	0.00413	0.0543	--	0.000653	0.0207	0.0313	V, J	0.00152	0.0620	1.31	V	0.00180	0.0207	0.157	--	0.00156	0.0103
CDP-DMMU-03 Rep. 3	0.00174	J	0.00161	0.0200	1.29	--	0.00246	0.0100	0.00170	J	0.000200	0.00400	0.0517	--	0.000632	0.0200	0.0388	V, J	0.00147	0.0600	1.28	V	0.00174	0.0200	0.117	--	0.00151	0.0100
CDP-DMMU-03 Rep. 4	<0.00175	U	0.00175	0.0217	1.15	--	0.00267	0.0109	0.00150	J	0.000217	0.00435	0.0570	--	0.000687	0.0217	0.0413	V, J	0.00160	0.0652	1.51	V	0.00189	0.0217	0.118	--	0.00164	0.0109
CDP-DMMU-03 Rep. 5	<0.00168	U	0.00168	0.0208	1.28	--	0.00256	0.0104	0.00165	J	0.000208	0.00417	0.0516	--	0.000658	0.0208	0.0355	V, J	0.00153	0.0625	1.26	V	0.00181	0.0208	0.120	--	0.00157	0.0104
CDP-03 Mean	0.00173				1.22				0.00164				0.0513				0.0369				1.38				***0.131***			
% of Reference	100				97				118				99				115				96				142			
CDP-DMMU-04 Rep. 1	<0.00168	U	0.00168	0.0208	1.07	--	0.00256	0.0104	0.00133	J	0.000208	0.00417	0.0518	--	0.000658	0.0208	0.0297	V, J	0.00153	0.0625	1.21	V	0.00181	0.0208	0.0836	--	0.00157	0.0104
CDP-DMMU-04 Rep. 2	<0.00140	U	0.00140	0.0174	1.13	--	0.00214	0.00871	0.00131	J	0.000174	0.00348	0.0506	--	0.000551	0.0174	0.0265	V, J	0.00128	0.0523	1.06	V	0.00152	0.0174	0.0852	--	0.00132	0.00871
CDP-DMMU-04 Rep. 3	0.00162	J	0.00154	0.0191	1.41	--	0.00235	0.00954	0.00151	J	0.000191	0.00382	0.0620	--	0.000603	0.0191	0.0327	V, J	0.00140	0.0573	1.27	V	0.00166	0.0191	0.102	--	0.00144	0.00954
CDP-DMMU-04 Rep. 4	<0.00186	U	0.00186	0.0231	1.28	--	0.00285	0.0116	0.00157	J	0.000231	0.00463	0.0515	--	0.000731	0.0231	0.0751	V	0.00170	0.0694	1.04	V	0.00201	0.0231	0.0688	--	0.00175	0.0116
CDP-DMMU-04 Rep. 5	<0.00143	U	0.00143	0.0178	1.27	--	0.00219	0.00890	0.00158	J	0.000178	0.00356	0.0689	--	0.000562	0.0178	0.0453	V, J	0.00131	0.0534	1.24	V	0.00155	0.0178	0.0943	--	0.00134	0.00890
CDP-04 Mean	0.00160				1.23				0.00146				0.0570				0.0419				1.16				0.0868			
% of Reference	92				98				105				110				131				81				94			
CDP-DMMU-05 Rep. 1	<0.00152	U	0.00152	0.0189	1.21	--	0.00233	0.00947	0.00159	J	0.000189	0.00379	0.0469	--	0.000598	0.0189	0.0352	V, J	0.00139	0.0568	1.34	V	0.00165	0.0189	0.0745	--	0.00143	0.00947
CDP-DMMU-05 Rep. 2	<0.00160	U	0.00160	0.0199	1.25	--	0.00245	0.00996	0.00157	J	0.000199	0.00398	0.0554	--	0.000629	0.0199	0.0310	V, J	0.00146	0.0598	1.24	V	0.00173	0.0199	0.0825	--	0.00150	0.00996
CDP-DMMU-05 Rep. 3	0.00242	J	0.00177	0.0220	1.21	--	0.00271	0.0110	0.00148	J	0.000220	0.00441	0.0441	--	0.000696	0.0220	0.0320	V, J	0.00162	0.0661	1.15	V	0.00192	0.0220	0.0869	--	0.00166	0.0110
CDP-DMMU-05 Rep. 4	<0.00156	U	0.00156	0.0194	1.23	--	0.00238	0.00969	0.00167	J	0.000194	0.00388	0.0460	--	0.000612	0.0194	0.0413	V, J	0.00142	0.0581	1.45	V	0.00169	0.0194	0.105	--	0.00146	0.00969
CDP-DMMU-05 Rep. 5	<0.00173	U	0.00173	0.0215	1.28	--	0.00264	0.0107	0.00165	J	0.000215	0.00429	0.0562	--	0.000678	0.0215	0.0399	V, J	0.00158	0.0644	1.19	V	0.00187	0.0215	0.0858	--	0.00162	0.0107
CDP-05 Mean	0.00177				1.24				0.00159				0.0497				0.0359				1.27				0.0869			
% of Reference	102				98				115				96				112				89				94			
CDP-REF Rep. 1	<0.00158	U	0.00158	0.0197	1.31	--	0.00242	0.00984	0.00134	J	0.000197	0.00394	0.0578	--	0.000622	0.0197	0.0319	V, J	0.00145	0.0591	1.55	V	0.00171	0.0197	0.102	--	0.00149	0.00984
CDP-REF Rep. 2	<0.00160	U	0.00160	0.0198	1.39	--	0.00244	0.00992	0.00149	J	0.000198	0.00397	0.0519	--	0.000627	0.0198	0.0323	V, J	0.00146	0.0595	1.74	V	0.00173	0.0198	0.0940	--	0.00150	0.00992
CDP-REF Rep. 3	<0.00180	U	0.00180	0.0223	1.16	--	0.00275	0.0112	0.00150	J	0.000223	0.00446	0.0510	--	0.000705	0.0223	0.0340	V, J	0.00164	0.0670	1.28	V	0.00194	0.0223	0.0931	--	0.00169	0.0112
CDP-REF Rep. 4	<0.00185	U	0.00185	0.0230	1.22	--	0.00283	0.0115	0.00131	J	0.000230	0.00461	0.0495	--	0.000728	0.0230	0.0330	V, J	0.00169	0.0691	1.39	V	0.00200	0.0230	0.0872	--	0.00174	0.0115
CDP-REF Rep. 5	<0.00181	U	0.00181	0.0225	1.22	--	0.00277	0.0113	0.00128	J	0.000225	0.00450	0.0482	--	0.000712	0.0225	0.0285	V, J	0.00166	0.0676	1.22	V	0.00196	0.0225	0.0845	--	0.00170	0.0113
CDP-REF Mean	0.00173				1.26				0.00138				0.0517				0.0319				1.44				0.0922			
Pre-exposure Rep. 1	<0.00188	U	0.00188	0.0234	1.34	--	0.00287	0.0117	0.00154	J	0.000234	0.00467	0.0546	--	0.000738	0.0234	0.0386	V, J	0.00172	0.0701	1.54	V	0.00203	0.0234	0.152	--	0.00176	0.0117
Pre-exposure Rep. 2	<0.00171	U	0.00171	0.0212	1.51	--	0.00261	0.0106	0.00108	J	0.000212	0.00424	0.0566	--	0.000669	0.0212	0.0315	V, J	0.00156	0.0636	1.80	V	0.00184	0.0212	0.144	--	0.00160	0.0106
Pre-exposure Rep. 3	<0.00158	U	0.00158	0.0197	1.61	--	0.00242	0.00984	0.00152	J	0.000197	0.00394	0.0514	--	0.000622	0.0197	0.0497	V, J	0.00145	0.0591	2.21	V	0.00171	0.0197	0.252	--	0.00149	0.00984
Pre-exposure Mean	0.00172				1.49				0.00138				0.0542				0.0399				1.85				0.183			
FDA Action Level	x				86				x				4				13				x				1.7			
Eco. Effects Threshold	x				12.6				x				1.0				6.3				0.2				0.1			
N. Gulf of Mexico Bkgd	0.22-0.47				3.4-5.4				<0.14				0.15-0.83				0.49-5.2				0.58-2.8				<0.47			

TABLE 13 *(continued)*

Analytical Results for Wet Weight Metals in *Mercenaria mercenaria* Tissues

Analyte:	Mercury				Nickel				Selenium				Silver				Thallium				Zinc				Total Petroleum Hydrocarbons (TPHs)			
Sample-Replicate #	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**
CDP-DMMU-01 Rep. 1	<0.00432	U	0.00432	0.00863	0.352	V	0.000364	0.0206	0.163	--	0.0226	0.103	0.0200	--	0.000146	0.0103	0.000350	J	0.000142	0.0103	13.6	V	0.0386	0.206	ND	U	42.2	100
CDP-DMMU-01 Rep. 2	<0.00328	U	0.00328	0.00656	0.501	V	0.000364	0.0206	0.189	--	0.0226	0.103	0.0124	--	0.000146	0.0103	0.000473	J	0.000142	0.0103	17.0	V	0.0386	0.206	ND	U	42.2	100
CDP-DMMU-01 Rep. 3	<0.00484	U	0.00484	0.00968	0.451	V	0.000386	0.0218	0.164	--	0.0240	0.109	0.0193	--	0.000155	0.0109	0.000306	J	0.000151	0.0109	15.3	V	0.0410	0.218	ND	U	42.2	100
CDP-DMMU-01 Rep. 4	<0.00438	U	0.00438	0.00876	0.514	V	0.000339	0.0192	0.176	--	0.0211	0.0958	0.0157	--	0.000136	0.00958	0.000345	J	0.000132	0.00958	16.2	V	0.0360	0.192	49.3	J	42.0	99.6
CDP-DMMU-01 Rep. 5	<0.00357	U	0.00357	0.00714	0.477	V	0.000372	0.0210	0.158	--	0.0231	0.105	0.0272	--	0.000149	0.0105	0.000315	J	0.000145	0.0105	14.3	V	0.0394	0.210	51.5	J	42.2	100
CDP-01 Mean	0.00408				0.459				0.170				0.0189				**0.00036**				15.3				45.5			
% of Reference	95				97				108				68				129				110				107			
CDP-DMMU-02 Rep. 1	<0.00373	U	0.00373	0.00745	0.419	V	0.000329	0.0186	0.226	--	0.0204	0.0929	0.0217	--	0.000132	0.00929	0.000260	J	0.000128	0.00929	15.6	V	0.0349	0.186	ND	U	42.0	99.6
CDP-DMMU-02 Rep. 2	<0.00455	U	0.00455	0.00909	0.479	V	0.000334	0.0189	0.230	--	0.0208	0.0943	0.0211	--	0.000134	0.00943	0.000302	J	0.000130	0.00943	17.4	V	0.0354	0.189	ND	U	42.2	100
CDP-DMMU-02 Rep. 3	<0.00385	U	0.00385	0.00769	0.367	V	0.000360	0.0203	0.253	--	0.0224	0.102	0.0106	--	0.000144	0.0102	0.000325	J	0.000140	0.0102	20.7	V	0.0382	0.203	ND	U	42.0	99.6
CDP-DMMU-02 Rep. 4	<0.00411	U	0.00411	0.00822	0.404	V	0.000354	0.0200	0.247	--	0.0220	0.100	0.0161	--	0.000142	0.0100	0.000300	J	0.000138	0.0100	19.7	V	0.0376	0.200	ND	U	42.2	100
CDP-DMMU-02 Rep. 5	<0.00444	U	0.00444	0.00889	0.450	V	0.000377	0.0213	0.296	--	0.0234	0.106	0.0251	--	0.000151	0.0106	0.000298	J	0.000147	0.0106	24.5	V	0.0399	0.213	ND	U	42.2	100
CDP-02 Mean	0.00414				0.424				**0.250**				0.0189				0.00030				***19.6***				42.1			
% of Reference	97				89				160				68				107				140				99			
CDP-DMMU-03 Rep. 1	<0.00387	U	0.00387	0.00774	0.410	V	0.000385	0.0217	0.194	--	0.0239	0.109	0.0151	--	0.000154	0.0109	0.000348	J	0.000150	0.0109	18.3	V	0.0408	0.217	ND	U	42.2	100
CDP-DMMU-03 Rep. 2	<0.00492	U	0.00492	0.00984	0.420	V	0.000366	0.0207	0.242	--	0.0227	0.103	0.0557	--	0.000147	0.0103	0.000269	J	0.000143	0.0103	17.7	V	0.0388	0.207	ND	U	42.2	100
CDP-DMMU-03 Rep. 3	<0.00397	U	0.00397	0.00795	0.527	V	0.000354	0.0200	0.229	--	0.0220	0.100	0.0218	--	0.000142	0.0100	0.000400	J	0.000138	0.0100	18.6	V	0.0376	0.200	ND	U	42.2	100
CDP-DMMU-03 Rep. 4	<0.00500	U	0.00500	0.0100	0.448	V	0.000385	0.0217	0.213	--	0.0239	0.109	0.0311	--	0.000154	0.0109	0.000283	J	0.000150	0.0109	16.9	V	0.0408	0.217	ND	U	42.2	100
CDP-DMMU-03 Rep. 5	<0.00444	U	0.00444	0.00889	0.445	V	0.000369	0.0208	0.218	--	0.0229	0.104	0.0242	--	0.000148	0.0104	0.000271	J	0.000144	0.0104	12.7	V	0.0391	0.208	ND	U	42.2	100
CDP-03 Mean	0.00444				0.450				**0.219**				0.0296				0.00031				16.8				42.2			
% of Reference	104				95				140				106				113				121				99			
CDP-DMMU-04 Rep. 1	<0.00323	U	0.00323	0.00645	0.332	V	0.000369	0.0208	0.172	--	0.0229	0.104	0.0268	--	0.000148	0.0104	0.000208	J	0.000144	0.0104	11.0	V	0.0391	0.208	ND	U	42.2	100
CDP-DMMU-04 Rep. 2	<0.00368	U	0.00368	0.00736	0.455	V	0.000308	0.0174	0.162	--	0.0192	0.0871	0.0208	--	0.000124	0.00871	0.000192	J	0.000120	0.00871	12.9	V	0.0327	0.174	ND	U	42.2	100
CDP-DMMU-04 Rep. 3	<0.00339	U	0.00339	0.00678	0.498	V	0.000338	0.0191	0.192	--	0.0210	0.0954	0.0233	--	0.000135	0.00954	0.000305	J	0.000132	0.00954	14.2	V	0.0358	0.191	ND	U	42.2	100
CDP-DMMU-04 Rep. 4	<0.00513	U	0.00513	0.0103	0.534	V	0.000410	0.0231	0.160	--	0.0255	0.116	0.0242	--	0.000164	0.0116	0.000208	J	0.000160	0.0116	13.6	V	0.0435	0.231	ND	U	41.9	99.4
CDP-DMMU-04 Rep. 5	<0.00476	U	0.00476	0.00952	0.534	V	0.000315	0.0178	0.191	--	0.0196	0.0890	0.0476	--	0.000126	0.00890	0.000302	J	0.000123	0.00890	14.0	V	0.0334	0.178	ND	U	42.2	100
CDP-04 Mean	0.00404				0.471				0.175				0.0285				0.00024				13.1				42.1			
% of Reference	94				99				112				103				88				94				99			
CDP-DMMU-05 Rep. 1	<0.00472	U	0.00472	0.00945	0.496	V	0.000335	0.0189	0.184	--	0.0208	0.0947	0.0319	--	0.000134	0.00947	0.000398	J	0.000131	0.00947	14.5	V	0.0356	0.189	ND	U	42.2	100
CDP-DMMU-05 Rep. 2	<0.00500	U	0.00500	0.0100	0.453	V	0.000353	0.0199	0.180	--	0.0219	0.0996	0.0284	--	0.000141	0.00996	0.000279	J	0.000137	0.00996	13.2	V	0.0374	0.199	ND	U	42.2	100
CDP-DMMU-05 Rep. 3	<0.00420	U	0.00420	0.00839	0.466	V	0.000390	0.0220	0.170	--	0.0242	0.110	0.0240	--	0.000156	0.0110	0.000264	J	0.000152	0.0110	14.3	V	0.0414	0.220	ND	U	42.2	100
CDP-DMMU-05 Rep. 4	<0.00484	U	0.00484	0.00968	0.480	V	0.000343	0.0194	0.173	--	0.0213	0.0969	0.0217	--	0.000138	0.00969	0.000291	J	0.000134	0.00969	14.7	V	0.0364	0.194	ND	U	42.2	100
CDP-DMMU-05 Rep. 5	<0.00566	U	0.00566	0.0113	0.565	V	0.000380	0.0215	0.171	--	0.0236	0.107	0.0288	--	0.000152	0.0107	0.000258	J	0.000148	0.0107	14.4	V	0.0403	0.215	ND	U	42.2	100
CDP-05 Mean	0.00488				0.492				0.176				0.0270				0.00030				14.2				42.2			
% of Reference	114				104				112				97				107				102				99			
CDP-REF Rep. 1	<0.00488	U	0.00488	0.00976	0.526	V	0.000348	0.0197	0.167	--	0.0217	0.0984	0.0471	--	0.000140	0.00984	0.000197	J	0.000136	0.00984	15.0	V	0.0370	0.197	ND	U	42.2	100
CDP-REF Rep. 2	<0.00400	U	0.00400	0.00800	0.439	V	0.000351	0.0198	0.175	--	0.0218	0.0992	0.0219	--	0.000141	0.00992	0.000278	J	0.000137	0.00992	14.0	V	0.0373	0.198	ND	U	42.2	100
CDP-REF Rep. 3	<0.00405	U	0.00405	0.00811	0.511	V	0.000395	0.0223	0.145	--	0.0246	0.112	0.0257	--	0.000158	0.0112	0.000179	J	0.000154	0.0112	12.1	V	0.0419	0.223	ND	U	42.2	100
CDP-REF Rep. 4	<0.00420	U	0.00420	0.00839	0.433	V	0.000408	0.0230	0.150	--	0.0253	0.115	0.0193	--	0.000164	0.0115	0.000576	J	0.000159	0.0115	13.3	V	0.0433	0.230	43.4	J	42.2	100
CDP-REF Rep. 5	<0.00426	U	0.00426	0.00851	0.467	V	0.000399	0.0225	0.147	--	0.0248	0.113	0.0250	--	0.000160	0.0113	0.000158	J	0.000155	0.0113	15.3	V	0.0423	0.225	ND	U	42.2	100
CDP-REF Mean	0.00428				0.475				0.157				0.0278				0.00028				13.9				42.4			
Pre-exposure Rep. 1	<0.00451	U	0.00451	0.00902	0.487	V	0.000414	0.0234	0.198	--	0.0257	0.117	0.0225	--	0.000166	0.0117	0.000187	J	0.000161	0.0117	13.8	V	0.0439	0.234	ND	U	42.2	100
Pre-exposure Rep. 2	<0.00414	U	0.00414	0.00828	0.513	V	0.000375	0.0212	0.212	--	0.0233	0.106	0.0243	--	0.000150	0.0106	0.000169	J	0.000146	0.0106	14.4	V	0.0398	0.212	ND	U	42.2	100
Pre-exposure Rep. 3	<0.00451	U	0.00451	0.00902	0.511	V	0.000348	0.0197	0.220	--	0.0217	0.0984	0.0205	--	0.000140	0.00984	0.000236	J	0.000136	0.00984	16.5	V	0.0370	0.197	ND	U	42.2	100
Pre-exposure Mean	0.00439				0.504				0.210				0.0224				0.00020				14.9				42.2			
FDA Action Level	1				80				x				x				x				x				x			
Eco. Effects Threshold	0.3				2.2				14.2				1.0				0.3				11.6				x			
N. Gulf of Mexico Bkgd	<0.028				0.7-3.1				0.5-1.5				0.11-0.56				<0.47				7.0-30.0				x			

Bolded values indicate a mean concentration of project tissue that is statistically significantly greater than that of the reference tissue and includes at least one replicate result greater than the MDL.

Italicized and bolded values indicate results that are statistically significantly greater than that of the reference tissues and also exceed the ecological effects threshold and (or) the upper boundary of the N. Gulf of Mexico background concentration (see Section 7.5.3 of SERIM for details).

< #.## = The analyte was not detected (ND) at or above the MDL (U-qualified). The value indicates the MDL. U-qualified results use the MDL for calculating average concentrations. (J-qualified results use the value reported by the laboratory for calculating average concentrations.)

J = Estimated value. The reported value is between the MDL and MRL. V = The analyte was detected in both sample and method blank. B = Analyte was detected in the method blank.

Sources: Results from NWDLS; FDA action levels from FDA (2001, 2011); thresholds and background concentrations from Appendix H of SERIM (EPA and USACE 2008); trivalent and hexavalent chromium use total chromium levels, thresholds, and background concentrations.

Compiled by: ANAMAR Environmental Consulting, Inc.

TABLE 14

Analytical Results for Wet Weight Metals in *Alitta virens* Tissues

Analyte:	Antimony				Arsenic				Beryllium				Cadmium				Chromium				Copper				Lead			
Sample-Replicate #	Result mg/kg	Qualifier	MDL	MRL	Result mg/kg	Qualifier	MDL	MRL	Result mg/kg	Qualifier	MDL	MRL	Result mg/kg	Qualifier	MDL	MRL	Result mg/kg	Qualifier	MDL	MRL	Result mg/kg	Qualifier	MDL	MRL	Result mg/kg	Qualifier	MDL	MRL
CDP-DMMU-01 Rep. 1	0.00281	J	0.00150	0.0186	2.02	--	0.0114	0.0465	0.00134	J	0.000186	0.00372	0.0326	--	0.000587	0.0186	0.0772	V	0.00137	0.0558	1.39	V	0.00162	0.0186	0.166	--	0.00140	0.00929
CDP-DMMU-01 Rep. 2	0.00270	J	0.00164	0.0203	2.32	--	0.0125	0.0508	0.000854	J	0.000203	0.00407	0.0373	--	0.000642	0.0203	0.109	V	0.00149	0.0610	1.21	V	0.00177	0.0203	0.174	--	0.00153	0.0102
CDP-DMMU-01 Rep. 3	0.00252	J	0.00178	0.0221	2.35	--	0.0136	0.0553	0.000465	J	0.000221	0.00442	0.0379	--	0.000699	0.0221	0.0835	V	0.00163	0.0664	1.39	V	0.00192	0.0221	0.170	--	0.00167	0.0111
CDP-DMMU-01 Rep. 4	0.00261	J	0.00162	0.0201	2.39	--	0.0123	0.0502	0.000602	J	0.000201	0.00402	0.0335	--	0.000635	0.0201	0.131	V	0.00148	0.0602	1.30	V	0.00175	0.0201	0.163	--	0.00152	0.0100
CDP-DMMU-01 Rep. 5	0.00282	J	0.00189	0.0235	2.65	--	0.0144	0.0587	0.000493	J	0.000235	0.00469	0.0325	--	0.000742	0.0235	0.125	V	0.00173	0.0704	1.36	V	0.00204	0.0235	0.155	--	0.00177	0.0117
CDP-01 Mean	0.00269				2.35				0.00075				0.0348				0.1051				1.33				***0.166***			
% of Reference	91				90				136				115				131				69				144			
CDP-DMMU-02 Rep. 1	0.00363	J	0.00173	0.0215	2.89	--	0.0132	0.0536	0.000343	J	0.000215	0.00429	0.0376	--	0.000678	0.0215	0.0988	V	0.00158	0.0644	2.20	V	0.00187	0.0215	0.199	--	0.00162	0.0107
CDP-DMMU-02 Rep. 2	0.00312	J	0.00173	0.0216	3.21	--	0.0133	0.0539	0.000323	J	0.000216	0.00431	0.0345	--	0.000681	0.0216	0.0902	V	0.00158	0.0647	1.91	V	0.00188	0.0216	0.177	--	0.00163	0.0108
CDP-DMMU-02 Rep. 3	<0.00303	U	0.00303	0.0376	2.70	--	0.0231	0.0940	0.000526	J	0.000376	0.00752	0.0341	J	0.00119	0.0376	0.0597	V, J	0.00276	0.113	1.45	V	0.00327	0.0376	0.160	--	0.00284	0.0188
CDP-DMMU-02 Rep. 4	0.00255	J	0.00171	0.0213	2.75	--	0.0131	0.0532	0.000745	J	0.000213	0.00426	0.0340	--	0.000672	0.0213	0.0873	V	0.00156	0.0638	1.26	V	0.00185	0.0213	0.153	--	0.00161	0.0106
CDP-DMMU-02 Rep. 5	0.00278	J	0.00155	0.0193	2.85	--	0.0119	0.0483	0.000637	J	0.000193	0.00386	0.0319	--	0.000610	0.0193	0.0772	V	0.00142	0.0579	1.44	V	0.00168	0.0193	0.154	--	0.00146	0.00965
CDP-02 Mean	0.00302				2.88				0.00051				0.0344				0.0826				1.65				***0.169***			
% of Reference	102				111				93				114				103				86				147			
CDP-DMMU-03 Rep. 1	0.00296	J	0.00173	0.0215	2.59	--	0.0132	0.0536	0.000794	J	0.000215	0.00429	0.0348	--	0.000678	0.0215	0.0733	V	0.00158	0.0644	1.30	V	0.00187	0.0215	0.155	--	0.00162	0.0107
CDP-DMMU-03 Rep. 2	0.00269	J	0.00173	0.0216	2.60	--	0.0133	0.0539	0.000690	J	0.000216	0.00431	0.0347	--	0.000681	0.0216	0.0839	V	0.00158	0.0647	1.20	V	0.00188	0.0216	0.168	--	0.00163	0.0108
CDP-DMMU-03 Rep. 3	0.00305	J	0.00201	0.0250	2.57	--	0.0154	0.0625	0.00230	J	0.000250	0.00500	0.0372	--	0.000790	0.0250	0.175	V	0.00184	0.0750	1.21	V	0.00218	0.0250	0.209	--	0.00189	0.0125
CDP-DMMU-03 Rep. 4	0.00381	J	0.00171	0.0213	3.12	--	0.0131	0.0532	0.00136	J	0.000213	0.00426	0.0375	--	0.000672	0.0213	0.136	V	0.00156	0.0638	1.25	V	0.00185	0.0213	0.182	--	0.00161	0.0106
CDP-DMMU-03 Rep. 5	0.00226	J	0.00195	0.0243	2.56	--	0.0149	0.0607	0.00129	J	0.000243	0.00485	0.0333	--	0.000767	0.0243	0.140	V	0.00178	0.0728	1.10	V	0.00211	0.0243	0.155	--	0.00183	0.0121
CDP-03 Mean	0.00295				2.69				**0.00129**				0.0355				0.1216				1.21				***0.174***			
% of Reference	100				103				233				118				151				63				151			
CDP-DMMU-04 Rep. 1	0.00175	J	0.00173	0.0216	1.78	--	0.0133	0.0539	0.000302	J	0.000216	0.00431	0.0216	--	0.000681	0.0216	0.0394	V, J	0.00158	0.0647	0.960	V	0.00188	0.0216	0.0889	--	0.00163	0.0108
CDP-DMMU-04 Rep. 2	0.00217	J	0.00150	0.0186	2.41	--	0.0114	0.0465	0.000297	J	0.000186	0.00372	0.0256	--	0.000587	0.0186	0.0601	V	0.00137	0.0558	1.23	V	0.00162	0.0186	0.100	--	0.00140	0.00929
CDP-DMMU-04 Rep. 3	0.00230	J	0.00178	0.0221	2.84	--	0.0136	0.0553	0.000354	J	0.000221	0.00442	0.0301	--	0.000699	0.0221	0.0626	V, J	0.00163	0.0664	1.18	V	0.00192	0.0221	0.117	--	0.00167	0.0111
CDP-DMMU-04 Rep. 4	0.00217	J	0.00160	0.0199	2.66	--	0.0123	0.0498	0.000359	J	0.000199	0.00398	0.0299	--	0.000629	0.0199	0.0530	V, J	0.00146	0.0598	1.10	V	0.00173	0.0199	0.112	--	0.00150	0.00996
CDP-DMMU-04 Rep. 5	0.00248	J	0.00181	0.0225	2.79	--	0.0139	0.0563	0.000360	J	0.000225	0.00450	0.0340	--	0.000712	0.0225	0.0570	V, J	0.00166	0.0676	1.21	V	0.00196	0.0225	0.124	--	0.00170	0.0113
CDP-04 Mean	0.00217				2.50				0.00033				0.0282				0.0544				1.14				0.108			
% of Reference	73				96				61				94				68				59				94			
CDP-DMMU-05 Rep. 1	0.00188	J	0.00166	0.0207	2.62	--	0.0127	0.0517	0.000517	J	0.000207	0.00413	0.0278	--	0.000653	0.0207	0.0628	V	0.00152	0.0620	1.11	V	0.00180	0.0207	0.108	--	0.00156	0.0103
CDP-DMMU-05 Rep. 2	0.00238	J	0.00162	0.0202	2.73	--	0.0124	0.0504	0.000565	J	0.000202	0.00403	0.0329	--	0.000637	0.0202	0.0886	V	0.00148	0.0605	1.16	V	0.00175	0.0202	0.127	--	0.00152	0.0101
CDP-DMMU-05 Rep. 3	0.00235	J	0.00164	0.0204	2.79	--	0.0126	0.0510	0.000694	J	0.000204	0.00408	0.0349	--	0.000645	0.0204	0.0816	V	0.00150	0.0612	1.20	V	0.00178	0.0204	0.120	--	0.00154	0.0102
CDP-DMMU-05 Rep. 4	0.00193	J	0.00154	0.0191	2.45	--	0.0117	0.0477	0.000363	J	0.000191	0.00382	0.0297	--	0.000603	0.0191	0.0623	V	0.00140	0.0573	1.17	V	0.00166	0.0191	0.103	--	0.00144	0.00954
CDP-DMMU-05 Rep. 5	0.00210	J	0.00180	0.0223	2.35	--	0.0137	0.0558	0.000335	J	0.000223	0.00446	0.0303	--	0.000705	0.0223	0.0598	V, J	0.00164	0.0670	0.992	V	0.00194	0.0223	0.108	--	0.00169	0.0112
CDP-05 Mean	0.00213				2.59				0.00049				0.0311				0.0710				1.13				0.113			
% of Reference	72				99				90				103				88				59				98			
CDP-REF Rep. 1	0.00299	J	0.00178	0.0221	2.52	--	0.0272	0.111	0.00106	J	0.000221	0.00442	0.0311	--	0.000699	0.0221	0.0405	V, J	0.00163	0.0664	1.51	V	0.00192	0.0221	0.101	--	0.00167	0.0111
CDP-REF Rep. 2	0.00347	J	0.00164	0.0204	2.39	--	0.0251	0.102	0.000388	J	0.000204	0.00408	0.0266	--	0.000645	0.0204	0.114	V	0.00150	0.0612	2.80	V	0.00355	0.0408	0.126	--	0.00154	0.0102
CDP-REF Rep. 3	0.00329	J	0.00166	0.0206	2.80	--	0.0253	0.103	0.000432	J	0.000206	0.00412	0.0299	--	0.000650	0.0206	0.103	V	0.00151	0.0617	2.31	V	0.00358	0.0412	0.129	--	0.00155	0.0103
CDP-REF Rep. 4	0.00266	J	0.00158	0.0197	3.07	--	0.00484	0.0197	0.000512	J	0.000197	0.00394	0.0356	--	0.000622	0.0197	0.0772	V	0.00145	0.0591	1.70	V	0.00343	0.0394	0.124	--	0.00149	0.00984
CDP-REF Rep. 5	0.00242	J	0.00174	0.0216	2.25	--	0.0266	0.108	0.000368	J	0.000216	0.00433	0.0278	--	0.000684	0.0216	0.0676	V	0.00159	0.0649	1.29	V	0.00377	0.0433	0.0948	--	0.00163	0.0108
CDP-REF Mean	0.00297				2.61				0.00055				0.0302				0.0805				1.92				0.115			
Pre-exposure Rep. 1	0.00340	J	0.00195	0.0243	2.81	--	0.0149	0.0607	0.000971	J	0.000243	0.00485	0.0245	--	0.000767	0.0243	0.117	V	0.00178	0.0728	1.41	V	0.00211	0.0243	0.0995	--	0.00183	0.0121
Pre-exposure Rep. 2	0.00321	J	0.00140	0.0174	3.16	--	0.00427	0.0174	0.00368	--	0.000174	0.00347	0.0260	--	0.000549	0.0174	0.256	V	0.00128	0.0521	1.37	V	0.00151	0.0174	0.162	--	0.00131	0.00868
Pre-exposure Rep. 3	0.00275	J	0.00176	0.0218	2.52	--	0.0134	0.0546	0.00124	J	0.000218	0.00437	0.0378	--	0.000690	0.0218	0.133	V	0.00160	0.0655	2.46	V	0.00190	0.0218	0.168	--	0.00165	0.0109
Pre-exposure Mean	0.00312				2.83				0.00196				0.0294				0.169				1.75				0.143			
FDA Action Level	x				76				x				3				12				x				1.5			
Eco. Effects Threshold	x				12.6				x				27.8				10.0				0.4				0.1			
N. Gulf of Mexico Bkgd	<0.31				7.4-37.0				<0.09				0.34-1.4				0.89-4.6				2.3-5.3				0.31-1.2			

TABLE 14 ***(continued)***

Analytical Results for Wet Weight Metals in *Alitta virens* Tissues

Analyte:	**Mercury**				**Nickel**				**Selenium**				**Silver**				**Thallium**				**Zinc**				**Total Petroleum Hydrocarbons (TPHs)**			
Sample-Replicate #	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**
CDP-DMMU-01 Rep. 1	<0.00500	U	0.00500	0.0100	0.188	V	0.000329	0.0186	0.313	--	0.0204	0.0929	0.0205	--	0.000132	0.00929	0.000706	J	0.000128	0.00929	24.6	V	0.0349	0.186	426	J	211	500
CDP-DMMU-01 Rep. 2	<0.00462	U	0.00462	0.00923	0.204	V	0.000360	0.0203	0.352	--	0.0224	0.102	0.0224	--	0.000144	0.0102	0.000630	J	0.000140	0.0102	11.6	V	0.0382	0.203	493	J	211	500
CDP-DMMU-01 Rep. 3	<0.00448	U	0.00448	0.00896	0.224	V	0.000392	0.0221	0.396	--	0.0243	0.111	0.0224	--	0.000157	0.0111	0.000509	J	0.000153	0.0111	32.3	V	0.0415	0.221	329	J	211	500
CDP-DMMU-01 Rep. 4	<0.00385	U	0.00385	0.00769	0.255	V	0.000355	0.0201	0.366	--	0.0221	0.100	0.0190	--	0.000143	0.0100	0.000502	J	0.000139	0.0100	9.61	V	0.0377	0.201	441	J	211	500
CDP-DMMU-01 Rep. 5	<0.00469	U	0.00469	0.00937	0.245	V	0.000415	0.0235	0.377	--	0.0258	0.117	0.0168	--	0.000167	0.0117	0.000493	J	0.000162	0.0117	39.7	V	0.0441	0.235	429	J	211	500
CDP-01 Mean	0.00453				**0.223**				0.361				0.0202				0.000568				23.6				424			
% of Reference	96				178				105				87				98				123				83			
CDP-DMMU-02 Rep. 1	<0.00405	U	0.00405	0.00811	0.271	V	0.000380	0.0215	0.396	--	0.0236	0.107	0.0122	--	0.000152	0.0107	0.000601	J	0.000148	0.0107	11.7	V	0.0403	0.215	226	J	211	500
CDP-DMMU-02 Rep. 2	<0.00370	U	0.00370	0.00741	0.239	V	0.000381	0.0216	0.407	--	0.0237	0.108	0.00912	J	0.000153	0.0108	0.000603	J	0.000149	0.0108	9.34	V	0.0405	0.216	396	J	211	500
CDP-DMMU-02 Rep. 3	<0.00531	U	0.00531	0.0106	0.226	V	0.000665	0.0376	0.364	--	0.0414	0.188	0.00816	J	0.000267	0.0188	0.000639	J	0.000259	0.0188	21.3	V	0.0706	0.376	678	--	211	500
CDP-DMMU-02 Rep. 4	<0.00451	U	0.00451	0.00902	0.235	V	0.000377	0.0213	0.385	--	0.0234	0.106	0.00819	J	0.000151	0.0106	0.000745	J	0.000147	0.0106	9.56	V	0.0399	0.213	921	--	211	500
CDP-DMMU-02 Rep. 5	<0.00504	U	0.00504	0.0101	0.258	V	0.000342	0.0193	0.396	--	0.0212	0.0965	0.00859	J	0.000137	0.00965	0.000560	J	0.000133	0.00965	16.1	V	0.0362	0.193	467	J	211	500
CDP-02 Mean	0.00452				**0.246**				0.390				0.0093				0.000630				13.6				538			
% of Reference	95				196				114				40				109				71				105			
CDP-DMMU-03 Rep. 1	<0.00517	U	0.00517	0.0103	0.208	V	0.000380	0.0215	0.366	--	0.0236	0.107	0.0174	--	0.000152	0.0107	0.000601	J	0.000148	0.0107	31.4	V	0.0403	0.215	1070	--	211	500
CDP-DMMU-03 Rep. 2	<0.00462	U	0.00462	0.00923	0.214	V	0.000381	0.0216	0.406	--	0.0237	0.108	0.0191	--	0.000153	0.0108	0.000625	J	0.000149	0.0108	38.7	V	0.0405	0.216	1120	--	211	500
CDP-DMMU-03 Rep. 3	<0.00455	U	0.00455	0.00909	0.248	V	0.000442	0.0250	0.402	--	0.0275	0.125	0.0170	--	0.000178	0.0125	0.00102	J	0.000172	0.0125	17.2	V	0.0469	0.250	1080	--	211	500
CDP-DMMU-03 Rep. 4	<0.00550	U	0.00550	0.0110	0.243	V	0.000377	0.0213	0.453	--	0.0234	0.106	0.0178	--	0.000151	0.0106	0.000660	J	0.000147	0.0106	23.3	V	0.0399	0.213	1080	--	211	500
CDP-DMMU-03 Rep. 5	<0.00517	U	0.00517	0.0103	0.228	V	0.000430	0.0243	0.359	--	0.0267	0.121	0.0146	--	0.000172	0.0121	0.000777	J	0.000167	0.0121	20.1	V	0.0456	0.243	1280	--	211	500
CDP-03 Mean	0.00500				**0.228**				0.397				0.0172				0.000737				26.1				**1126**			
% of Reference	106				182				116				74				127				136				221			
CDP-DMMU-04 Rep. 1	<0.00397	U	0.00397	0.00795	0.103	V	0.000381	0.0216	0.242	--	0.0237	0.108	0.0125	--	0.000153	0.0108	0.000474	J	0.000149	0.0108	7.10	V	0.00809	0.0431	810	--	211	500
CDP-DMMU-04 Rep. 2	<0.00500	U	0.00500	0.0100	0.143	V	0.000329	0.0186	0.316	--	0.0204	0.0929	0.0136	--	0.000132	0.00929	0.000595	J	0.000128	0.00929	20.7	V	0.0349	0.186	1200	--	211	500
CDP-DMMU-04 Rep. 3	<0.00476	U	0.00476	0.00952	0.137	V	0.000392	0.0221	0.312	--	0.0243	0.111	0.0179	--	0.000157	0.0111	0.000597	J	0.000153	0.0111	35.4	V	0.0415	0.221	914	--	211	500
CDP-DMMU-04 Rep. 4	<0.00435	U	0.00435	0.00870	0.147	V	0.000353	0.0199	0.383	--	0.0219	0.0996	0.0189	--	0.000141	0.00996	0.000697	J	0.000137	0.00996	20.6	V	0.0374	0.199	1120	--	209	495
CDP-DMMU-04 Rep. 5	<0.00390	U	0.00390	0.00779	0.143	V	0.000399	0.0225	0.349	--	0.0248	0.113	0.0201	--	0.000160	0.0113	0.000676	J	0.000155	0.0113	12.4	V	0.0423	0.225	738	--	211	500
CDP-04 Mean	0.00440				0.135				0.320				0.0166				0.000608				19.2				**956**			
% of Reference	93				107				93				71				105				100				188			
CDP-DMMU-05 Rep. 1	<0.00469	U	0.00469	0.00937	0.139	V	0.000366	0.0207	0.318	--	0.0227	0.103	0.0213	--	0.000147	0.0103	0.000496	J	0.000143	0.0103	17.0	V	0.0388	0.207	1130	--	42.2	100
CDP-DMMU-05 Rep. 2	<0.00438	U	0.00438	0.00876	0.152	V	0.000357	0.0202	0.382	--	0.0222	0.101	0.0222	--	0.000143	0.0101	0.000544	J	0.000139	0.0101	22.5	V	0.0379	0.202	284	--	42.2	100
CDP-DMMU-05 Rep. 3	<0.00480	U	0.00480	0.00960	0.146	V	0.000361	0.0204	0.370	--	0.0224	0.102	0.0248	--	0.000145	0.0102	0.000592	J	0.000141	0.0102	38.2	V	0.0383	0.204	588	--	42.2	100
CDP-DMMU-05 Rep. 4	<0.00397	U	0.00397	0.00795	0.140	V	0.000338	0.0191	0.358	--	0.0210	0.0954	0.0157	--	0.000135	0.00954	0.000515	J	0.000132	0.00954	37.9	V	0.0717	0.382	1100	--	42.2	100
CDP-DMMU-05 Rep. 5	<0.00465	U	0.00465	0.00930	0.129	V	0.000395	0.0223	0.322	--	0.0246	0.112	0.0179	--	0.000158	0.0112	0.000580	J	0.000154	0.0112	15.0	V	0.0419	0.223	533	--	42.2	100
CDP-05 Mean	0.00450				0.141				0.350				0.0204				0.000545				26.1				727			
% of Reference	95				113				102				87				94				136				143			
CDP-REF Rep. 1	<0.00466	U	0.00466	0.00932	0.116	V	0.000392	0.0221	0.355	--	0.0243	0.111	0.0227	--	0.000157	0.0111	0.000642	J	0.000153	0.0111	29.2	V	0.0415	0.221	607	--	42.2	100
CDP-REF Rep. 2	<0.00469	U	0.00469	0.00939	0.138	V	0.000361	0.0204	0.342	--	0.0224	0.102	0.0196	--	0.000145	0.0102	0.000531	J	0.000141	0.0102	13.9	V	0.0383	0.204	1000	--	42.2	100
CDP-REF Rep. 3	<0.00481	U	0.00481	0.00962	0.134	V	0.000364	0.0206	0.368	--	0.0226	0.103	0.0243	--	0.000146	0.0103	0.000576	J	0.000142	0.0103	34.3	V	0.0386	0.206	564	--	42.2	100
CDP-REF Rep. 4	<0.00486	U	0.00486	0.00972	0.128	V	0.000348	0.0197	0.363	--	0.0217	0.0984	0.0294	--	0.000140	0.00984	0.000630	J	0.000136	0.00984	10.4	V	0.0370	0.197	291	--	42.2	100
CDP-REF Rep. 5	<0.00467	U	0.00467	0.00933	0.111	V	0.000383	0.0216	0.288	--	0.0238	0.108	0.0206	--	0.000154	0.0108	0.000519	J	0.000149	0.0108	7.97	V	0.0406	0.216	87.7	J	42.2	100
CDP-REF Mean	0.00474				0.125				0.343				0.0233				0.000580				19.2				510			
Pre-exposure Rep. 1	<0.00476	U	0.00476	0.00952	0.185	V	0.000430	0.0243	0.421	--	0.0267	0.121	0.0214	--	0.000172	0.0121	0.000291	J	0.000167	0.0121	15.8	V	0.0456	0.243	797	--	42.2	100
Pre-exposure Rep. 2	<0.00390	U	0.00390	0.00779	0.229	V	0.000307	0.0174	0.427	--	0.0191	0.0868	0.0297	--	0.000123	0.00868	0.000833	J	0.000120	0.00868	39.0	V	0.0652	0.347	827	--	42.2	100
Pre-exposure Rep. 3	<0.00470	U	0.00470	0.00940	0.123	V	0.000386	0.0218	0.403	--	0.0240	0.109	0.0358	--	0.000155	0.0109	0.000524	J	0.000151	0.0109	15.9	V	0.0410	0.218	229	--	42.2	100
Pre-exposure Mean	0.00445				0.179				0.417				0.0290				0.000549				23.6				618			
FDA Action Level	1				70				x				x				x				x				x			
Eco. Effects Threshold	0.3				2.2				14.2				1.0				0.3				0.3				x			
N. Gulf of Mexico Bkgd	0.03-0.04				0.53-3.5				0.61-0.99				<0.15				<0.31				14-16				x			

Bolded values indicate a mean concentration of project tissue that is statistically significantly greater than that of the reference tissue and includes at least one replicate result greater than the MDL.

Italicized and bolded values indicate results that are statistically significantly greater than that of the reference tissues and also exceed the ecological effects threshold and (or) the upper boundary of the N. Gulf of Mexico background concentration (see Section 7.5.3 of SERIM for details).

< #.## = The analyte was not detected (ND) at or above the MDL (U-qualified). The value indicates the MDL. U-qualified results use the MDL for calculating average concentrations. (J-qualified results use the value reported by the laboratory for calculating average concentrations.)

J = Estimated value. The reported value is between the detection limit and reporting limit. V = Analyte was detected in both sample and method blank. B = Analyte was detected in the method blank. Compiled by: ANAMAR Environmental Consulting, Inc.

Sources: Results from NWDLS; FDA action levels from FDA (2001, 2011); thresholds and background concentrations from Appendix H of SERIM (EPA and USACE 2008); trivalent and hexavalent chromium use total chromium levels, thresholds, and background concentrations.

TABLE 15

Analytical Results for Dry Weight Metals in *Mercenaria mercenaria* Tissues

Analyte:	Antimony				Arsenic				Beryllium				Cadmium				Chromium				Copper				Lead			
Sample-Replicate #	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**
CDP-DMMU-01 Rep. 1	0.0207	J	0.0189	0.235	15.6	--	0.0290	0.118	0.0148	J	0.00235	0.0471	0.682	--	0.00744	0.235	0.426	V, J	0.0173	0.706	15.4	V	0.0205	0.235	1.17	--	0.0178	0.118
CDP-DMMU-01 Rep. 2	0.0220	J	0.0195	0.242	17.0	--	0.0297	0.121	0.0244	J	0.00242	0.0484	0.632	--	0.00764	0.242	0.423	V, J	0.0178	0.725	16.4	V	0.0210	0.242	1.81	--	0.0183	0.121
CDP-DMMU-01 Rep. 3	<0.0204	U	0.0204	0.253	15.1	--	0.0311	0.127	0.0187	J	0.00253	0.0506	0.578	--	0.00800	0.253	0.332	V, J	0.0186	0.759	13.6	V	0.0220	0.253	0.989	--	0.0191	0.127
CDP-DMMU-01 Rep. 4	0.0215	J	0.0199	0.248	18.7	--	0.0305	0.124	0.0238	J	0.00248	0.0495	0.708	--	0.00782	0.248	0.639	V, J	0.0182	0.743	17.9	V	0.0215	0.248	1.59	--	0.0187	0.124
CDP-DMMU-01 Rep. 5	<0.0209	U	0.0209	0.260	15.8	--	0.0320	0.130	0.0208	J	0.00260	0.0520	0.667	--	0.00822	0.260	0.442	V, J	0.0191	0.780	15.4	V	0.0226	0.260	1.44	--	0.0196	0.130
CDP-01 Mean	0.021				**16.4**				**0.0205**				0.653				0.45				15.7				1.40			
% of Reference	106				114				129				110				124				96				133			
CDP-DMMU-02 Rep. 1	<0.0161	U	0.0161	0.200	15.6	--	0.0246	0.100	0.0170	J	0.00200	0.0400	0.570	--	0.00632	0.200	0.435	V, J	0.0147	0.600	13.1	V	0.0174	0.200	1.01	--	0.0151	0.100
CDP-DMMU-02 Rep. 2	<0.0160	U	0.0160	0.198	15.5	--	0.0244	0.0991	0.0184	J	0.00198	0.0396	0.592	--	0.00626	0.198	0.615	V	0.0146	0.594	12.3	V	0.0172	0.198	1.30	--	0.0150	0.0991
CDP-DMMU-02 Rep. 3	<0.0190	U	0.0190	0.236	15.0	--	0.0290	0.118	0.0175	J	0.00236	0.0472	0.554	--	0.00746	0.236	0.467	V, J	0.0174	0.708	17.5	V	0.0205	0.236	1.94	--	0.0178	0.118
CDP-DMMU-02 Rep. 4	<0.0179	U	0.0179	0.222	14.3	--	0.0273	0.111	0.0153	J	0.00222	0.0444	0.578	--	0.00702	0.222	0.458	V, J	0.0163	0.666	17.6	V	0.0193	0.222	1.59	--	0.0168	0.111
CDP-DMMU-02 Rep. 5	<0.0173	U	0.0173	0.215	15.1	--	0.0264	0.108	0.0163	J	0.00215	0.0430	0.585	--	0.00680	0.215	0.374	V, J	0.0158	0.645	13.4	V	0.0187	0.215	0.996	--	0.0162	0.108
CDP-02 Mean	0.01726				15.1				0.017				0.576				0.47				14.8				1.37			
% of Reference	87				104				107				97				128				90				130			
CDP-DMMU-03 Rep. 1	<0.0211	U	0.0211	0.262	13.6	--	0.0323	0.131	0.0207	J	0.00262	0.0525	0.507	--	0.00829	0.262	0.453	V, J	0.0193	0.787	18.7	V	0.0228	0.262	1.74	--	0.0198	0.131
CDP-DMMU-03 Rep. 2	0.0192	J	0.0187	0.232	14.1	--	0.0285	0.116	0.0181	J	0.00232	0.0464	0.610	--	0.00733	0.232	0.351	V, J	0.0170	0.696	14.8	V	0.0202	0.232	1.76	--	0.0175	0.116
CDP-DMMU-03 Rep. 3	0.0203	J	0.0188	0.233	15.1	--	0.0287	0.117	0.0198	J	0.00233	0.0467	0.603	--	0.00737	0.233	0.452	V, J	0.0171	0.700	14.9	V	0.0203	0.233	1.37	--	0.0176	0.117
CDP-DMMU-03 Rep. 4	<0.0189	U	0.0189	0.235	12.4	--	0.0289	0.117	0.0162	J	0.00235	0.0470	0.616	--	0.00742	0.235	0.447	V, J	0.0173	0.704	16.3	V	0.0204	0.235	1.28	--	0.0177	0.117
CDP-DMMU-03 Rep. 5	<0.0184	U	0.0184	0.228	14.1	--	0.0281	0.114	0.0180	J	0.00228	0.0457	0.565	--	0.00722	0.228	0.389	V, J	0.0168	0.685	13.8	V	0.0199	0.228	1.31	--	0.0172	0.114
CDP-03 Mean	0.0196				13.9				0.0186				0.580				0.418				15.7				**1.492**			
% of Reference	99				96				117				98				114				95				142			
CDP-DMMU-04 Rep. 1	<0.0182	U	0.0182	0.226	11.6	--	0.0278	0.113	0.0145	J	0.00226	0.0452	0.562	--	0.00714	0.226	0.322	V, J	0.0166	0.678	13.1	V	0.0197	0.226	0.908	--	0.0171	0.113
CDP-DMMU-04 Rep. 2	<0.0159	U	0.0159	0.197	12.7	--	0.0242	0.0985	0.0148	J	0.00197	0.0394	0.572	--	0.00622	0.197	0.299	V, J	0.0145	0.591	11.9	V	0.0171	0.197	0.963	--	0.0149	0.0985
CDP-DMMU-04 Rep. 3	0.0173	J	0.0164	0.204	15.0	--	0.0251	0.102	0.0161	J	0.00204	0.0408	0.662	--	0.00644	0.204	0.350	V, J	0.0150	0.612	13.6	V	0.0177	0.204	1.09	--	0.0154	0.102
CDP-DMMU-04 Rep. 4	<0.0207	U	0.0207	0.257	14.2	--	0.0317	0.129	0.0175	J	0.00257	0.0515	0.573	--	0.00813	0.257	0.836	V	0.0189	0.772	11.6	V	0.0224	0.257	0.765	--	0.0194	0.129
CDP-DMMU-04 Rep. 5	<0.0157	U	0.0157	0.195	13.9	--	0.0240	0.0974	0.0173	J	0.00195	0.0390	0.755	--	0.00616	0.195	0.496	V, J	0.0143	0.585	13.6	V	0.0170	0.195	1.03	--	0.0147	0.0974
CDP-04 Mean	0.018				13.5				0.0160				0.625				0.461				12.8				0.9512			
% of Reference	88				93				101				105				126				78				90			
CDP-DMMU-05 Rep. 1	<0.0162	U	0.0162	0.201	12.8	--	0.0247	0.101	0.0169	J	0.00201	0.0402	0.497	--	0.00635	0.201	0.373	V, J	0.0148	0.603	14.2	V	0.0175	0.201	0.790	--	0.0152	0.101
CDP-DMMU-05 Rep. 2	<0.0164	U	0.0164	0.204	12.8	--	0.0251	0.102	0.0161	J	0.00204	0.0408	0.568	--	0.00645	0.204	0.318	V, J	0.0150	0.613	12.7	V	0.0178	0.204	0.846	--	0.0154	0.102
CDP-DMMU-05 Rep. 3	0.0264	J	0.0193	0.240	13.2	--	0.0295	0.120	0.0161	J	0.00240	0.0480	0.481	--	0.00759	0.240	0.349	V, J	0.0177	0.720	12.5	V	0.0209	0.240	0.947	--	0.0181	0.120
CDP-DMMU-05 Rep. 4	<0.0164	U	0.0164	0.203	12.9	--	0.0250	0.102	0.0175	J	0.00203	0.0407	0.482	--	0.00643	0.203	0.433	V, J	0.0149	0.610	15.2	V	0.0177	0.203	1.10	--	0.0154	0.102
CDP-DMMU-05 Rep. 5	<0.0185	U	0.0185	0.229	13.7	--	0.0282	0.115	0.0177	J	0.00229	0.0458	0.600	--	0.00724	0.229	0.427	V, J	0.0168	0.688	12.7	V	0.0199	0.229	0.917	--	0.0173	0.115
CDP-05 Mean	0.019				13.1				0.0169				0.526				0.380				13.5				0.92			
% of Reference	95				90				106				89				104				82				87			
CDP-REF Rep. 1	<0.0181	U	0.0181	0.225	15.0	--	0.0277	0.113	0.0153	J	0.00225	0.0450	0.661	--	0.00711	0.225	0.364	V, J	0.0165	0.675	17.8	V	0.0196	0.225	1.16	--	0.0170	0.113
CDP-REF Rep. 2	<0.0179	U	0.0179	0.223	15.6	--	0.0274	0.111	0.0167	J	0.00223	0.0445	0.582	--	0.00703	0.223	0.363	V, J	0.0164	0.668	19.5	V	0.0194	0.223	1.05	--	0.0168	0.111
CDP-REF Rep. 3	<0.0207	U	0.0207	0.257	13.3	--	0.0316	0.128	0.0172	J	0.00257	0.0514	0.587	--	0.00811	0.257	0.391	V, J	0.0189	0.770	14.7	V	0.0223	0.257	1.07	--	0.0194	0.128
CDP-REF Rep. 4	<0.0209	U	0.0209	0.259	13.8	--	0.0319	0.130	0.0148	J	0.00259	0.0519	0.557	--	0.00819	0.259	0.372	V, J	0.0191	0.778	15.7	V	0.0226	0.259	0.981	--	0.0196	0.130
CDP-REF Rep. 5	<0.0217	U	0.0217	0.269	14.6	--	0.0331	0.134	0.0153	J	0.00269	0.0538	0.576	--	0.00850	0.269	0.341	V, J	0.0198	0.807	14.6	V	0.0234	0.269	1.01	--	0.0203	0.134
CDP-REF Mean	0.020				14.5				0.0159				0.5926				0.366				16.5				1.054			
Pre-exposure Rep. 1	<0.0192	U	0.0192	0.239	13.7	--	0.0294	0.119	0.0158	J	0.00239	0.0478	0.559	--	0.00755	0.239	0.395	V, J	0.0176	0.717	15.7	V	0.0208	0.239	1.56	--	0.0180	0.119
Pre-exposure Rep. 2	<0.0173	U	0.0173	0.215	15.3	--	0.0265	0.108	0.0110	J	0.00215	0.0431	0.576	--	0.00681	0.215	0.321	V, J	0.0158	0.646	18.3	V	0.0187	0.215	1.46	--	0.0163	0.108
Pre-exposure Rep. 3	<0.0149	U	0.0149	0.185	15.2	--	0.0228	0.0926	0.0143	J	0.00185	0.0370	0.483	--	0.00585	0.185	0.467	V, J	0.0136	0.555	20.8	V	0.0161	0.185	2.37	--	0.0140	0.0926
Pre-exposure Mean	0.0171				14.7				0.0137				0.539				0.394				18.3				1.797			

TABLE 15 ***(continued)***

Analytical Results for Dry Weight Metals in *Mercenaria mercenaria* Tissues

Analyte:	**Mercury**				**Nickel**				**Selenium**				**Silver**				**Thallium**				**Zinc**				**Total Petroleum Hydrocarbons (TPHs)**			
Sample-Replicate #	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**
CDP-DMMU-01 Rep. 1	<0.0494	U	0.0494	0.0988	4.03	V	0.00417	0.235	1.86	--	0.259	1.18	0.229	--	0.00167	0.118	0.00400	J	0.00162	0.118	156	V	0.442	2.35	ND	U	483	1144
CDP-DMMU-01 Rep. 2	<0.0385	U	0.0385	0.0771	5.89	V	0.00428	0.242	2.22	--	0.266	1.21	0.146	--	0.00172	0.121	0.00556	J	0.00167	0.121	200	V	0.454	2.42	ND	U	496	1175
CDP-DMMU-01 Rep. 3	<0.0561	U	0.0561	0.112	5.22	V	0.00448	0.253	1.90	--	0.278	1.27	0.223	--	0.00180	0.127	0.00354	J	0.00175	0.127	178	V	0.475	2.53	ND	U	489	1159
CDP-DMMU-01 Rep. 4	<0.0566	U	0.0566	0.113	6.65	V	0.00438	0.248	2.28	--	0.272	1.24	0.203	--	0.00176	0.124	0.00446	J	0.00171	0.124	210	V	0.465	2.48	637	J	543	1287
CDP-DMMU-01 Rep. 5	<0.0442	U	0.0442	0.0884	5.90	V	0.00460	0.260	1.95	--	0.286	1.30	0.337	--	0.00185	0.130	0.00390	J	0.00179	0.130	177	V	0.488	2.60	637	J	522	1238
CDP-01 Mean	0.0490				5.54				2.04				0.228				**0.0043**				184				548			
% of Reference	100				102				114				71				136				115				113			
CDP-DMMU-02 Rep. 1	<0.0401	U	0.0401	0.0802	4.51	V	0.00354	0.200	2.43	--	0.220	1.00	0.233	--	0.00142	0.100	0.00280	J	0.00138	0.100	168	V	0.375	2.00	ND	U	452	1072
CDP-DMMU-02 Rep. 2	<0.0477	U	0.0477	0.0955	5.03	V	0.00351	0.198	2.41	--	0.218	0.991	0.222	--	0.00141	0.0991	0.00317	J	0.00137	0.0991	182	V	0.372	1.98	ND	U	443	1050
CDP-DMMU-02 Rep. 3	<0.0447	U	0.0447	0.0894	4.26	V	0.00418	0.236	2.94	--	0.260	1.18	0.123	--	0.00168	0.118	0.00378	J	0.00163	0.118	240	V	0.443	2.36	ND	U	488	1157
CDP-DMMU-02 Rep. 4	<0.0456	U	0.0456	0.0913	4.49	V	0.00393	0.222	2.75	--	0.244	1.11	0.179	--	0.00158	0.111	0.00333	J	0.00153	0.111	219	V	0.417	2.22	ND	U	469	1111
CDP-DMMU-02 Rep. 5	<0.0449	U	0.0449	0.0898	4.54	V	0.00381	0.215	3.00	--	0.237	1.08	0.254	--	0.00153	0.108	0.00301	J	0.00148	0.108	248	V	0.404	2.15	ND	U	427	1011
CDP-02 Mean	0.0446				4.566				**2.71**				0.202				0.00322				**211**				456			
% of Reference	91				84				151				63				102				132				94			
CDP-DMMU-03 Rep. 1	<0.0467	U	0.0467	0.0935	4.94	V	0.00464	0.262	2.34	--	0.289	1.31	0.182	--	0.00186	0.131	0.00420	J	0.00181	0.131	220	V	0.493	2.62	ND	U	510	1208
CDP-DMMU-03 Rep. 2	<0.0552	U	0.0552	0.110	4.72	V	0.00410	0.232	2.72	--	0.255	1.16	0.625	--	0.00165	0.116	0.00301	J	0.00160	0.116	199	V	0.435	2.32	ND	U	474	1122
CDP-DMMU-03 Rep. 3	<0.0463	U	0.0463	0.0927	6.15	V	0.00413	0.233	2.67	--	0.257	1.17	0.255	--	0.00166	0.117	0.00467	J	0.00161	0.117	217	V	0.438	2.33	ND	U	492	1167
CDP-DMMU-03 Rep. 4	<0.0540	U	0.0540	0.108	4.84	V	0.00416	0.235	2.30	--	0.258	1.17	0.336	--	0.00167	0.117	0.00305	J	0.00162	0.117	182	V	0.441	2.35	ND	U	456	1080
CDP-DMMU-03 Rep. 5	<0.0487	U	0.0487	0.0975	4.88	V	0.00404	0.228	2.39	--	0.251	1.14	0.266	--	0.00162	0.114	0.00297	J	0.00158	0.114	139	V	0.429	2.28	ND	U	463	1096
CDP-03 Mean	0.0502				5.106				**2.484**				0.333				0.00358				191				479			
% of Reference	102				94				138				104				113				120				98			
CDP-DMMU-04 Rep. 1	<0.0350	U	0.0350	0.0700	3.60	V	0.00400	0.226	1.87	--	0.249	1.13	0.291	--	0.00161	0.113	0.00226	J	0.00156	0.113	120	V	0.424	2.26	ND	U	458	1085
CDP-DMMU-04 Rep. 2	<0.0416	U	0.0416	0.0832	5.14	V	0.00349	0.197	1.83	--	0.217	0.985	0.236	--	0.00140	0.0985	0.00217	J	0.00136	0.0985	146	V	0.370	1.97	ND	U	477	1130
CDP-DMMU-04 Rep. 3	<0.0362	U	0.0362	0.0724	5.32	V	0.00361	0.204	2.05	--	0.224	1.02	0.249	--	0.00145	0.102	0.00326	J	0.00141	0.102	152	V	0.383	2.04	ND	U	451	1068
CDP-DMMU-04 Rep. 4	<0.0570	U	0.0570	0.114	5.94	V	0.00456	0.257	1.78	--	0.283	1.29	0.269	--	0.00183	0.129	0.00232	J	0.00178	0.129	151	V	0.483	2.57	ND	U	466	1106
CDP-DMMU-04 Rep. 5	<0.0521	U	0.0521	0.104	5.85	V	0.00345	0.195	2.09	--	0.214	0.974	0.521	--	0.00138	0.0974	0.00331	J	0.00134	0.0974	153	V	0.366	1.95	ND	U	462	1095
CDP-04 Mean	0.0444				5.17				1.92				0.313				0.00266				144				463			
% of Reference	90				95				107				98				84				90				95			
CDP-DMMU-05 Rep. 1	<0.0501	U	0.0501	0.100	5.26	V	0.00356	0.201	1.95	--	0.221	1.01	0.338	--	0.00143	0.101	0.00422	J	0.00139	0.101	154	V	0.377	2.01	ND	U	447.983	1061.571
CDP-DMMU-05 Rep. 2	<0.0513	U	0.0513	0.103	4.65	V	0.00361	0.204	1.84	--	0.225	1.02	0.291	--	0.00145	0.102	0.00286	J	0.00141	0.102	136	V	0.383	2.04	ND	U	432.8205	1025.641
CDP-DMMU-05 Rep. 3	<0.0457	U	0.0457	0.0915	5.08	V	0.00425	0.240	1.85	--	0.264	1.20	0.261	--	0.00171	0.120	0.00288	J	0.00166	0.120	156	V	0.451	2.40	ND	U	460.1963	1090.513
CDP-DMMU-05 Rep. 4	<0.0508	U	0.0508	0.102	5.04	V	0.00360	0.203	1.82	--	0.224	1.02	0.228	--	0.00144	0.102	0.00305	J	0.00140	0.102	154	V	0.382	2.03	ND	U	442.8122	1049.318
CDP-DMMU-05 Rep. 5	<0.0605	U	0.0605	0.121	6.03	V	0.00406	0.229	1.83	--	0.252	1.15	0.308	--	0.00163	0.115	0.00275	J	0.00158	0.115	154	V	0.430	2.29	ND	U	450.8547	1068.376
CDP-05 Mean	0.0517				5.21				1.86				0.285				0.00315				151				447			
% of Reference	105				96				104				89				100				94				92			
CDP-REF Rep. 1	<0.0558	U	0.0558	0.112	6.01	V	0.00398	0.225	1.91	--	0.248	1.13	0.538	--	0.00160	0.113	0.00225	J	0.00155	0.113	172	V	0.423	2.25	ND	U	482	1143
CDP-REF Rep. 2	<0.0449	U	0.0449	0.0898	4.93	V	0.00394	0.223	1.96	--	0.245	1.11	0.246	--	0.00158	0.111	0.00312	J	0.00154	0.111	157	V	0.418	2.23	ND	U	474	1122
CDP-REF Rep. 3	<0.0466	U	0.0466	0.0933	5.87	V	0.00455	0.257	1.67	--	0.282	1.28	0.296	--	0.00182	0.128	0.00205	J	0.00177	0.128	139	V	0.482	2.57	ND	U	486	1151
CDP-REF Rep. 4	<0.0472	U	0.0472	0.0944	4.87	V	0.00459	0.259	1.68	--	0.285	1.30	0.217	--	0.00184	0.130	0.00648	J	0.00179	0.130	150	V	0.487	2.59	488	J	475	1125
CDP-REF Rep. 5	<0.0508	U	0.0508	0.102	5.57	V	0.00476	0.269	1.75	--	0.296	1.34	0.299	--	0.00191	0.134	0.00188	J	0.00186	0.134	182	V	0.505	2.69	ND	U	504	1195
CDP-REF Mean	0.0491				5.45				1.79				0.319				0.0032				160				487			
Pre-exposure Rep. 1	<0.0461	U	0.0461	0.0923	4.98	V	0.00423	0.239	2.02	--	0.263	1.19	0.230	--	0.00170	0.119	0.00191	J	0.00165	0.119	141	V	0.449	2.39	ND	U	431	1022
Pre-exposure Rep. 2	<0.0421	U	0.0421	0.0842	5.22	V	0.00381	0.215	2.16	--	0.237	1.08	0.247	--	0.00153	0.108	0.00172	J	0.00149	0.108	147	V	0.404	2.15	ND	U	429	1017
Pre-exposure Rep. 3	<0.0424	U	0.0424	0.0849	4.81	V	0.00328	0.185	2.07	--	0.204	0.926	0.192	--	0.00131	0.0926	0.00222	J	0.00128	0.0926	155	V	0.348	1.85	ND	U	398	943
Pre-exposure Mean	0.0435				5.00				2.08				0.223				0.0020				148				420			

Bolded values indicate a mean concentration of project tissue that is statistically significantly greater than that of the reference tissue and includes at least one replicate result greater than the MDL.

< #.## = The analyte was not detected (ND) at or above the MDL (U-qualified). The value indicates the MDL. Non-detect (ND) results use the MDL for calculating average concentrations. (J-qualified results use the value reported by the laboratory for calculating average concentrations.)

J = Estimated value. The reported value is between the MDL and MRL. V = The analyte was detected in both sample and method blank. B = Analyte was detected in the method blank.

Source: Results from NWDLS.

Compiled by: ANAMAR Environmental Consulting, Inc.

TABLE 16

Analytical Results for Dry Weight Metals in *Alitta virens* Tissues

Analyte:	Antimony				Arsenic				Beryllium				Cadmium				Chromium				Copper				Lead			
Sample-Replicate #	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**
CDP-DMMU-01 Rep. 1	0.0206	J	0.0110	0.137	14.8	--	0.0840	0.341	0.00983	J	0.00137	0.0273	0.239	--	0.00431	0.137	0.567	V	0.0100	0.410	10.2	V	0.0119	0.137	1.22	--	0.0103	0.0683
CDP-DMMU-01 Rep. 2	0.0188	J	0.0114	0.142	16.2	--	0.0871	0.354	0.00595	J	0.00142	0.0283	0.260	--	0.00448	0.142	0.761	V	0.0104	0.425	8.40	V	0.0123	0.142	1.21	--	0.0107	0.0708
CDP-DMMU-01 Rep. 3	0.0174	J	0.0123	0.153	16.2	--	0.0938	0.381	0.00320	J	0.00153	0.0305	0.262	--	0.00482	0.153	0.576	V	0.0112	0.458	9.60	V	0.0133	0.153	1.17	--	0.0115	0.0763
CDP-DMMU-01 Rep. 4	0.0178	J	0.0110	0.137	16.3	--	0.0841	0.342	0.00410	J	0.00137	0.0274	0.228	--	0.00432	0.137	0.892	V	0.0101	0.410	8.82	V	0.0119	0.137	1.11	--	0.0103	0.0684
CDP-DMMU-01 Rep. 5	0.0195	J	0.0131	0.163	18.4	--	0.100	0.407	0.00342	J	0.00163	0.0325	0.225	--	0.00514	0.163	0.865	V	0.0120	0.488	9.42	V	0.0142	0.163	1.08	--	0.0123	0.0813
CDP-01 Mean	0.0188				16.4				0.00530				0.243				0.732				9.288				**1.158**			
% of Reference	83				83				127				106				119				64				133			
CDP-DMMU-02 Rep. 1	0.0259	J	0.0124	0.154	20.7	--	0.0944	0.384	0.00246	J	0.00154	0.0307	0.269	--	0.00485	0.154	0.707	V	0.0113	0.461	15.7	V	0.0134	0.154	1.42	--	0.0116	0.0768
CDP-DMMU-02 Rep. 2	0.0221	J	0.0123	0.152	22.7	--	0.0937	0.381	0.00229	J	0.00152	0.0305	0.244	--	0.00481	0.152	0.638	V	0.0112	0.457	13.5	V	0.0133	0.152	1.25	--	0.0115	0.0762
CDP-DMMU-02 Rep. 3	<0.0208	U	0.0208	0.258	18.6	--	0.159	0.645	0.00361	J	0.00258	0.0516	0.234	J	0.00815	0.258	0.410	V, J	0.0190	0.774	9.96	V	0.0224	0.258	1.10	--	0.0195	0.129
CDP-DMMU-02 Rep. 4	0.0179	J	0.0120	0.149	19.2	--	0.0915	0.372	0.00521	J	0.00149	0.0298	0.238	--	0.00470	0.149	0.610	V	0.0109	0.446	8.80	V	0.0129	0.149	1.07	--	0.0112	0.0744
CDP-DMMU-02 Rep. 5	0.0204	J	0.0114	0.142	21.0	--	0.0873	0.355	0.00468	J	0.00142	0.0284	0.235	--	0.00449	0.142	0.567	V	0.0104	0.426	10.6	V	0.0123	0.142	1.13	--	0.0107	0.0710
CDP-02 Mean	0.02142				20.44				0.00365				0.244				0.586				11.71				**1.194**			
% of Reference	95				104				88				107				96				80				137			
CDP-DMMU-03 Rep. 1	0.0215	J	0.0125	0.156	18.8	--	0.0958	0.389	0.00576	J	0.00156	0.0312	0.252	--	0.00492	0.156	0.532	V	0.0114	0.467	9.42	V	0.0136	0.156	1.12	--	0.0118	0.0779
CDP-DMMU-03 Rep. 2	0.0184	J	0.0118	0.147	17.7	--	0.0904	0.367	0.00470	J	0.00147	0.0294	0.236	--	0.00464	0.147	0.572	V	0.0108	0.441	8.19	V	0.0128	0.147	1.15	--	0.0111	0.0735
CDP-DMMU-03 Rep. 3	0.0203	J	0.0134	0.166	17.1	--	0.102	0.416	0.0153	J	0.00166	0.0333	0.248	--	0.00526	0.166	1.16	V	0.0122	0.499	8.04	V	0.0145	0.166	1.39	--	0.0126	0.0832
CDP-DMMU-03 Rep. 4	0.0250	J	0.0112	0.140	20.5	--	0.0858	0.349	0.00893	J	0.00140	0.0279	0.246	--	0.00441	0.140	0.895	V	0.0103	0.419	8.17	V	0.0121	0.140	1.19	--	0.0105	0.0698
CDP-DMMU-03 Rep. 5	0.0166	J	0.0144	0.178	18.8	--	0.110	0.446	0.00945	J	0.00178	0.0357	0.244	--	0.00563	0.178	1.03	V	0.0131	0.535	8.06	V	0.0155	0.178	1.14	--	0.0135	0.0891
CDP-03 Mean	0.0204				18.6				**0.00883**				0.245				0.8378				8.38				**1.198**			
% of Reference	90				94				212				107				137				57				138			
CDP-DMMU-04 Rep. 1	0.0163	J	0.0162	0.202	16.6	--	0.124	0.504	0.00282	J	0.00202	0.0403	0.202	--	0.00637	0.202	0.368	V, J	0.0148	0.605	8.99	V	0.0175	0.202	0.832	--	0.0152	0.101
CDP-DMMU-04 Rep. 2	0.0166	J	0.0114	0.141	18.3	--	0.0870	0.354	0.00226	J	0.00141	0.0283	0.195	--	0.00447	0.141	0.457	V	0.0104	0.424	9.34	V	0.0123	0.141	0.764	--	0.0107	0.0707
CDP-DMMU-04 Rep. 3	0.0167	J	0.0129	0.161	20.6	--	0.0987	0.401	0.00257	J	0.00161	0.0321	0.219	--	0.00507	0.161	0.454	V, J	0.0118	0.482	8.53	V	0.0140	0.161	0.849	--	0.0121	0.0803
CDP-DMMU-04 Rep. 4	0.0154	J	0.0114	0.141	18.9	--	0.0868	0.353	0.00254	J	0.00141	0.0282	0.212	--	0.00446	0.141	0.376	V, J	0.0104	0.423	7.76	V	0.0123	0.141	0.795	--	0.0107	0.0706
CDP-DMMU-04 Rep. 5	0.0179	J	0.0131	0.163	20.2	--	0.100	0.407	0.00261	J	0.00163	0.0326	0.246	--	0.00515	0.163	0.412	V, J	0.0120	0.489	8.71	V	0.0142	0.163	0.897	--	0.0123	0.0814
CDP-04 Mean	0.0166				18.9				0.00256				0.215				0.413				8.7				0.827			
% of Reference	73				96				61				94				67				59				95			
CDP-DMMU-05 Rep. 1	0.0151	J	0.0134	0.166	21.0	--	0.102	0.415	0.00415	J	0.00166	0.0332	0.224	--	0.00525	0.166	0.505	V	0.0122	0.498	8.88	V	0.0144	0.166	0.871	--	0.0125	0.0830
CDP-DMMU-05 Rep. 2	0.0186	J	0.0127	0.158	21.4	--	0.0969	0.394	0.00441	J	0.00158	0.0315	0.257	--	0.00498	0.158	0.693	V	0.0116	0.473	9.03	V	0.0137	0.158	0.993	--	0.0119	0.0788
CDP-DMMU-05 Rep. 3	0.0167	J	0.0117	0.145	19.8	--	0.0891	0.362	0.00493	J	0.00145	0.0290	0.248	--	0.00458	0.145	0.579	V	0.0107	0.435	8.51	V	0.0126	0.145	0.854	--	0.0109	0.0725
CDP-DMMU-05 Rep. 4	0.0143	J	0.0114	0.142	18.2	--	0.0871	0.354	0.00269	J	0.00142	0.0283	0.220	--	0.00448	0.142	0.462	V	0.0104	0.425	8.71	V	0.0123	0.142	0.762	--	0.0107	0.0708
CDP-DMMU-05 Rep. 5	0.0158	J	0.0136	0.168	17.8	--	0.104	0.421	0.00252	J	0.00168	0.0337	0.229	--	0.00532	0.168	0.451	V, J	0.0124	0.505	7.48	V	0.0146	0.168	0.811	--	0.0127	0.0842
CDP-05 Mean	0.0161				19.6				0.00374				0.236				0.538				8.5				0.858			
% of Reference	71				100				90				103				88				58				99			
CDP-REF Rep. 1	0.0224	J	0.0134	0.166	18.9	--	0.204	0.830	0.00797	J	0.00166	0.0332	0.233	--	0.00524	0.166	0.304	V, J	0.0122	0.498	11.3	V	0.0144	0.166	0.760	--	0.0125	0.0830
CDP-REF Rep. 2	0.0276	J	0.0131	0.163	19.0	--	0.200	0.813	0.00309	J	0.00163	0.0325	0.212	--	0.00514	0.163	0.910	V	0.0119	0.488	22.3	V	0.0283	0.325	1.00	--	0.0123	0.0813
CDP-REF Rep. 3	0.0239	J	0.0120	0.149	20.3	--	0.183	0.745	0.00313	J	0.00149	0.0298	0.217	--	0.00471	0.149	0.744	V	0.0110	0.447	16.7	V	0.0259	0.298	0.932	--	0.0113	0.0745
CDP-REF Rep. 4	0.0182	J	0.0108	0.135	21.0	--	0.0331	0.135	0.00350	J	0.00135	0.0269	0.243	--	0.00425	0.135	0.528	V	0.00990	0.404	11.6	V	0.0234	0.269	0.848	--	0.0102	0.0673
CDP-REF Rep. 5	0.0208	J	0.0149	0.186	19.3	--	0.228	0.928	0.00315	J	0.00186	0.0371	0.238	--	0.00586	0.186	0.580	V	0.0136	0.557	11.1	V	0.0323	0.371	0.813	--	0.0140	0.0928
CDP-REF Mean	0.02258				19.7				0.0042				0.229				0.613				14.6				0.871			
Pre-exposure Rep. 1	0.0238	J	0.0137	0.170	19.7	--	0.104	0.425	0.00680	J	0.00170	0.0340	0.171	--	0.00537	0.170	0.820	V	0.0125	0.510	9.86	V	0.0148	0.170	0.696	--	0.0128	0.0849
Pre-exposure Rep. 2	0.0213	J	0.00927	0.115	20.9	--	0.0283	0.115	0.0244	--	0.00115	0.0230	0.172	--	0.00364	0.115	1.70	V	0.00847	0.346	9.08	V	0.0100	0.115	1.07	--	0.00870	0.0576
Pre-exposure Rep. 3	0.0174	J	0.0111	0.138	16.0	--	0.0850	0.346	0.00788	J	0.00138	0.0276	0.239	--	0.00437	0.138	0.842	V	0.0102	0.415	15.6	V	0.0120	0.138	1.07	--	0.0104	0.0691
Pre-exposure Mean	0.021				18.9				0.0130				0.194				1.12				11.5				0.945			

TABLE 16 ***(continued)***

Analytical Results for Dry Weight Metals in *Alitta virens* Tissues

Analyte:	**Mercury**				**Nickel**				**Selenium**				**Silver**				**Thallium**				**Zinc**				**Total Petroleum Hydrocarbons (TPHs)**			
Sample-Replicate #	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**	**Result mg/kg**	**Qualifier**	**MDL**	**MRL**
CDP-DMMU-01 Rep. 1	<0.0367	U	0.0367	0.0734	1.38	V	0.00242	0.137	2.30	--	0.150	0.683	0.150	--	0.000969	0.0683	0.00519	J	0.000942	0.0683	180	V	0.256	1.37	3132	J	1551	3676
CDP-DMMU-01 Rep. 2	<0.0322	U	0.0322	0.0643	1.42	V	0.00251	0.142	2.45	--	0.156	0.708	0.156	--	0.00101	0.0708	0.00439	J	0.000977	0.0708	80.6	V	0.266	1.42	3424	J	1465	3472
CDP-DMMU-01 Rep. 3	<0.0309	U	0.0309	0.0618	1.55	V	0.00270	0.153	2.73	--	0.168	0.763	0.155	--	0.00108	0.0763	0.00351	J	0.00105	0.0763	223	V	0.286	1.53	2269	J	1455	3448
CDP-DMMU-01 Rep. 4	<0.0262	U	0.0262	0.0524	1.74	V	0.00242	0.137	2.49	--	0.150	0.684	0.129	--	0.000971	0.0684	0.00342	J	0.000944	0.0684	65.5	V	0.257	1.37	3000	J	1435	3401
CDP-DMMU-01 Rep. 5	<0.0325	U	0.0325	0.0650	1.70	V	0.00288	0.163	2.61	--	0.179	0.813	0.116	--	0.00116	0.0813	0.00342	J	0.00112	0.0813	275	V	0.305	1.63	2979	J	1465	3472
CDP-01 Mean	0.0317				**1.56**				2.516				0.141				0.00399				165				2961			
% of Reference	88				163				97				80				91				115				77			
CDP-DMMU-02 Rep. 1	<0.0290	U	0.0290	0.0580	1.94	V	0.00272	0.154	2.83	--	0.169	0.768	0.0870	--	0.00109	0.0768	0.00430	J	0.00106	0.0768	83.4	V	0.288	1.54	1614	J	1507	3571
CDP-DMMU-02 Rep. 2	<0.0262	U	0.0262	0.0524	1.69	V	0.00270	0.152	2.88	--	0.168	0.762	0.0644	J	0.00108	0.0762	0.00427	J	0.00105	0.0762	66.0	V	0.286	1.52	2809	J	1496	3546
CDP-DMMU-02 Rep. 3	<0.0364	U	0.0364	0.0728	1.55	V	0.00456	0.258	2.50	--	0.284	1.29	0.0560	J	0.00183	0.129	0.00438	J	0.00178	0.129	146	V	0.484	2.58	4644	--	1445	3425
CDP-DMMU-02 Rep. 4	<0.0316	U	0.0316	0.0631	1.64	V	0.00263	0.149	2.70	--	0.164	0.744	0.0573	J	0.00106	0.0744	0.00521	J	0.00103	0.0744	66.9	V	0.279	1.49	6441	--	1476	3497
CDP-DMMU-02 Rep. 5	<0.0371	U	0.0371	0.0741	1.89	V	0.00251	0.142	2.91	--	0.156	0.710	0.0632	J	0.00101	0.0710	0.00412	J	0.000979	0.0710	118	V	0.266	1.42	3434	J	1551	3676
CDP-02 Mean	0.0321				**1.74**				2.764				0.066				0.00446				96				3788			
% of Reference	89				183				106				37				101				67				98			
CDP-DMMU-03 Rep. 1	<0.0375	U	0.0375	0.0751	1.51	V	0.00276	0.156	2.66	--	0.171	0.779	0.127	--	0.00111	0.0779	0.00436	J	0.00107	0.0779	228	V	0.292	1.56	7754	--	1529	3623
CDP-DMMU-03 Rep. 2	<0.0315	U	0.0315	0.0629	1.46	V	0.00260	0.147	2.77	--	0.162	0.735	0.130	--	0.00104	0.0735	0.00426	J	0.00101	0.0735	264	V	0.276	1.47	7619	--	1435	3401
CDP-DMMU-03 Rep. 3	<0.0302	U	0.0302	0.0605	1.65	V	0.00294	0.166	2.67	--	0.183	0.832	0.113	--	0.00118	0.0832	0.00682	J	0.00115	0.0832	114	V	0.312	1.66	7200	--	1407	3333
CDP-DMMU-03 Rep. 4	<0.0361	U	0.0361	0.0722	1.59	V	0.00247	0.140	2.97	--	0.154	0.698	0.117	--	0.000991	0.0698	0.00433	J	0.000963	0.0698	153	V	0.262	1.40	7105	--	1388	3289
CDP-DMMU-03 Rep. 5	<0.0380	U	0.0380	0.0760	1.68	V	0.00316	0.178	2.64	--	0.196	0.891	0.107	--	0.00127	0.0891	0.00570	J	0.00123	0.0891	148	V	0.335	1.78	9412	--	1551	3676
CDP-03 Mean	0.0347				**1.578**				2.74				0.119				0.00509				181				**7818**			
% of Reference	96				166				105				68				116				126				202			
CDP-DMMU-04 Rep. 1	<0.0372	U	0.0372	0.0744	0.960	V	0.00357	0.202	2.27	--	0.222	1.01	0.117	--	0.00143	0.101	0.00444	J	0.00139	0.101	66.4	V	0.0757	0.403	7570	--	1972	4673
CDP-DMMU-04 Rep. 2	<0.0381	U	0.0381	0.0761	1.09	V	0.00250	0.141	2.41	--	0.156	0.707	0.103	--	0.00100	0.0707	0.00453	J	0.000976	0.0707	158	V	0.266	1.41	9160	--	1611	3817
CDP-DMMU-04 Rep. 3	<0.0346	U	0.0346	0.0691	0.993	V	0.00284	0.161	2.26	--	0.177	0.803	0.130	--	0.00114	0.0803	0.00434	J	0.00111	0.0803	257	V	0.301	1.61	6623	--	1529	3623
CDP-DMMU-04 Rep. 4	<0.0308	U	0.0308	0.0616	1.04	V	0.00250	0.141	2.71	--	0.155	0.706	0.134	--	0.00100	0.0706	0.00494	J	0.000974	0.0706	146	V	0.265	1.41	7943	--	1482	3511
CDP-DMMU-04 Rep. 5	<0.0282	U	0.0282	0.0563	1.04	V	0.00288	0.163	2.52	--	0.179	0.814	0.146	--	0.00116	0.0814	0.00489	J	0.00112	0.0814	89.4	V	0.306	1.63	5348	--	1529	3623
CDP-04 Mean	0.0338				1.02				2.434				0.126				0.00463				143				**7329**			
% of Reference	94				108				94				72				105				100				190			
CDP-DMMU-05 Rep. 1	<0.0377	U	0.0377	0.0754	1.12	V	0.00294	0.166	2.55	--	0.183	0.830	0.171	--	0.00118	0.0830	0.00399	J	0.00115	0.0830	136	V	0.312	1.66	9113	--	340	806
CDP-DMMU-05 Rep. 2	<0.0342	U	0.0342	0.0685	1.19	V	0.00279	0.158	2.98	--	0.173	0.788	0.174	--	0.00112	0.0788	0.00425	J	0.00109	0.0788	176	V	0.296	1.58	2219	--	330	781
CDP-DMMU-05 Rep. 3	<0.0341	U	0.0341	0.0682	1.04	V	0.00256	0.145	2.63	--	0.159	0.725	0.176	--	0.00103	0.0725	0.00420	J	0.00100	0.0725	271	V	0.272	1.45	4170	--	299	709
CDP-DMMU-05 Rep. 4	<0.0295	U	0.0295	0.0590	1.04	V	0.00251	0.142	2.65	--	0.156	0.708	0.117	--	0.00101	0.0708	0.00382	J	0.000977	0.0708	281	V	0.532	2.83	8148	--	313	741
CDP-DMMU-05 Rep. 5	<0.0351	U	0.0351	0.0701	0.976	V	0.00298	0.168	2.43	--	0.185	0.842	0.135	--	0.00120	0.0842	0.00438	J	0.00116	0.0842	113	V	0.316	1.68	4008	--	317	752
CDP-05 Mean	0.0341				1.07				2.648				0.155				0.00413				195				5532			
% of Reference	94				113				102				88				94				136				143			
CDP-REF Rep. 1	<0.0350	U	0.0350	0.0699	0.867	V	0.00294	0.166	2.66	--	0.183	0.830	0.171	--	0.00118	0.0830	0.00481	J	0.00115	0.0830	219	V	0.312	1.66	4564	--	317	752
CDP-REF Rep. 2	<0.0374	U	0.0374	0.0748	1.10	V	0.00288	0.163	2.72	--	0.179	0.813	0.156	--	0.00115	0.0813	0.00423	J	0.00112	0.0813	111	V	0.305	1.63	7937	--	335	794
CDP-REF Rep. 3	<0.0349	U	0.0349	0.0697	0.970	V	0.00264	0.149	2.67	--	0.164	0.745	0.176	--	0.00106	0.0745	0.00417	J	0.00103	0.0745	249	V	0.280	1.49	4087	--	306	725
CDP-REF Rep. 4	<0.0333	U	0.0333	0.0665	0.878	V	0.00238	0.135	2.48	--	0.148	0.673	0.201	--	0.000956	0.0673	0.00431	J	0.000929	0.0673	71.0	V	0.253	1.35	1993	--	289	685
CDP-REF Rep. 5	<0.0400	U	0.0400	0.0800	0.950	V	0.00328	0.186	2.47	--	0.204	0.928	0.176	--	0.00132	0.0928	0.00445	J	0.00128	0.0928	68.4	V	0.348	1.86	750	J	361	855
CDP-REF Mean	0.0361				0.95				2.60				0.176				0.0044				144				3866			
Pre-exposure Rep. 1	<0.0333	U	0.0333	0.0667	1.29	V	0.00301	0.170	2.95	--	0.187	0.849	0.150	--	0.00121	0.0849	0.00204	J	0.00117	0.0849	111	V	0.319	1.70	5573	--	295	699
Pre-exposure Rep. 2	<0.0259	U	0.0259	0.0517	1.52	V	0.00204	0.115	2.83	--	0.127	0.576	0.197	--	0.000818	0.0576	0.00553	J	0.000795	0.0576	259	V	0.433	2.30	5477	--	279	662
Pre-exposure Rep. 3	<0.0298	U	0.0298	0.0595	0.780	V	0.00245	0.138	2.55	--	0.152	0.691	0.227	--	0.000981	0.0691	0.00332	J	0.000954	0.0691	101	V	0.260	1.38	1449	--	267	633
Pre-exposure Mean	0.0297				1.197				2.78				0.191				0.0036				157				4167			

Bolded values indicate a mean concentration of project tissue that is statistically significantly greater than that of the reference tissue and includes at least one replicate result greater than the MDL.

< #.## = The analyte was not detected (ND) at or above the MDL. The value indicates the MDL (U-qualified). Non-detect (ND) results use the MDL for calculating average concentrations. (J-qualified results use the value reported by the laboratory for calculating average concentrations.)

B = Analyte was found in the associated method blank. J = Estimated value. The reported value is between the detection limit and reporting limit. V = Analyte was detected in both sample and method blank.

Source: Results from Analytical Resources, Inc

Compiled by: ANAMAR Environmental Consulting, Inc.

TABLE 17

Analytical Results for Wet Weight SVOCs in *Mercenaria mercenaria* Tissues

Analyte:	Bis(2-ethylhexyl)phthalate				Di-n-Butyl phthalate			
Sample-Replicate #	**Result µg/kg**	**Qualifier**	**MDL**	**MRL**	**Result µg/kg**	**Qualifier**	**MDL**	**MRL**
CDP-DMMU-01 Rep. 1	7.06	H, V	2.50	2.50	12.2	H, V	2.50	2.50
CDP-DMMU-01 Rep. 2	3.83	H, V	2.50	2.50	12.5	H, V	2.50	2.50
CDP-DMMU-01 Rep. 3	4.24	H, V	2.50	2.50	8.45	H, V	2.50	2.50
CDP-DMMU-01 Rep. 4	3.73	H, V	2.50	2.50	8.97	H, V	2.50	2.50
CDP-DMMU-01 Rep. 5	4.85	H, V	2.50	2.50	6.15	H, V	2.50	2.50
CDP-01 Mean	4.74				**9.65**			
Adjusted Concentration	13.3				**9.65**			
% of Reference	115				127			
CDP-DMMU-02 Rep. 1	14.0	H, V	2.50	2.50	9.63	H, V	2.50	2.50
CDP-DMMU-02 Rep. 2	6.96	H, V	2.50	2.50	8.62	H, V	2.50	2.50
CDP-DMMU-02 Rep. 3	6.02	H, V	2.50	2.50	5.96	H, V	2.50	2.50
CDP-DMMU-02 Rep. 4	4.10	H, V	2.50	2.50	10.5	H, V	2.50	2.50
CDP-DMMU-02 Rep. 5	3.77	H, V	2.50	2.50	9.15	H, V	2.50	2.50
CDP-02 Mean	6.97				8.77			
Adjusted Concentration	19.5				8.77			
% of Reference	169				116			
CDP-DMMU-03 Rep. 1	7.84	H, V	2.50	2.50	11.6	H, V	2.50	2.50
CDP-DMMU-03 Rep. 2	3.67	H, V	2.50	2.50	10.2	H, V	2.50	2.50
CDP-DMMU-03 Rep. 3	8.64	H, V	2.50	2.50	10.0	H, V	2.50	2.50
CDP-DMMU-03 Rep. 4	6.14	H, V	2.50	2.50	8.20	H, V	2.50	2.50
CDP-DMMU-03 Rep. 5	4.59	H, V	2.50	2.50	8.96	H, V	2.50	2.50
CDP-03 Mean	6.18				9.79			
Adjusted Concentration	17.3				9.79			
% of Reference	150				129			
CDP-REF Rep. 1	3.25	H, V	2.50	2.50	7.93	H, V	2.50	2.50
CDP-REF Rep. 2	4.14	H, V	2.50	2.50	8.25	H, V	2.50	2.50
CDP-REF Rep. 3	4.47	H, V	2.50	2.50	7.07	H, V	2.50	2.50
CDP-REF Rep. 4	5.88	H, V	2.50	2.50	7.48	H, V	2.50	2.50
CDP-REF Rep. 5	2.84	H, V	2.50	2.50	7.18	H, V	2.50	2.50
CDP-REF Mean	4.12				7.58			
Adjusted Concentration	11.5				7.58			
Pre-exposure Rep. 1	<2.50	B, H, U	2.50	2.50	5.72	H, V	2.50	2.50
Pre-exposure Rep. 2	<2.50	B, H, U	2.50	2.50	7.88	H, V	2.50	2.50
Pre-exposure Rep. 3	3.16	H, V	2.50	2.50	7.06	H, V	2.50	2.50
Pre-exposure Mean	2.72				6.89			
Steady State Factor[1]	2.8				1.0			
Eco. Effects Threshold[1]	847.0				x			
North Gulf of Mexico Bkgd[1]	x				x			

Bolded values indicate a mean concentration of project tissue that is statistically significantly greater than that of the reference tissue and includes at least one replicate result greater than the MDL.

< #.## = The analyte was not detected (ND) at or above the MDL (U-qualified). The value indicates the MDL. U-qualified results use the MDL for calculating average concentrations. (J-qualified results use the value reported by the laboratory for calculating average concentrations.)

B = Analyte was found in the associated method blank. V = Analyte was detected in both sample and method blank. H = parameter was analyzed outside method specified holding time.

Sources: Results from NWDLS; [1] Steady State Factors and Levels/Limits from Appendix H of SERIM (EPA/USACE 2008).
Compiled by: ANAMAR Environmental Consulting, Inc.

TABLE 18
Analytical Results for Wet Weight SVOCs in *Alitta virens* Tissues

Analyte:	**Bis(2-ethylhexyl)phthalate**				**Di-n-Butyl phthalate**			
Sample-Replicate #	**Result µg/kg**	**Qualifier**	**MDL**	**MRL**	**Result µg/kg**	**Qualifier**	**MDL**	**MRL**
CDP-DMMU-01 Rep. 1	<5.00	B, H, U	5.00	5.00	12.3	H, V	5.00	5.00
CDP-DMMU-01 Rep. 2	<5.00	B, H, U	5.00	5.00	12.5	H, V	5.00	5.00
CDP-DMMU-01 Rep. 3	8.24	H, V	5.00	5.00	13.4	H, V	5.00	5.00
CDP-DMMU-01 Rep. 4	<5.00	B, H, U	5.00	5.00	11.9	H, V	5.00	5.00
CDP-DMMU-01 Rep. 5	<5.00	B, H, U	5.00	5.00	13.2	H, V	5.00	5.00
CDP-01 Mean	**5.65**				12.7			
Adjusted Concentration	**15.8**				12.7			
% of Reference	226				46			
CDP-DMMU-02 Rep. 1	8.48	H, V	5.00	5.00	14.4	H, V	5.00	5.00
CDP-DMMU-02 Rep. 2	10.9	H, V	5.00	5.00	11.2	H, V	5.00	5.00
CDP-DMMU-02 Rep. 3	10.3	H, V	5.00	5.00	12.8	H, V	5.00	5.00
CDP-DMMU-02 Rep. 4	11.9	H, V	5.00	5.00	17.8	H, V	5.00	5.00
CDP-DMMU-02 Rep. 5	12.5	H, V	2.50	2.50	15.3	H, V	2.50	2.50
CDP-02 Mean	**10.8**				14.3			
Adjusted Concentration	**30.3**				14.3			
% of Reference	433				52			
CDP-DMMU-03 Rep. 1	10.8	H, V	5.00	5.00	14.6	H, V	5.00	5.00
CDP-DMMU-03 Rep. 2	13.6	H, V	5.00	5.00	16.8	H, V	5.00	5.00
CDP-DMMU-03 Rep. 3	<5.00	H, B, U	5.00	5.00	48.4	H, V	5.00	5.00
CDP-DMMU-03 Rep. 4	<5.00	B, H, U	5.00	5.00	12.9	H, V	5.00	5.00
CDP-DMMU-03 Rep. 5	<5.00	B, H, U	5.00	5.00	10.0	H, V	5.00	5.00
CDP-03 Mean	**7.88**				20.5			
Adjusted Concentration	**22.1**				20.5			
% of Reference	315				75			
CDP-REF Rep. 1	<2.50	B, H, U	2.50	2.50	27.7	H, V	2.50	2.50
CDP-REF Rep. 2	<2.50	B, H, U	2.50	2.50	17.1	H, V	2.50	2.50
CDP-REF Rep. 3	<2.50	B, H, U	2.50	2.50	17.3	C, H, V	2.50	2.50
CDP-REF Rep. 4	<2.50	B, H, U	2.50	2.50	10.5	C, H, V	2.50	2.50
CDP-REF Rep. 5	<2.50	B, H, U	2.50	2.50	64.5	C-, H, V	5.00	5.00
CDP-REF Mean	2.50				27.4			
Adjusted Concentration	7.00				27.4			
Pre-exposure Rep. 1	<5.00	B, H, U	5.00	5.00	37.1	H, V	5.00	5.00
Pre-exposure Rep. 2	<5.00	B, H, U	5.00	5.00	10.8	H, V	5.00	5.00
Pre-exposure Rep. 3	9.97	H, V	2.50	2.50	63.3	H, V	2.50	2.50
Pre-exposure Mean	6.66				37.1			
Steady State Factor[1]	2.8				1.0			
Eco. Effects Threshold[1]	x				x			
North Gulf of Mexico Bkgd[1]	x				x			

Bolded values indicate a mean concentration of project tissue that is statistically significantly greater than that of the reference tissue and includes at least one replicate result greater than the MDL.

< #.## = The analyte was not detected (ND) at or above the MDL (U-qualified). The value indicates the MDL. U-qualified results use the MDL for calculating average concentrations. (J-qualified results use the value reported by the laboratory for calculating average concentrations.)

B = analyte was found in the associated method blank. V = analyte was detected in both sample and method blank. C = associated calibration QC is outside established quality control criteria for accuracy. H = parameter was analyzed outside method specified holding time.

Sources: Results from NWDLS; [1] Steady State Factors and Levels/Limits from Appendix H of SERIM (EPA/USACE 2008).
Compiled by: ANAMAR Environmental Consulting, Inc.

TABLE 19

Analytical Results for Dry Weight SVOCs in *Mercenaria mercenaria* Tissues

Analyte:	Bis(2-ethylhexyl)phthalate				Di-n-Butyl phthalate			
Sample-Replicate #	**Result µg/kg**	**Qualifier**	**MDL**	**MRL**	**Result µg/kg**	**Qualifier**	**MDL**	**MRL**
CDP-DMMU-01 Rep. 1	80.7	H, V	28.6	28.6	139	H, V	28.6	28.6
CDP-DMMU-01 Rep. 2	45.0	H, V	29.4	29.4	147	H, V	29.4	29.4
CDP-DMMU-01 Rep. 3	49.2	H, V	29.0	29.0	98.0	H, V	29.0	29.0
CDP-DMMU-01 Rep. 4	48.3	H, V	32.3	32.3	116	H, V	32.3	32.3
CDP-DMMU-01 Rep. 5	60.0	H, V	31.0	31.0	76.2	H, V	31.0	31.0
CDP-01 Mean	56.6				**115**			
% of Reference	120				133			
CDP-DMMU-02 Rep. 1	151	H, V	26.9	26.9	104	H, V	26.9	26.9
CDP-DMMU-02 Rep. 2	73.1	H, V	26.3	26.3	90.5	H, V	26.3	26.3
CDP-DMMU-02 Rep. 3	70.0	H, V	29.0	29.0	69.3	H, V	29.0	29.0
CDP-DMMU-02 Rep. 4	45.5	H, V	27.8	27.8	117	H, V	27.8	27.8
CDP-DMMU-02 Rep. 5	38.1	H, V	25.3	25.3	92.4	H, V	25.3	25.3
CDP-02 Mean	75.5				94.6			
% of Reference	161				109			
CDP-DMMU-03 Rep. 1	94.6	H, V	30.2	30.2	139	H, V	30.2	30.2
CDP-DMMU-03 Rep. 2	41.2	H, V	28.1	28.1	114	H, V	28.1	28.1
CDP-DMMU-03 Rep. 3	101	H, V	29.2	29.2	117	H, V	29.2	29.2
CDP-DMMU-03 Rep. 4	66.3	H, V	27.0	27.0	88.6	H, V	27.0	27.0
CDP-DMMU-03 Rep. 5	50.3	H, V	27.4	27.4	98.2	H, V	27.4	27.4
CDP-03 Mean	70.7				111			
% of Reference	150				128			
CDP-REF Rep. 1	37.2	H, V	28.6	28.6	90.6	H, V	28.6	28.6
CDP-REF Rep. 2	46.5	H, V	28.0	28.0	92.6	H, V	28.0	28.0
CDP-REF Rep. 3	51.5	H, V	28.8	28.8	81.3	H, V	28.8	28.8
CDP-REF Rep. 4	66.2	H, V	28.1	28.1	84.2	H, V	28.1	28.1
CDP-REF Rep. 5	33.9	H, V	29.9	29.9	85.8	H, V	29.9	29.9
CDP-REF Mean	47.1				86.9			
Pre-exposure Rep. 1	<25.6	B, H, U	25.6	25.6	58.5	H, V	25.6	25.6
Pre-exposure Rep. 2	<25.4	B, H, U	25.4	25.4	80.1	H, V	25.4	25.4
Pre-exposure Rep. 3	29.7	H, V	23.5	23.5	66.4	H, V	23.5	23.5
Pre-exposure Mean	26.9				68.3			

Bolded values indicate that the mean concentration of project tissue is statistically significantly greater than that of the reference and at least one replicate result is greater than the MDL.

< #.## = The analyte was not detected (ND) at or above the MDL (U-qualified). The value indicates the MDL. Non-detect (ND) results use the MDL for calculating average concentrations. (J-qualified results use the value reported by the laboratory for calculating average concentrations.)

B = the analyte was found in the associated method blank. V = Analyte was detected in both sample and method blank.
H = parameter was analyzed outside the method specified holding time.

Sources: Results from NWDLS.
Compiled by: ANAMAR Environmental Consulting, Inc.

TABLE 20
Analytical Results for Dry Weight SVOCs in *Alitta virens* Tissues

Analyte:	**Bis(2-ethylhexyl)phthalate**				**Di-n-Butyl phthalate**			
Sample-Replicate #	**Result µg/kg**	**Qualifier**	**MDL**	**MRL**	**Result µg/kg**	**Qualifier**	**MDL**	**MRL**
CDP-DMMU-01 Rep. 1	<36.7	B, H, U	36.7	36.7	90.1	H, V	36.7	36.7
CDP-DMMU-01 Rep. 2	<34.8	B, H, U	34.8	34.8	87.1	H, V	34.8	34.8
CDP-DMMU-01 Rep. 3	56.8	H, V	34.5	34.5	92.5	H, V	34.5	34.5
CDP-DMMU-01 Rep. 4	<34.1	B, H, U	34.1	34.1	80.7	H, V	34.1	34.1
CDP-DMMU-01 Rep. 5	<34.7	B, H, U	34.7	34.7	91.4	H, V	34.7	34.7
CDP-01 Mean	**39.4**				88.4			
% of Reference	207				40			
CDP-DMMU-02 Rep. 1	60.7	H, V	35.8	35.8	103	H, V	35.8	35.8
CDP-DMMU-02 Rep. 2	77.1	H, V	35.3	35.3	79.5	H, V	35.3	35.3
CDP-DMMU-02 Rep. 3	70.5	H, V	34.3	34.3	87.5	H, V	34.3	34.3
CDP-DMMU-02 Rep. 4	83.4	H, V	35.0	35.0	125	H, V	35.0	35.0
CDP-DMMU-02 Rep. 5	92.2	H, V	18.4	18.4	113	H, V	18.4	18.4
CDP-02 Mean	**76.8**				102			
% of Reference	403				46			
CDP-DMMU-03 Rep. 1	78.7	H, V	36.3	36.3	106	H, V	36.3	36.3
CDP-DMMU-03 Rep. 2	92.6	H, V	34.1	34.1	114	H, V	34.1	34.1
CDP-DMMU-03 Rep. 3	<33.3	H, B, U	33.3	33.3	322	H, V	33.3	33.3
CDP-DMMU-03 Rep. 4	<32.8	B, H, U	32.8	32.8	84.3	H, V	32.8	32.8
CDP-DMMU-03 Rep. 5	<36.7	B, H, U	36.7	36.7	73.8	H, V	36.7	36.7
CDP-03 Mean	**54.8**				140			
% of Reference	288				64			
CDP-REF Rep. 1	<18.8	B, H, U	18.8	18.8	207	H, V	18.8	18.8
CDP-REF Rep. 2	<19.9	B, H, U	19.9	19.9	136	H, V	19.9	19.9
CDP-REF Rep. 3	<18.1	B, H, U	18.1	18.1	126	C, H, V	18.1	18.1
CDP-REF Rep. 4	<17.1	B, H, U	17.1	17.1	72.1	C, H, V	17.1	17.1
CDP-REF Rep. 5	<21.4	B, H, U	21.4	21.4	553	C-, H, V	42.9	42.9
CDP-REF Mean	19.1				219			
Pre-exposure Rep. 1	<35.0	B, H, U	35.0	35.0	260	H, V	35.0	35.0
Pre-exposure Rep. 2	<33.2	B, H, U	33.2	33.2	72.0	H, V	33.2	33.2
Pre-exposure Rep. 3	63.1	H, V	15.8	15.8	401	H, V	15.8	15.8
Pre-exposure Mean	43.8				244			

Bolded values indicate that the mean concentration of project tissue is statistically significantly greater than that of the reference and at least one replicate result is greater than the MDL.

< #.## = The analyte was not detected (ND) at or above the MDL (U-qualified). The value indicates the MDL. Non-detect (ND) results use the MDL for calculating average concentrations. (J-qualified results use the value reported by the laboratory for calculating average concentrations.)

B = the analyte was found in the associated method blank. V = analyte was detected in both sample and method blank. C = associated calibration QC is outside the established quality control criteria for accuracy. H = parameter was analyzed outside method specified holding time.

Sources: Results from NWDLS.
Compiled by: ANAMAR Environmental Consulting, Inc.

APPENDIX A THROUGH I

APPENDIX A

SAMPLING AND ANALYSIS PLAN
(PCCA July 2021 – Version 2)

Job No. PCA20166

FINAL

STATEMENT OF WORK AND SAMPLING ANALYSIS PLAN

MPRSA SECTION 103 EVALUATION OF SEDIMENT FROM THE PORT OF CORPUS CHRISTI AUTHORITY CHANNEL DEEPENING PROJECT, CORPUS CHRISTI, TEXAS

Prepared for:

U.S. Army Corps of Engineers
and
U.S. Environmental Protection Agency

Prepared by:

Freese and Nichols, Inc.
10431 Morado Circle, Suite 300
Austin, Texas 78759

July 2021 – Version 2

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Acronyms and Abbreviations

°C	degrees Centigrade
CCSC	Corpus Christi Ship Channel
CCSCIP	Corpus Christi Ship Channel Improvement Project
CDP	Channel Deepening Project
CFR	Code of Federal Regulations
DMMU	Dredge Material Management Unit
DOC	dissolved organic carbon
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ERL	effects range low
FDA	U.S. Food and Drug Administration
FSP	Field Sampling Plan
HSP	Health and Safety Plan
ITM	Inland Testing Manual
LPC	limiting permissible concentration
LRL	Laboratory Reporting Limit
MDL	Method Detection Limits
MLLW	mean lower low water
MPRSA	Marine Protection, Research, and Sanctuaries Act
NELAC	National Environmental Laboratory Association Conference
NOAA	National Oceanic and Atmospheric Administration
ODMDS	Ocean Dredged Material Disposal Site
OTM	Ocean Testing Manual
PAH	polyaromatic hydrocarbons
PCB	polychlorinated biphenyls
PCCA	Port of Corpus Christi Authority
ppt	parts per thousand
QA	Quality Assurance
QC	Quality Control
RIA	Regional Implementation Agreement
SAP	Sampling and Analysis Plan
SD	sediment
SOPs	Standard Operating Procedures
SOW	Statement of Work
SPP	Suspended Particulate Phase
SRM	Standard Reference Material
SVOC	semi-volatile volatile organic compounds
SW	surface water

TDL	target detection limit
TOC	total organic carbon
ug/L	micrograms per liter
USACE	U.S. Army Corps of Engineers
VLCC	very large crude carriers
VOC	volatile organic compounds

1.0 PROJECT OVERVIEW

1.1 INTRODUCTION

The Port of Corpus Christi Authority (PCCA) applied to the U.S. Army Corps of Engineers (USACE), Galveston District under Section 10 of the Rivers and Harbors Act of 1899, Section 404 of the Clean Water Act (CWA), and Section 103 of the Marine Protection, Research and Sanctuaries Act for deepening of the Corpus Christi Ship Channel (CCSC).

Located in the Gulf of Mexico on the south-central portion of the Texas coast as shown in Figure 1, the Corpus Christi Ship Channel (CCSC) is approximately 200 miles southwest of Galveston and 150 miles north of the mouth of the Rio Grande River, and provides deep water access from the Gulf of Mexico to the PCCA, via Port Aransas, through Redfish Bay and Corpus Christi Bay. The CCSC is currently authorized by the U.S. Army Corps of Engineers (USACE) to –54 feet and –56 feet mean lower low water (MLLW) from Station 110+00 to Station –330+00 as part of the Corpus Christi Ship Channel Improvement Project (CCSCIP). The current authorized width of the CCSC is 600 feet inside the Port Aransas Jetties and 700 feet along the entrance channel in the Gulf of Mexico.

The PCCA Channel Deepening Project (CDP) would deepen the channel from Station 110+00 to Station –72+50 to a maximum depth of –79 feet MLLW (–75 feet MLLW plus two feet of advanced maintenance and two feet of allowable overdredge), and from Station –72+50 to Station –330+00, the channel would be deepened to a maximum depth of –81 MLLW –77 feet MLLW plus two feet of advanced maintenance and two foot of allowable overdredge (Figure 2). The proposed project includes a 29,000-foot extension of the CCSC from Station –330+00 to Station 620+00 to a maximum depth of –81 MLLW (–77 feet MLLW plus two feet of advanced maintenance and two foot of allowable overdredge) to reach the –80-foot MLLW bathymetric contour in the Gulf of Mexico. The proposed project is needed to accommodate transit of fully laden very large crude carriers (VLCCs) that draft approximately 70 feet.

The purpose of this proposed sampling is to determine if the new work material sediments proposed to be dredged are acceptable for disposal in the Corpus Christi Ocean Dredge Material Disposal Site (ODMDS). This Sampling and Analysis Plan (SAP) was developed in compliance with the regulations outlined below.

1.2 BACKGROUND

Channel Deepening Project: Per Marine Protection, Research, and Sanctuaries Act (MPRSA) Section 103 guidelines, PCCA is requesting to place 38.4 million cubic yards (MCY) of new work material generated from the deepening of the Outer Channel Reach offshore in the Corpus Christi New Work ODMDS. Material in the Outer Channel Reach (Stations –620+00 to –330+00) is new work material, and therefore, no maintenance material is anticipated. In all other reaches, navigational maintenance dredging

Legend

- 🟥 Corpus Christi Ship Channel
- 🟩 CCSC Deepening Extension
- ▭ Project Location
- ▭ Texas Coastal Boundary
- ▭ County Boundary

Title:

Vicinity Map

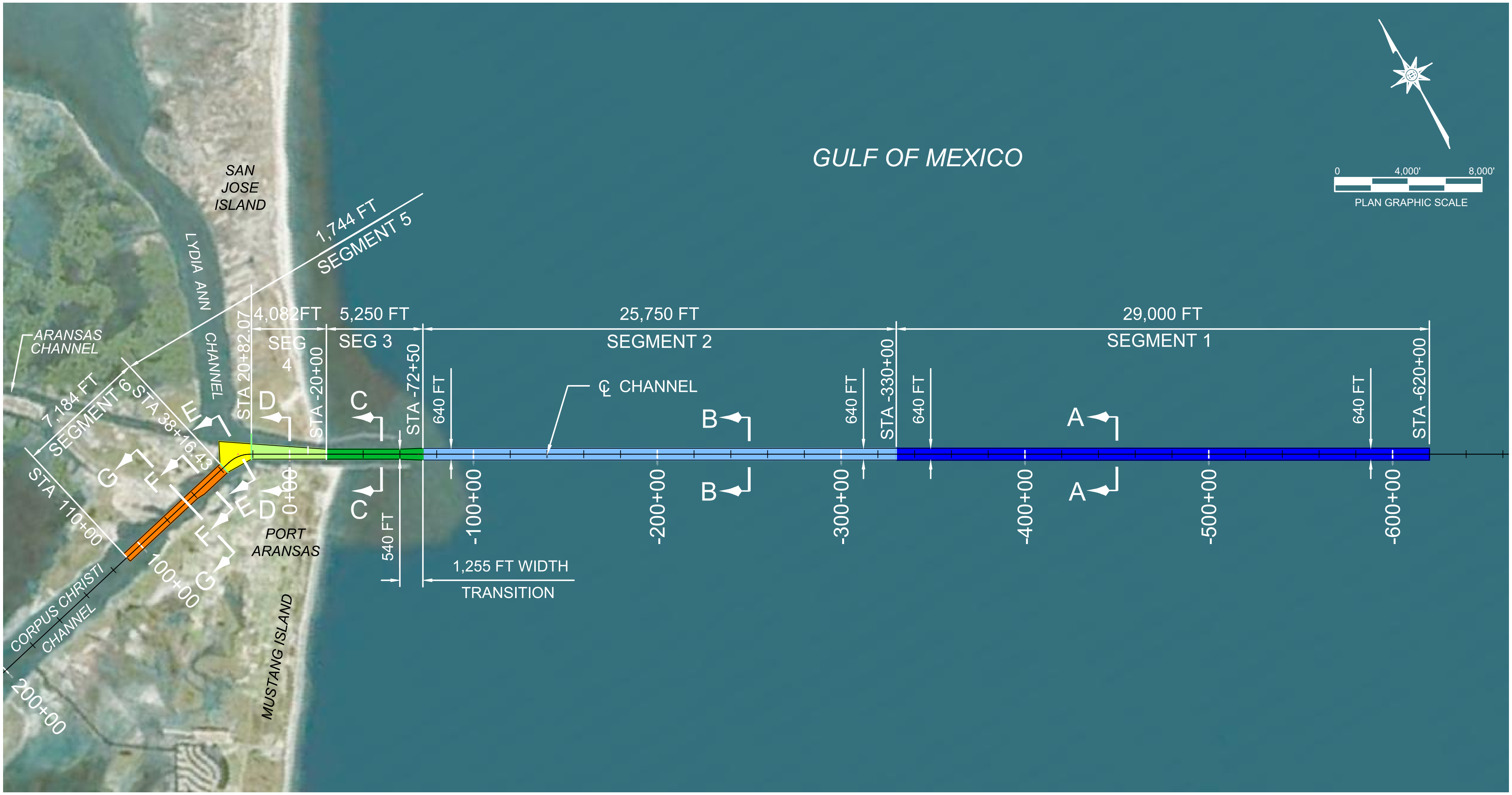
Project:

Corpus Christi Ship Channel Deepening Project

Client:

Port of Corpus Christi Authority

Drawn By:	Date:	Project No.:
DS	5/28/2019	60578532



DREDGING PLAN

SCALE: 1" = 8000'

SEGMENT	STATIONING (@ CHANNEL CL)		*DEPTH (FT BELOW MLLW)	DESCRIPTION	PLAN VIEW LEGEND
	FROM	TO			
1	STA -620+00	STA -330+00	-77.0	*Outer Channel*	🟦
2	STA -330+00	STA -72+50	-77.0	*Approach Channel*	🟦
3	STA -72+50	STA -20+00	-75.0	*Jetties to Harbor Island Transition Flare*	🟩
4	STA -20+00	STA 20+82.07	-75.0	*Harbor Island Transition Flare*	🟩
5	STA 20+82.07	STA 38+16.43	-75.0	*Harbor Island Junction*	🟨
6	STA 38+16.43	STA 110+00	-75.0	*Corpus Christi Channel*	🟧

* DESIGN DEPTH SHOWN. DOES NOT INCLUDE 2.0 FT ADVANCED MAINTENANCE DREDGING OR 2.0 FT ALLOWABLE OVER DREDGE.

Corpus Christi Ship Channel Deepening Project
Individual Permit Application SWG-2019-00067

Preferred Channel Alternative

County: Aransas and Nueces
Application By: Port of Corpus Christi Authority
State: Texas
Date: April 2020

occurs at regular intervals and therefore, any shoaling will be negligible. A capacity analysis for expanding the Corpus Christi New Work ODMDS was performed on behalf of U.S. Environmental Protection Agency (EPA) Region 6 and the USACE Galveston District by a PCCA contract to Freese and Nichols, Inc. (2021). This analysis was accomplished using the MDFATE model and the coupled MPFATE/Delft3D models. The analysis concluded that an expanded New Work ODMDS could accommodate approximately 47.0 MCY of in-situ new work dredged material.

Assumptions: The proposed project includes a 29,000-foot extension of the CCSC from Station –330+00 to Station 620+00 to a maximum depth of –81 feet MLLW (–77 feet MLLW plus two feet of advanced maintenance and two feet of allowable overdredge) to reach the channel depth limits at the –80-foot MLLW bathymetric contour in the Gulf of Mexico.

Description: The CDP would deepen the channel from Station 110+00 to Station –72+50 to a maximum depth of –79 feet MLLW (–75 feet MLLW plus two feet of advanced maintenance and two feet of allowable overdredge), and from Station –72+50 to Station –620+00, the channel would be deepened to a maximum depth of –81 MLLW (–77 feet MLLW plus two feet of advanced maintenance and two feet of allowable overdredge). The project will generate approximately 46.0 MCY from channel stations 110+00 to –620+00. A total of 38.4 MCY from CDP is proposed for placement in the expanded New Work ODMDS.

New Work ODMDS Quantity Summary:

Design Volume	Advanced Maintenance	Paid Allowable Overdredge	Unpaid Allowable Overdredge
38.4 MCY	(2 feet)	(2 feet)	Zero

Location: The proposed CDP is located within the existing channel bottom of the CCSC stating at Station 110+00 near the southeast side of Harbor Island, traversing easterly through Aransas Pass, and extending beyond the currently authorized terminus Station –330+00 an additional 29,000 feet terminating out into the Gulf of Mexico at the proposed new Terminus Station –620+00, an approximate distance of 13.8 miles, in Port Aransas, Nueces County, Texas. The project can be located on the U.S. Geological Survey quadrangle map entitled: Port Aransas, Texas.

Type of Facility Involved: New Work ODMDS, formerly the U.S. Navy Homeport ODMDS, which is located approximately 15,300 feet southeast of the Aransas Pass South Jetty (see Figure 1).

Type of Activity Supported: The activity involves dredging of a portion of the CCSC.

Purpose of the Proposed Dredging: Deepening of the CCSC to accommodate safe navigation and transit of fully laden VLCCs.

Areas, Depths, Volume:

- Area: Approximately 1,150 acres
- Depth: The CCSC Outer Channel Reach (Stations –620+00 to –330+00) would be deepened to –77 feet required (–81 feet allowable) to accommodate safe navigation of VLCCs.
- Allowable Paid Overdredge: 2 feet
- Allowable Non-Paid Overdredge: N/A

Existing Conditions and Depth(s): Depths currently range from –54 feet and –56 feet MLLW between Station 110+00 to Station –330+00 and the Outer Channel Reach (Stations –620+00 to –330+00) is currently undredged with existing Gulf of Mexico sea bottom. Dredged material from the open water in this segment is expected to be new work material, consisting solely of undisturbed base layer geological formations free of impacts from industrial sources or transport mechanisms. The sediment in the area is expected to be similar to nearby areas of the channel for which testing has taken place.

Proposed Dredging Method: The project will be dredged by Cutter Suction Dredges, Trailing Hopper Dredges (Hopper), or by a combination of both.

Proposed Disposal Site/Zone: Corpus Christi Expanded New Work ODMDS

1.3 OBJECTIVES

The purpose of this MPRSA Section 103 sediment characterization testing program is to obtain concurrence from EPA for ocean disposal and Federal permits from USACE in support of new work and future maintenance dredging in the Outer Channel Reach.

The objectives of this Section 103 Testing Program are as follows:

- Provide a SAP for approval before sampling and testing work begins.
- Provide an effective Quality Assurance (QA) program which ensures that laboratory test data are defensible and of sufficiently high quality to support the final decisions regarding the suitability of the dredged materials sampled for ocean disposal.
- Collect a sufficient volume of sediment and site water for required tests and analyses from locations specified in this SAP.
- Collect reference sediment from a site offshore for use in test comparisons.
- Conduct sediment testing in accordance with requirements set forth in Ocean Dumping Regulations, guidance testing including the Regional Implementation Agreement (RIA) (EPA and USACE, 2003) and this scope of work. Provide sufficient information to determine if the proposed discharge of dredged materials will meet or exceed the Limiting Permissible Concentration (LPC) (40 Code of Federal Regulations [CFR] 227.27). Determine if the proposed dredged materials are acceptable for ocean disposal.

- Provide a MPRSA Section 103 sediment testing report and supporting documentation that describes all aspects of the study and presents the results of field sampling and the physical/chemical analyses of sediment. The report should provide the basis for a scientific recommendation regarding the management of dredged sediment.

1.4 PROJECT AUTHORITY AND NEW WORK REQUIREMENTS

The Corpus Christi New Work ODMDS was approved in 1989 and includes two areas, one for maintenance and the other for new work material. Material for this project would fall under the new work category.

On September 15, 2015, EPA modified 40 CRF Part 228 to allow other entities besides the USACE to seek permit approval by EPA to dispose of dredged material into ocean waters pursuant to the Marine Protection Research and Sanctuaries Act (Ocean Dumping Regulations). It is under this regulation that the PCCA is requesting the new work material dredged from the proposed CDP dredge footprint be approved for disposal at the Corpus Christi New Work ODMDS.

Additionally, in 2020, EPA Region 6 proposed to expand the New Work ODMDS to accommodate the placement of additional volumes of construction dredged material. In 2021, a capacity analysis for expanding the Corpus Christi New Work ODMDS was conducted by Freese and Nichols, Inc. (2021) and concluded that an expanded New Work ODMDS could accommodate approximately 47.0 MCY of in-situ new work dredged material.

The proposed CDP dredge area is approximately 1,150 acres. The CDP would deepen the channel from Station 110+00 to Station –72+50 to a maximum depth of –79 feet MLLW (–75 feet MLLW plus two feet of advanced maintenance and two feet of allowable overdredge), and from Station –72+50 to Station –620+00, the channel would be deepened to a maximum depth of –81 MLLW (–77 feet MLLW plus two feet of advanced maintenance and two feet of allowable overdredge). Approximately 46.0 MCY of material would be dredged by Cutter Suction Dredges, Trailing Hopper Dredges, or a combination of both. Of this, a total of 38.4 MCY from the CDP is proposed for placement in the expanded New Work ODMDS.

1.5 TIER I EVALUATION – POTENTIAL SOURCES OF CONTAMINATION

The following sections provide information related to previous material analysis at and adjacent to the proposed CDP as well as background information. This information is included within this SAP as a Tier I evaluation for the proposed CDP.

Historical testing and reporting are summarized in the CCSCIP Environmental Impact Statement (EIS) (USACE, 2003; Appendix A) and the 2018 MPRSA Section 103 Report (USACE, 2018). Findings from the CCSCIP EIS and subsequent sampling reviewed for the 2018 MPRSA Section 103 Report (USACE, 2018) are summarized below by test type and reach.

1.5.1 Corpus Christi Ship Channel Environmental Impact Statement (2003)

The CCSCIP EIS examined water, elutriate, and sediment samples from 1984, 1990, and 1999, and bioassay data from 1980, 1985, and 1995 for the Entrance Channel reach (Station –38+00 to 310+00). For the Lower Bay Channel reach (Station 12+55 to 54+00), data from 1986, 1988, and 1991 for water, elutriate, and sediment samples were examined, with bioassay data from 1981. These are summarized below.

1.5.1.1 Water and Elutriate Chemistry

Entrance Channel. Of the metals, arsenic and copper were found above detection limits in 1984. In 1999, arsenic, barium, cadmium, and zinc concentrations were found above detection limits for water and elutriate samples; nickel was detected in water samples; and chromium and copper were found only in elutriate samples. Elutriate concentrations in 1999 were consistently higher than ambient water concentrations, including Reference samples for barium and cadmium, but the opposite was true for zinc. All samples were well below the Texas Water Quality Standards except for copper in elutriate samples taken from the Harbor Island Transition Flair, however it was thought that the value may be an error since no trends for copper could be determined. Oil and grease were detected in 1984 for water and elutriate samples. No organics were detected in the 1990 or 1999 data for any medium, except for total organic carbon (TOC) and total petroleum hydrocarbons.

Elutriate bioassays were conducted on samples collected form the Entrance Channel in 1981. It was concluded that no acute toxicity to water column organisms could be expected from dredging the Entrance Channel or placement of Entrance Channel sediments.

There was no indication of water or elutriate problems in the Entrance Channel.

Lower Bay Channel. TOC was above detection limits in water and elutriate samples for two stations in 1991, at roughly the same range for both media. No other organics were detected in 1991 and no organics were reported in 1988 for water or elutriate samples. In the 1988, no Texas Water Quality Standards were exceeded in the water or elutriate samples. An increase in oil and grease and TOC in the elutriate samples was noticeable, although not high relative to other reaches, but elutriate concentrations in water samples were much lower than other reaches and the TOC values much higher comparable to the other reaches.

Toxicity testing was conducted on elutriate samples from maintenance material. It was concluded that no acute toxicity to water column organisms could be expected from dredging the Lower Bay Channel or placement of Lower Bay Channel sediments.

1.5.1.2 Sediment Chemistry

Entrance Channel. Arsenic was the only metal above detection limits in 1984; zinc was detected at all stations, chromium, and nickel at three stations, and copper at one station in 1990, all below the Effects Range Low (ERLs). Of the metals, only mercury (three stations), silver (one station), and selenium (no stations) were not found at all stations in 1999 samples. Aside from one sample in 1999 that exceeded the ERL for mercury, there was no indication of a cause for concern relative to maintenance material quality.

Solid Phase bioassays were conducted, it was concluded that no significant undesirable impacts would occur from ocean placement of maintenance material dredged from the Entrance Channel.

Lower Bay Channel. In 1988, chromium, copper, lead, and nickel were all above detection limits for one station and zinc was detected at all stations. In 1991, cadmium, chromium, copper, nickel, and zinc were found at most stations. The values for chromium, copper, nickel, and zinc for 1988 and 1991 were similar. No organics were detected sediments, and no ERLs were exceeded. There was no indication of a cause for concern relative to maintenance material quality.

Solid Phase bioassays were conducted, it was concluded that no significant undesirable impacts would occur from ocean placement of maintenance material dredged from the lower Bay Channel.

1.5.2 Corpus Christi Ship Channel Pre-Dredge Testing (2018)

The majority of the proposed CDP reach was recently tested for offshore disposal under MPRSA Section 103 as part of the CCSCIP. The results were documented in Sampling, Chemical Analysis, and Bioassessment in Accordance with MPSRA Section 103 (USACE, 2018). Based on the results of the sampling, testing, and evaluation of the CCSC Entrance Channel and Extension sediment completed in 2018, site water, and elutriate, as well as toxicity and bioaccumulation testing, a Lines-of-Evidence analysis concluded that no adverse environmental effects would be expected from dredging or placement of the sediment from the project area into the New Work ODMDS. The sediments from the six reaches of the project area met the LPC were deemed suitable for open water ocean placement.

In general, there are no chemicals of concern present in the CCSC Entrance Channel (Jetties to Harbor Island Transition Flare), Entrance Channel Extension (Approach Channel), and Lower Bay (Harbor Island Transition Flare, Harbor Island Junction, and Corpus Christi Channel) (Stations –330+00 to +70+00). Therefore, this SAP focuses on the Outer Channel from Station –330+00 to Station –620+00. However, due to the Harbor Island site history (see Section 1.5.3), this SAP also includes additional DMU sampling points in the vicinity of Harbor Island within the Harbor Island Junction and CCSC.

Based on the 2018 results of the sampling, testing and evaluation of the CCSC Entrance Channel and Extension sediment, site water, and elutriate, as well as toxicity and bioaccumulation testing, a LOE analysis concluded that no adverse environmental effects would be expected from dredging or placement of the sediment from the project area into the New Work ODMDS. The sediments from the project area met the LPC and were suitable for open water ocean placement in the New Work ODMDS.

The following summarizes the sampling conducted, and the conclusion from the results:

1.5.2.1 Particle Size Analysis

All sample locations and the Reference Area, except Dredge Material Management Unit (DMMU)-03, were dominated by sand ranging from 58 to 84%, with the remainder of particles silt and clay. DMMU-03 was classified as having a high percentage of sand but low fines and varied significantly from the sediment analyzed at the other channel DMMUs. The material at DMMU-03 met the exclusion criteria as defined in the RIA and is compliant with the regulations.

1.5.2.2 Site Water Chemistry

Site water was analyzed for semi-volatile volatile organic compounds (SVOCs), polyaromatic hydrocarbons (PAH), and pesticides all samples were below the Target Detection Limit (TDL) and published screening criteria, although for toxaphene (pesticide) the Laboratory Reporting Limit (LRL) is greater than the screening criteria, but at a non-detect concentration. with the exception of toxaphene (pesticides). Since all samples were non-detect and reported below TDL, no additional evaluations were considered.

Silver and cadmium were the only metals below Method Detection Limits (MDLs) at all stations, therefore non-detects. The remaining (arsenic, copper, lead, mercury, nickel, selenium, zinc) were above the MDL in one or more site water samples, but all were below LRL. Arsenic, cadmium, copper, nickel, silver, and zinc concentrations exceeded the TDLs. Silver exceeded the published screening criteria, but concentrations were below non-detect and MDL, therefore silver was reported at LRL.

Ammonia concentrations exceeded the TDL for all site water samples, with concentrations ranging from 98.2 micrograms per liter (ug/L) to 110 ug/L. Total organic carbon for all samples were below TDL. Total suspended solids concentrations ranged between 1,930 ug/L to 5,250 ug/L, and exceeded the TDL for all samples, but the actual MDL achieved was well below the TDL.

1.5.2.3 Sediment Chemistry

Sediment samples were analyzed for volatile organic compounds (VOCs) and SVOCs, all samples were below the MDL and TDL, and reported as LRLs. Additionally, 17 PAHs were tested 11 PAHs were above the MDL including: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k) fluoranthene, chrysene, fluoranthene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, and pyrene. Of these, chrysene, fluoranthene, and pyrene were detected above the LRL in sample DMMU CCNEW-02 (Entrance Channel), the rest were reported as non-detects. All analytes in all samples were below the TDL and published screening criteria where applicable. Polychlorinated biphenyls (PCBs) were below MDL and TDL in all samples.

All pesticides samples were below MDLs, laboratory detection limits, and screening criteria except for dieldrin. Although dieldrin was below the TDL for all samples, concentrations were greater than minimum screening criteria.

All metals analyzed were detected above the MDL in each sample, with the exception of cadmium in sample DMMU CCNEW-05 (Inner Basin to La Quinta) which was below the MDL. Arsenic, cadmium, total chromium, copper, lead, nickel, zinc) exceeded the TDLs; however, none exceeded the published screening criteria where available. As metals were detected in sediments, further evaluation of all 12 metals (antimony, arsenic, beryllium, cadmium, total chromium, copper, lead, mercury, nickel, selenium, silver, zinc) was required.

All samples exceeded TDLs for ammonia. TOC results were all below the TDL.

1.5.2.4 Elutriate Chemistry

Elutriate samples analyzed for SVOCs were below the MDL, TDL, and published screening criteria. PAHs were below the MDL and TDL for all samples. All pesticides samples were below the MDL and equal to the LRL, with the exception of alpha-BHC and beta-BHC. All samples were below TDLs with the exception of toxaphene.

For metals, arsenic, cadmium, copper, lead, mercury, nickel, selenium, silver, and zinc were detected above the MDL in at least one elutriate sample, all were greater than the MDL but below the LRL. Result concentrations for all but lead exceeded the TDLs, and of these, only silver exceeded the screening criteria. Silver concentrations were below the MDL and the LRL exceeded both applicable screening criteria and as a result was evaluated in the STFATE model.

All samples exceeded TDLs for ammonia and ranged from 1,520 ug/L to 5,610 ug/L. All samples were below the TDL for dissolved organic carbon and TOC. Total suspended solid concentrations exceeded the TDL.

1.5.2.5 Elutriate Bioassay

Three bioassay methods were used to assess the sediment elutriates, *Americamysis bahia* (48-hour method), *Americamysis bahia* (96-hour method), and *Menidia beryllina*. No significant toxicity was observed for any of the elutriate toxicity tests.

1.5.2.6 Whole Sediment Toxicity Bioassay

Two whole sediment toxicity bioassays were conducted, *Leptocheirus plumulosus* (10-day toxicity test) and *Americamysis bahia* (10-day toxicity test). Tests indicate no acute toxicity and the sediments from all the DMMUs met the limiting permissible concentration (LPC) for open water dredged sediment placement.

1.5.2.7 Whole Sediment Bioaccumulation

Whole sediment bioaccumulation tests for *Nereis virens* (28-day bioaccumulation) and *Macoma nasuta* (28-day bioaccumulation) were conducted. The results of testing and lines-of-evidence analysis indicate no significant contaminant bioaccumulation and the sediments from all DMMUs meet the LPC for open water dredged sediment placement.

1.5.3 Harbor Island Site History

Settled as early as 1833 as Sand Point, Port Aransas served as a point of commerce along the Texas coast. In the 1850s, regular steamship service ran between Port Aransas and the City of New Orleans in Louisiana. The City of Port Aransas was incorporated in 1911 with its original boundaries including only the tip of Harbor Island. Several ordinances were passed between 1970 and 1980 to incorporate more of Harbor Island into Port Aransas. Port Aransas now encompasses over 900 acres on Harbor Island. Port Aransas has developed since that time with a varied combination of residential, retail, light commercial and public land uses as well as some interspersed heavy commercial land uses (i.e., welding shops, lumber yards, nurseries, boat repair and storage facilities, construction companies, and construction yards) (City of Port Aransas, 2006). Port Aransas has largely continued its growth as a tourism center.

Harbor Island has been developed since as early as 1857 when Aransas Pass had become popular enough to warrant a lighthouse on the island. In the early 1900s, the USACE deepened Aransas Pass and dredged a deepwater port at Harbor Island. Since 1912, the port has seen the following significant industrial and maritime uses (Guthrie, 1986):

- Cotton compress and shipping from 1912 to 1926
- Shipyard from 1918 to 1919
- Oil terminals from 1912 to 1993
- Offshore rig fabrication from 1976 to 2003
- Offshore services from 1993 to today
- Transshipment of Eagle Ford Shale crude oil

Industrial operators on Harbor Island over the past 100 years have included Aransas Pass Channel and Dock Co. (port services), Aransas Harbor Terminal Railway Inc. (rail terminal), Magnolia Oil (terminal storage), Humble Oil (terminal storage), Atlantic Richfield (terminal storage), American Petrofina (terminal storage), France & Canada Transportation Co. (ferry operations), Brown & Root (fabrication), J. Ray McDermott (fabrication), Haliburton (offshore services), and Martin Midstream (offshore services) (Ford, 2013).

Harbor Island is zoned “HI” which is special use district that allows industrial uses not zoned in other developed areas of Port Aransas. A former shipyard and offshore services facility are present on Harbor Island today.

The Port of Corpus Christi is the third largest U.S. port and includes cargo shipping and receiving facilities for offshore drilling, wind turbine production, steel and steel pipe production, and heavy machinery. In addition, several facilities in and around the port contribute to increasing volumes of chemicals, crude oil, and petroleum products (PCCA, 2016).

The industrial land uses in the project area since as early as the 1910s has the potential to impact the chemical composition of deposited sediments. Specifically, petroleum hydrocarbons and VOCs used and/or stored in terminal storage facilities, shipyards, and other industries in the project area are potential contaminants in the deposited sediment. In addition, over 7,165 emergency response records were identified since 2001 for unauthorized releases/spills of oil and hazardous substances that were reported to the National Response Center.

1.5.4 Chemical Releases

The CDP is composed of six reaches as shown in Figure 2 and the anticipated dredged material by reach is described below:

1. Outer Channel (Gulf of Mexico) (Stations –620+00 to –330+00) – Dredged material from the open water in this segment is expected to be new work material, consisting solely of undisturbed base layer geological formations less likely to be impacted by industrial sources or transport mechanisms.
2. Approach Channel (Stations –72+50 to –330+00) – Dredged material in this reach from the open water is expected to be new work material, consisting solely of undisturbed base layer geological formations less likely to be impacted by industrial sources or transport mechanisms.
3. Jetties to Harbor Island Transition Flare (Stations –72+50 to –15+08.24) – Dredged material in this reach is regularly maintenance dredged. While previous studies and regulated uses in the surrounding area, including 102 reported releases or spills since 2001, 13 past or current leaking petroleum storage tank sites, and four registered hazardous waste generators, indicate that a limited quantity of the dredged material may potentially be impacted by industrial sources in the area, dredged material in this reach is expected to be new work material, consisting solely of undisturbed base layer geological formations less likely to be impacted by industrial sources or transport mechanisms due to the high energetics of this reach and extensive scouring.
4. Harbor Island Transition Flare (Stations –15+08.24 to Station 19+48.10) – Dredged material in this reach is regularly maintenance dredged. While previous studies and regulated uses in the surrounding area, including 142 reported releases or spills since 2001, 14 past or current leaking petroleum storage tank sites, 23 registered aboveground petroleum storage tank sites, and five registered hazardous waste generators, indicate that a limited quantity of the dredged material may potentially be impacted by industrial sources in the area, dredged material in this reach is expected to be new work material, consisting solely of undisturbed base layer geological formations less likely to be impacted by industrial sources or transport mechanisms due to the high energetics of this reach and extensive scouring.
5. Harbor Island Junction (Stations 19+48.10 to Station 38+16.42) – Dredged material in this reach is regularly maintenance dredged. While previous studies and regulated uses in the surrounding

area, including 102 reported releases or spills since 2001, 13 past or current leaking petroleum storage tank sites, and four registered hazardous waste generators, indicate that a limited quantity of the dredged material may potentially be impacted by industrial sources in the area. Although, dredged material in this reach is expected to be new work material, consisting mostly of undisturbed base layer geological formations, the close proximity of this reach to Harbor Island increases the risk that this area may have been exposed to contaminant transport mechanisms from industrial sources.

6. <u>Corpus Christi Channel (Stations 38+16.42 to Station 110+00)</u> – Dredged material in this reach is regularly maintenance dredged. While previous studies and regulated uses in the surrounding area, including 147 reported releases or spills since 2001, four closed landfills or dump sites, one active citizens collection station, 16 past or current leaking petroleum storage tank sites, 25 registered aboveground petroleum storage tank sites, and six registered hazardous waste generators, indicate that a limited quantity of the dredged material may potentially be impacted by industrial sources in the area. Although, dredged material in this reach is expected to be new work material, consisting mostly of undisturbed base layer geological formations, the close proximity of this reach to Harbor Island increases the risk that this area may have been exposed to contaminant transport mechanisms from industrial sources.

2.0 SCOPE OF WORK

2.1 GENERAL

Sediment, water, and elutriate samples, plus one duplicate of each will be collected from dredging units located within the proposed PCCA CDP footprint as outlined in this SAP, and all collected sample material will be delivered to the analytical laboratories. The laboratories will be accredited through the National Environmental Laboratory Accreditation Program (NELAP) for the analytes/analyte groups and matrices to be analyzed. All samples will be collected within a schedule suitable to meet analytical hold-time requirements. The evaluation of samples will include chemical and physical analysis of sediment, water and standard elutriate samples, and bioassays. Procedures for sample collection, required volume, handling, preservation and storage, and shipment to the laboratory are outlined in the proceeding sections.

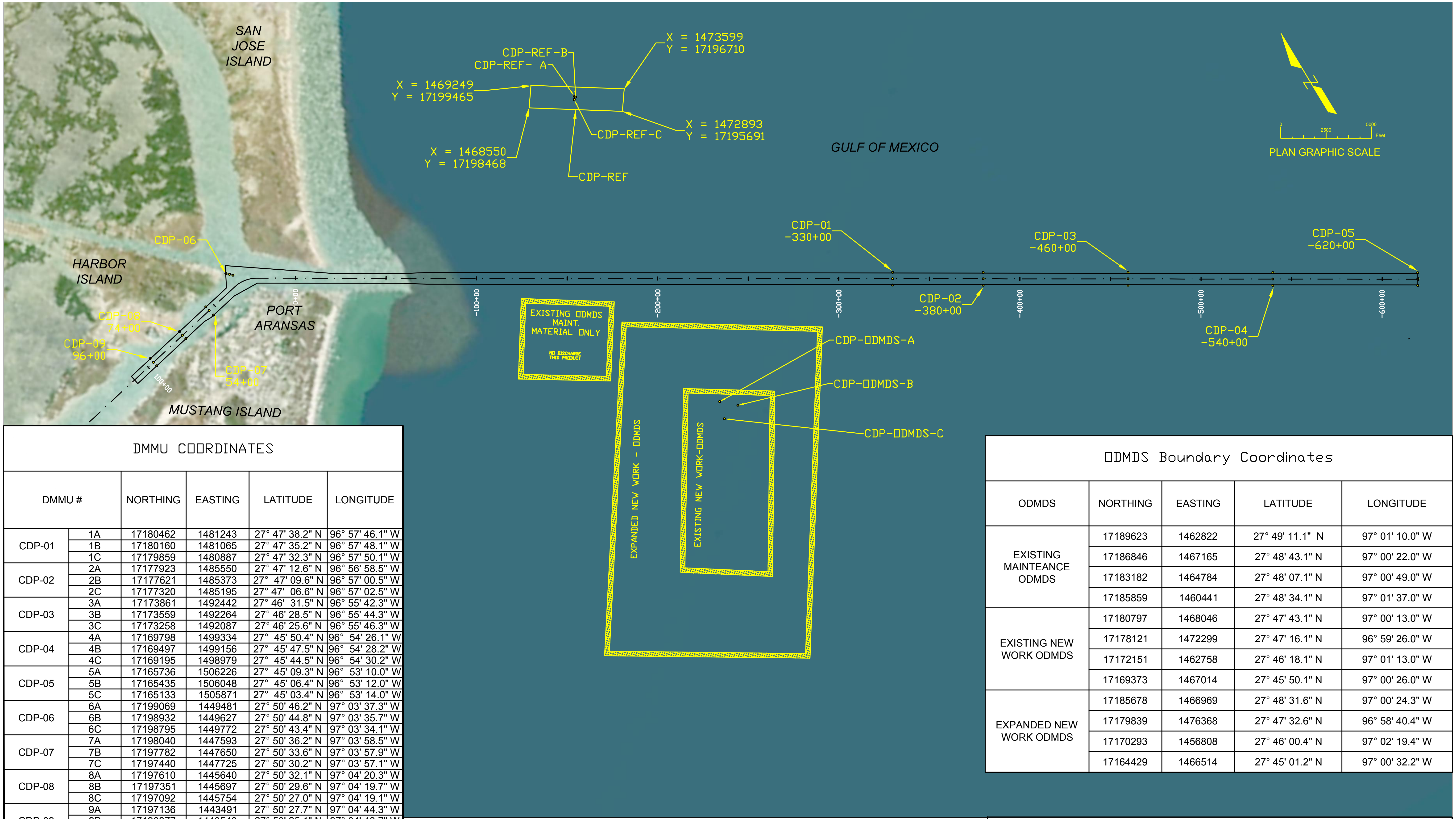
2.2 PROJECT AREA

Samples will be collected from the proposed PCCA CDP footprint, existing New Work ODMDS, and Reference Area (Figure 3).

2.3 SAMPLE LOCATIONS AND TYPE

Samples will evaluate site surface water, sediment, elutriates, Suspended Particulate Phase (SPP) bioassay, direct toxicity bioassay and the bioaccumulation bioassays for new work sediments within the Outer Channel Reach, Harbor Island Junction, and Corpus Christi Channel adjacent to Harbor Island. Surficial samples will be required at the Reference Area. Dredged material sampling locations have been selected to be spatially representative of the dredging prism materials and, for inshore channel samples proximity to Harbor Island. Sampling to refusal addresses the vertical component of the dredging prism. Water and sediment samples are to be collected from the dredge prism within each Dredge Material Management Unit (DMMU) for the purpose of conducting testing to characterize the material that will be excavated. Table 1 gives a summary of the proposed sample collection locations and sample testing. The location and number of samples are described in the following sections.

Sample locations and types are specified in Table 1. Sample coordinates have been selected based upon bathymetry surveys from 2018 (offshore) and 2021 (inshore). Exact sample coordinates for the DMMU stations will be determined in the field at the time of sampling. Each sample will be a composite of three samples from within each DMMU. If a sample cannot be acquired at a designated location, the location will be moved the least distance possible within the DMMU, while remaining within the dredge prism, it must be coordinated with the EPA beforehand.



DMMU COORDINATES

DMMU #		NORTHING	EASTING	LATITUDE	LONGITUDE
CDP-01	1A	17180462	1481243	27° 47' 38.2" N	96° 57' 46.1" W
	1B	17180160	1481065	27° 47' 35.2" N	96° 57' 48.1" W
	1C	17179859	1480887	27° 47' 32.3" N	96° 57' 50.1" W
CDP-02	2A	17177923	1485550	27° 47' 12.6" N	96° 56' 58.5" W
	2B	17177621	1485373	27° 47' 09.6" N	96° 57' 00.5" W
	2C	17177320	1485195	27° 47' 06.6" N	96° 57' 02.5" W
CDP-03	3A	17173861	1492442	27° 46' 31.5" N	96° 55' 42.3" W
	3B	17173559	1492264	27° 46' 28.5" N	96° 55' 44.3" W
	3C	17173258	1492087	27° 46' 25.6" N	96° 55' 46.3" W
CDP-04	4A	17169798	1499334	27° 45' 50.4" N	96° 54' 26.1" W
	4B	17169497	1499156	27° 45' 47.5" N	96° 54' 28.2" W
	4C	17169195	1498979	27° 45' 44.5" N	96° 54' 30.2" W
CDP-05	5A	17165736	1506226	27° 45' 09.3" N	96° 53' 10.0" W
	5B	17165435	1506048	27° 45' 06.4" N	96° 53' 12.0" W
	5C	17165133	1505871	27° 45' 03.4" N	96° 53' 14.0" W
CDP-06	6A	17199069	1449481	27° 50' 46.2" N	97° 03' 37.3" W
	6B	17198932	1449627	27° 50' 44.8" N	97° 03' 35.7" W
	6C	17198795	1449772	27° 50' 43.4" N	97° 03' 34.1" W
CDP-07	7A	17198040	1447593	27° 50' 36.2" N	97° 03' 58.5" W
	7B	17197782	1447650	27° 50' 33.6" N	97° 03' 57.9" W
	7C	17197440	1447725	27° 50' 30.2" N	97° 03' 57.1" W
CDP-08	8A	17197610	1445640	27° 50' 32.1" N	97° 04' 20.3" W
	8B	17197351	1445697	27° 50' 29.6" N	97° 04' 19.7" W
	8C	17197092	1445754	27° 50' 27.0" N	97° 04' 19.1" W
CDP-09	9A	17197136	1443491	27° 50' 27.7" N	97° 04' 44.3" W
	9B	17196877	1443548	27° 50' 25.1" N	97° 04' 43.7" W
	9C	17196618	1443605	27° 50' 22.5" N	97° 04' 43.1" W
CDP-REF	REF A	17197759	1471021	27° 50' 30.7" N	96° 59' 37.6" W
	REF B	17197676	1471064	27° 50' 29.9" N	96° 59' 37.1" W
	REF C	17197591	1470920	27° 50' 29.0" N	96° 59' 38.7" W
CDP-ODMDS	ODMDS-A	17179158	1469397	27° 47' 26.7" N	96° 59' 58.1" W
	ODMDS-B	17178470	1470167	27° 47' 19.8" N	96° 59' 49.6" W
	ODMDS-C	17178211	1469136	27° 47' 17.4" N	97° 00' 01.2" W

ODMDS Boundary Coordinates

ODMDS	NORTHING	EASTING	LATITUDE	LONGITUDE
EXISTING MAINTEANCE ODMDS	17189623	1462822	27° 49' 11.1" N	97° 01' 10.0" W
	17186846	1467165	27° 48' 43.1" N	97° 00' 22.0" W
	17183182	1464784	27° 48' 07.1" N	97° 00' 49.0" W
	17185859	1460441	27° 48' 34.1" N	97° 01' 37.0" W
EXISTING NEW WORK ODMDS	17180797	1468046	27° 47' 43.1" N	97° 00' 13.0" W
	17178121	1472299	27° 47' 16.1" N	96° 59' 26.0" W
	17172151	1462758	27° 46' 18.1" N	97° 01' 13.0" W
	17169373	1467014	27° 45' 50.1" N	97° 00' 26.0" W
EXPANDED NEW WORK ODMDS	17185678	1466969	27° 48' 31.6" N	97° 00' 24.3" W
	17179839	1476368	27° 47' 32.6" N	96° 58' 40.4" W
	17170293	1456808	27° 46' 00.4" N	97° 02' 19.4" W
	17164429	1466514	27° 45' 01.2" N	97° 00' 32.2" W

GENERAL NOTES

1. HORIZONTAL COORDINATE SYSTEM IS NAD83 TEXAS STATE PLANE, SOUTH ZONE, US FOOT.
2. VERTICAL DATUM IS REFERENCED TO NORTH AMERICAN VERTICAL DATUM OF 1958 (NAVD88)

Corpus Christi Ship Channel Deepening Project
FIGURE 3
SAMPLING LOCATIONS

State: Texas
Application By: Port of Corpus Christi Authority
SAP Date: September 2021

Table 1
Summary of Sample Collection and Testing

DMMU Number		Station	Distance from Channel Center Line (feet)	Coordinates*		Sample Matrix		
				X	Y	Sediment	Surface Water	Elutriate
CDP-01	1A	–330+00	350	1481243	17180462	X		X
	1B		0	1481065	17180160		X	
	1C		–350	1480887	17179859			
CDP-02	2A	–380+00	350	1485550	17177923	X		X
	2B		0	1485373	17177621		X	
	2C		–350	1485195	17177320			
CDP-03	3A	–460+00	350	1492442	17173861	X		X
	3B		0	1492264	17173559		X	
	3C		–350	1492087	17173258			
CDP-04	4A	–540+00	350	1499334	17169798	X		X
	4B		0	1499156	17169497		X	
	4C		–350	1498979	17169195			
CDP-05	5A	–620+00	350	1506226	17165736	X		X
	5B		0	1506048	17165435		X	
	5C		–350	1505871	17165133			
CDP-06	6A	31+93	558	1449481	17199069	X		X
	6B	32+90	708	1449627	17198932		X	
	6C	33+75	865	1449772	17198795			
CDP-07	7A	54+00	265	1447593	17198040	X		X
	7B		0	1447650	17197782		X	
	7C		–350	1447725	17197440			
CDP-08	8A	74+00	265	1445640	17197610	X		X
	8B		0	1445697	17197351		X	
	8C		–265	1445754	17197092			
CDP-09	9A	96+00	265	1443491	17197136	X		X
	9B		0	1443548	17196877		X	
	9C		–265	1443605	17196618			
CDP-REF	REF A	N/A	N/A	1471021	17197759	X		
	REF B			1471064	17197676		X	
	REF C			1470920	17197591			
CDP-ODMDS	ODMDS-A	N/A	N/A	1469397	17179158	X		
	ODMDS-B			1470167	17178470		X	
	ODMDS-C			1469136	17178211			

* NAD83 Texas State Plane, South Zone

A total of 11 water and 30 sediment samples will be collected: 27 new work material sediment samples, plus three sediment samples from the Reference Area. Only three water samples will be collected from the New Work ODMDS. One water sample will be collected from the central location at each station from approximately mid-column depth. Bioassay site water will also be collected from each DMMU. Water depths are expected to be about –50 to –80 feet within the DMMUs; –46 to –53 feet at the New Work ODMDS; and –46 to –53 feet at the Reference Area.

Eleven DMMUs will be sampled: nine in the new work improvement area, one at the Reference Area and one at the ODMDS. Each sample is a composite of material representative of the DMMU at that station. The three proposed sampling locations within each DMMU are selected to transect the channel. The location of these sampling points is based upon geotechnical boring information from the CCSC Plans (Appendix B) and hydrographic surveys:

- DMMU CDP-01 (Station –330+00) – This DMMU is located between BH-14 and BH-15 which show materials in this area to be predominantly silty sands with alternative layers of clays. One composited sample is proposed for this reach.
- DMMU CDP-02 (Station –380+00) – This DMMU is located between BH-12 and BH-13 which show materials in this area to be predominantly clays with pockets of clayey sands. One composited sample is proposed for this reach.
- DMMU CDP-03 (Station –460+00) – This DMMU is located between BH-9 and BH- 10 which show materials in this area to be predominantly lean and fat clays. One composited sample is proposed for this reach.
- DMMU CDP-04 (Station –540+00) – BH-6 is located in proximity to this DMMU with materials consisting predominantly of lean and fat clays. One composited sample is proposed for this reach.
- DMMU CDP-05 (Station –620+00) – BH-3 is located in proximity to this DMMU with materials consisting predominantly of lean and fat clays. One composited sample is proposed for this reach.
- DMMU CDP-06 (Station 32+90) – CDP-06 is within the Harbor Island Junction located within an area of shoaling (USACE, 2021) that is immediately east of the southeast corner of Harbor Island. BH-37 is the nearest boring to this DMMU, which consists of clayey sand with an overlay of lean clay. Sediment chemistry must be conducted prior to compositing. One composited sample is proposed for this station for bioassay and bioaccumulation testing.
- DMMU CDP-07 (Station 54+00) – CDP-07 is within the Corpus Christi Channel with BH-38 as the nearest boring to this DMMU with materials consisting predominantly of clayey sand and fat clay, with slightly shallower bathymetry at the channel toes (USACE, 2021). Sediment chemistry must be conducted prior to compositing. One composited sample is proposed for this station for bioassay and bioaccumulation testing.
- DMMU CDP-08 (Station 74+00) – CDP08- is within the Corpus Christi Channel with BH-38 and CB-2 as the nearest borings to this DMMU with materials consisting of a mix of clayey sand, lean clay, and fat clay, with slightly shallower bathymetry at the channel toes (USACE, 2021). Sediment chemistry must be conducted prior to compositing. One composited sample is proposed for this station for bioassay and bioaccumulation testing.

- DMMU CDP-09 (Station 96+00) – CDP-09 is within the Corpus Christi Channel with CB-3 as the nearest boring to this DMMU with materials consisting of predominantly silty sand, with slightly shallower bathymetry at the channel toes (USACE, 2021). Sediment chemistry must be conducted prior to compositing. One composited sample is proposed for this station for bioassay and bioaccumulation testing.
- DMMU CDP-REF (Reference Area) – Sediment samples will be acquired from three locations within the Reference Area and composited to form one Reference Area sample. The water sample will be collected from REF B.
- DMMU CDP-ODMDS (Placement Area [New Work ODMDS]) – Sediment samples will be acquired from three locations within the ODMDS and composited to form one ODMDS sample. The water sample will be collected from ODMDS B.

Numbers and types of samples are detailed in Table 1 and summarized in Table 2 as follows:

Table 2

Summary of Samples to be Collected

DMMU	Segment	Station	Media	Tests
CDP-01	open bay, channel extension	–330+00	SW, SD	physical, chemical, elutriate, bioassays
CDP-02	open bay, channel extension	–380+00	SW, SD	physical, chemical, elutriate, bioassays
CDP-03	open bay, channel extension	–460+00	SW, SD	physical, chemical, elutriate, bioassays
CDP-04	open bay, channel extension	–540+00	SW, SD	physical, chemical, elutriate, bioassays
CDP-05	open bay, channel extension	–620+00	SW, SD	physical, chemical, elutriate, bioassays
CPD-06	Harbor Island Junction, channel deepening	32+90	SW, SD	physical, chemical, elutriate, bioassays
CDP-07	Corpus Christi, Channel, channel deepening	54+00	SW, SD	physical, chemical, elutriate, bioassays
CPD-08	Corpus Christi Channel, channel deepening	74+00	SW, SD	physical, chemical, elutriate, bioassays
CDP-09	Corpus Christi Channel, channel deepening	96+00	SW, SD	physical, chemical, elutriate, bioassays
CDP-Ref	Reference Area	N/A	SW, SD	physical, chemical, elutriate, bioassays
CDP-ODMDS	ODMDS	N/A	SW, SD	physical, chemical, elutriate, bioassays

SW = surface water

SD = sediment

For sediment collection, dredge material sampling will be collected as transects at any given station, however, recent bathymetry (Appendix B) indicates scouring in some locations that may make transects impossible in some sections of the ship channel. In such instances, sampling may shift to be longitudinal to one side of the channel within the DMMU where new work material within the dredge prism is evident. If a sample cannot be acquired at a designated location, the location will be moved the least distance possible, while remaining within the dredge prism and within the DMMU, it must be coordinated with the EPA beforehand. Due to the minimal sampling plan, samples must be collected from all DMMUs, so depth readings will be used to select alternate locations if necessary. Accuracy of the sampling locations is critical in that they must be within the dredge prism. All field conditions and decisions made will be documented in the field notes, the contractors report, and the final project report. For the Reference Area, three samples will be collected from the central portion of the area (Figure 3).

2.4 GENERAL INSTRUCTIONS FOR SAMPLE COLLECTION

All samples will be collected as specified in Table 3. All sediment and water sample collection, handling, preservation, storage and tracking will be conducted in accordance with this Statement of Work (SOW)/SAP and the protocols outlined in Chapter 8 of the Green Book (EPA and USACE, 1998). Specific instructions on water and sediment are provided below. All samples must be collected within a 3- or 4-day window to meet analytical hold-time requirements. Specific instructions on water and sediment are provided below.

2.4.1 Station Positioning

Easting and northing (NAD83 Texas State Plane, South Zone) coordinates for all proposed sample locations are provided in Table 1. Exact sample coordinates for the DMMU stations will be determined in the field at the time of sample acquisition. The location of each sampling station shall be determined and recorded in the field at the time of sampling using a Differential Global Positioning System with ±6-foot horizontal accuracy. Three sample locations will be selected prior to going to the field for the Reference Area sampling locations such that three locations are approximately distributed over the central area of both areas. One central sampling location for the collection of surface water at the New Work ODMDS will be selected prior to starting field activities.

The station coordinates will be entered into a Garmin GPS (or equivalent) receiver capable of less than 10-meter accuracy, as well as a backup GPS unit. Coordinates entered into all GPS units will be double-checked, and target sampling stations will be plotted on a map prior to field sampling to make sure they are within the correct sampling areas and within dredge prism boundaries. Using the vessel's GPS, the captain will navigate as closely as possible to the target sampling location (typically within 100 feet of the target). GPS coordinates will be collected each time the sampler is deployed. Any sample that is not within 100 feet of the target location will be rejected and discarded or the reasons for not collecting a sample within 100 feet of the target location will be documented. The actual sampling points will be plotted on a map and provided in the report to document the accuracy of target sampling stations. Sediment surface and water elevations at each station will be determined in feet MLLW using a Spectra Precision SP80 Global Navigation Satellite System (accurate to ±2 centimeters) interfaced with the RTKNet network. Real-time water levels from the National Oceanic and Atmospheric Administration

Table 3

Summary of Recommended Procedures for Sample Collection Preservation and Storage[a]

Analyses/Test (per sample basis, 10 samples total)	Collection Method[b]	Volume Required[c]	Container[d]	Preservation Technique	Storage Conditions	Holding Times[e]
SEDIMENT (Volume per Sampling Point)						
Chemical/Physical Analyses, Elutriate Prep for Chemical Analyses and Bioassays						
Elutriate Prep for Chemical Analysis and Bioassay Volume of Sediment Required	Core/Grab	Standard Sample 34.6 gallons/QC Sample 39.4 gallons	5 gallon bucket	Completely fill and refrigerate	4°C/dark/ airtight	8 weeks
PAH and PCP	Core/Grab	250 grams	Solvent-rinsed amber glass jar with Teflon lid[f]	Dry ice[f] or freezer storage for extended storages; otherwise refrigerate	4°C[f]/dark[g]	14 days (extraction)[h]
Total Polychlorinated Biphenyl (PCBs) and Chlorinated Pesticides	Core/Grab	250 grams	Solvent-rinsed amber glass jar with Teflon lid[f]	Dry ice[f] or freezer storage for extended storages; otherwise refrigerate	4°C[f]/dark[g]	14 days (extraction)[h]
Metals	Core/Grab	100 grams	Amber glass jar	Dry ice[f] or freezer storage for extended storages; otherwise refrigerate	4°C	Mercury - 28 days Others - 180 days
Grain Size	Core/Grab	1,000 grams	Whirl-pac bag[f]	Refrigerate	<4°C	Undetermined
Total Organic Carbon	Core/Grab	50 grams	Heat treated amber glass jar	Dry ice[f] or freezer storage for extended storages; otherwise refrigerate	4°C[f]	14 days
Ammonia	Core/Grab	40 grams	Glass jar	Refrigerate	<4°C	7 days
pH	Core/Grab	50 grams	Glass jar	Refrigerate	<4°C	Immediate
Total solids	Core/Grab	50 grams	Whirl-pac bag	Refrigerate	<4°C	Undetermined
Miscellaneous	Core/Grab	50 grams	Whirl-pac bag	Refrigerate	<4°C	Undetermined
Volume of Sediment Required per DMMU	1 gallon total for chemical analysis (media) + 34 gallons for elutriates/bioassays; each duplicate requires 35 gallons					
Total Volume Sediment Required for 9-DMMUs + Reference	350 gallons total for chemical analysis (media), elutriates/bioassays; duplicate samples require 35 gallons each					

Analyses/Test (per sample basis, 10 samples total)	Collection Method[b]	Volume Required[c]	Container[d]	Preservation Technique	Storage Conditions	Holding Times[e]
SURFACE WATER						
Chemical/Physical Analyses, Elutriate Prep for Chemical Analyses and Bioassays						
Elutriate Prep for Chemical Analyses and Bioassay Volume of site Water Required	Discrete sampler or pump	30 gallons	5 gallon cubitainer	Completely fill and refrigerate	4°C/dark/ airtight	14 days
PAHs and PCP	Discrete sampler or pump	2 liters	Amber glass bottle with Teflon-lined lid[k]	pH <2, $Na_2S_2O_3$; airtight seal; refrigerate	4°C[k]	7 days for extraction; 40 days for extract analysis[k]
Total PCBs and Chlorinated Pesticides	Core	4 liters	Solvent-rinsed amber glass jar with Teflon lid[f]	Dry ice[f] or freezer storage for extended storages; otherwise refrigerate	4°C[f]/dark[g]	14 days (extraction)[h]
Metals	Discrete sampler or pump	250 milliliters	Acid-rinsed polyethylene or glass jar[k]	PH <2 with HNO_3[k]; refrigerate	4°C - 2°C[k]	Mercury - 14 days Others – 180 days
Ammonia	Discrete sampler or pump	500 milliliters	Plastic	H_2SO_4 to pH <2; refrigerate	4°C	7 days
Total Suspended Solids	Discrete sampler or pump	1,000 milliliters	Plastic or glass	Fill completely and refrigerate	4°C	7 Days
Total organic carbon	Discrete sampler or pump	100 milliliters	Amber glass VOA vials	H_2SO_4 to pH <2; refrigerate	4°C[I]	28 days[I]
Volume of Site Water per DMMU	2 gallons for chemical analysis (media) + 38 gallons for elutriate/bioassays					
Total Volume Surface Water Required for 9-DMMUs + Reference + New Work ODMDS	22 gallons for chemical analysis (media) + 418 gallons elutriate/bioassay[q]					

Analyses/Test (per sample basis, 10 samples total)	Collection Method[b]	Volume Required[c]	Container[d]	Preservation Technique	Storage Conditions	Holding Times[e]
BIOASSAY (Tissue Analyses)[o]						
Chemical Analysis						
Mass of Tissue from Bioassays[p] per DMMU	30 – 35 grams per replicate for each chemical analyses + 55 – 65 grams for QC					
Total Mass of Tissue for 9-DMMUs + Reference	1,800 – 2,100 grams for all chemical analyses + 220 – 260 grams for QC					

°C = degrees Centigrade; QC = quality control

Footnotes:

a (i) primary reference EPA and USACE (2003) revised for a project and site-specificity

(ii) This table contains only a summary of collection, preservation, and storage procedures for samples. Consultation with the selected analytical provider will be completed to confirm or modify for site-specific sampling and analyses. Table based upon the Inland Testing Manual (ITM), EPA-823-B-98-004

b Collection method should include appropriate liners

c Amount of sample required by the laboratory to perform the analysis (wet weight or volume provided, as appropriate). THESE QUANTITIES WILL BE CONFIRMED WITH THE ANALYTICAL PROVIDER PRIOR TO SAMPLE COLLECTION. Miscellaneous sample size for sediment will be increased if auxiliary analytes that cannot be included as part of the organic or metal analyses are added to the list. The amounts shown are not intended as firm values; more or less tissue may be required depending on the analytes, matrices, detection limits, and particular analytical laboratory

d All containers should be certified as clean according to EPA and USACE (1990)

e These holding times are for sediment, water, and tissue based on guidance that is sometimes administrative rather than technical in nature

There are no promulgated, scientifically based holding time criteria for sediments, tissues, or elutriates. References should be consulted if holding times for sample extracts are desired. Holding times are from the time of sample collection

f NOAA (1989)

g Tetra Tech (1986a)

h Sample may be held for up to one year if at –20°C

i Phthalates are not being analyzed for; therefore, polypropylene does not need to be used

j Two weeks is recommended; sediments must not be held for longer than eight weeks prior to biological testing

k EPA (1987); 40 CFR Part 136, Table III

l Plumb (1981)

m If samples are not preserved to pH<2, then aromatic compounds must be analyzed within 7 days

n Tetra Tech (1986b)

o Analyses categories for tissue will be determined from the initial chemical screening. Chemical analytical list is inclusive and conservative for the purposes of writing the SAP. For % lipids, if the micro method is use, lipid samples can be as low as 0.150 milligrams

p Total tissue mass (conservative estimate) reported

q Elutriate/bioassay water not collected at ODMDS

(NOAA) station (#8775237 Port Aransas, Texas) will be used as a backup. In addition, the latest available bathymetric survey information will be on board each sampling vessel to be used as a reference in the field to confirm depths.

All sediment samples will be collected within the DMMU boundary as close as possible to the proposed sampling location. If the total volume required cannot be collected at a particular station, the vessel will be relocated to a site as close as possible to the initial sampling location. If a suitable location cannot be found within the DMMU, the field team leader will contact PCCA and USACE to determine the appropriate corrective action.

2.4.2 Conventional Water Quality

Conventional water quality parameters at mid-water column depth will be measured and recorded from the central location within each DMMU, including water temperature, salinity, pH, conductivity, Oxidation Reduction Potential, turbidity, and dissolved oxygen. Water depth, adjusted to MLLW, at each station will be noted along with general site observations (air temperature, wind speed, sea-state, etc.).

2.4.3 Sample Numbering

A sample numbering system that will provide a unique and unambiguous label for each sample will be decided upon and documented prior to going into the field. Labels will be preprinted with as much project information as possible prior to going into the field. Surplus labels should be available should the need arise to utilize them.

2.4.4 Decontamination Procedures

All equipment contacting sediment or water samples will be cleaned and decontaminated as described below. Work surfaces on the sampling vessel will be cleaned before the sampling day begins and before leaving each station. All equipment contacting sediment or water samples, gloves, and any protective clothing will be changed and/or cleaned between sampling stations to prevent cross-contamination. Decontamination procedures include:

- Wash and scrub using site water or tap water to remove gross contamination
- Wash/scrub with Liquinox®
- Rinse with site water
- Rinse with DI water
- Air dry

Any derived waste will be contained and disposed of in accordance with Federal, state, and local laws.

2.4.5 Sample Preservation and Storage

A suitable method for preservation and shipment of all sediment and water samples will be used, as indicated in Table 3 and according to sample handling instructions coordinated with the testing laboratory. Such instructions must be obtained no later than the week preceding field work. The testing laboratory shall furnish clean, appropriately sized glass and/or plastic containers for sediment and water samples, labeled accordingly and containing preservatives, as appropriate. PCCA's subconsultant shall instruct the field contractor as to the nature, size, and precleaning of containers for the collection of bulk media.

All samples will be iced or refrigerated immediately after collection and must be stored at 4 ± 1°C, never frozen, within 24 hours after collection. Samples will be protected from light during storage and transportation and must remain at 4 ± 1°C throughout transport and until received and logged in at the testing laboratory.

2.4.6 Chain of Custody

A dated Chain of Custody document shall be furnished to record all collected samples and must accompany the samples from the field through all shipping to reporting and sample destruction. All Chain of Custody forms must clearly note the sample name, date and time of collection, container type, any special handling (i.e., filtering or acidification), type of analyses required by the laboratories, date relinquished, and signature of all individuals involved in the stages of sample collection, handling, and shipping.

Additional guidance on appropriate Chain of Custody protocols can be found reference guidance documents (EPA, 1986; EPA and USACE, 1995; 1998; Plumb, 1981).

Shipping and sample distribution to the testing facilities will be managed by PCCA's subconsultant and the field contractor.

2.5 SPECIFIC INSTRUCTIONS FOR SEDIMENT SAMPLING

Sediment samples will be collected from each of the nine channel DMMUs, the Reference Area, and the New Work ODMDS (see Table 1 and Figure 3). Since the DMMUs are selected to be representative of reaches, shifts in position will be allowed. If circumstances require, the sampling location will be shifted as minimally as possible while remaining within the dredge prism and within the DMMU to facilitate acquisition of sufficient sample volume. Any deviations will be noted in the field notes and documented in the final report.

For the 27 channel DMMU stations, sediment samples will be collected to project depth or refusal, whichever is encountered first. The sampling is expected to require a vibracore sampler with the stainless steel core tubes, however, if sampling depths are short, other equipment may be utilized. Rationalization for the type of equipment used must be written in the field logs and documented in the final report. Regardless of the equipment used, the material must be representative of the dredge prism and any debris within the sample will be discarded in such a manner as to not compromise the representativeness of the sample.

Prior to collection at each station, the core sampler will be washed with an Alconox solution, flushed with ambient water to remove all remnant sample material, and then rinsed with de-ionized water to avoid cross-contamination among sample sites. At each DMMU, as well as within the Reference Area and the ODMDS, each core/grab collected within the correlated area will, in its entirety, be placed in appropriately labeled pre-cleaned containers, 5-gallon buckets or other suitable containers (Table 3). Sediment cores will be taken to project depth or refusal, whichever is encountered first, using a sampling method capable of accomplishing such a task. Eastings and northings will be recorded for each of the three sampling point replicates (replicates ‘A’, ‘B’, and ‘C’) for DMMUs CDP-01 through CDP-09, as well as from the Reference Area (Table 1). Samples between or from more than one DMMU will not be composited.

It is expected that multiple cores/grabs will be required to obtain the required volume for both chemical and physical analyses as well as bioassays. All containers, regardless of size, will be filled completely to avoid head space. The lids will then be tightly secured, and the containers will be placed into an ice chest or refrigerating unit with sufficient cushioning material to prevent leakage and breakage during shipment.

The Reference Area sediment volume need only be surficial sediment and may be collected as surficial grab samples.

See Table 3 for a summary of sediment sampling parameters including sample volume, container type, handling, storage etc.

Field Data: Field data from all sampling stations shall be described at the time of sampling and will include but not limited to date, time, water depth adjusted to MLLW, sample appearance, odor, horizons, total length of core and horizons, stratifications, texture, plasticity measurements (hand rolled method), GPS coordinates, and photos.

2.6 SPECIFIC INSTRUCTIONS FOR WATER SAMPLING

Water samples will be collected from the central channel location for each of the nine channel DMMUs (see Table 1 and Figure 3). Prior to sample collection, conventional water quality parameters will be measured and recorded at mid-depth in the water column at the center (i.e., location “B”) of each channel DMMU and at one central location from the three selected at the Reference Area and the New Work ODMDS (see Figure 3). These parameters will include water temperature, salinity, pH, conductivity, Oxidation Reduction Potential, turbidity and dissolved oxygen.

At each sample station, the water depth to the top of sediment will be determined. Sediment surface and water elevations at each station will be determined in feet MLLW using a Spectra Precision SP80 Global Navigation Satellite System (accurate to ±2 centimeters) interfaced with the RTKNet network. Real-time water levels from the NOAA station (#8775237 Port Aransas, Texas) will be used as a backup. General site observations will be recorded including, at a minimum, air temperature, wind speed, and sea-state.

The depth of the water sample shall be mid-depth in the water column, but under no circumstances will the water intake hose end be any closer than three feet from the sediment surface.

Special care should be taken to avoid the introduction of contaminants from the sampling device and the containers. PCCA's subconsultant and field contractor shall collect water samples with a non-contaminating stainless steel and Teflon® pump and Teflon®-lined tubing. Prior to sample collection, an initial volume of water equaling at least 10 times the hose volume will be pumped through the sampling device and discarded. If cubitainers are used, they must be made of non-contaminating material and rinsed 10 times prior to filling.

See Table 3 for a summary of surface water sampling parameters including sample volume, container type, handling, preservation, storage, etc.

All water samples that will be submitted for any type of chemical analyses will be field filtered and placed into suitable pre-cleaned laboratory supplied polyethylene bottles or amber glass bottles with appropriate acid or base preservatives (see Table 3). Water samples to be analyzed for metals, with the exception of mercury and selenium, will be field filtered through a clean 0.45 micrometer filter prior to dispensing into containers with acid preservatives as needed. All containers are to be filled completely, avoiding the presence of any head space in the sample bottles. The lids will then be tightly secured, and the containers will be placed into an ice chest with sufficient cushioning material to prevent breakage during shipment. Exact sampling position will be recorded for each sub-sample/sample collected. Water volumes collected for non-chemical testing need not be field filtered.

Water samples from separate DMMUs will not be composited to create a single site sample. Each location will be sampled, analyzed, and reported as a distinct data point collocated with the sediment sample(s) for that point. All water samples are to be filtered with the following exceptions: 1) VOC analyses; 2) metals for mercury and selenium ONLY; and 3) water intended for elutriate testing. A determination as to whether water samples are field filtered or filtered in the laboratory will be made prior to sample collection.

2.7 SPECIFIC INSTRUCTIONS FOR BIOASSAY/ BIOACCUMULATION ANALYSIS

Sufficient sample volume of sediment will be collected so that the laboratory is able to complete all bioassay/bioaccumulation tests for each DMMU. Approximate volumes are noted in Table 3; however, sample volumes will be confirmed with the testing laboratory prior to field collection commencing.

- **SPP (elutriate)** toxicity tests using three species: Zooplankton (*Americamysis bahia*), ≤1 day old; Crustacean (*Americamysis bahia*), 1-5 days old (average); Fish (*Menidia beryllina*), 9 – 14 days old (If water quality conditions are outside the tolerance range of Menidia species (e.g., salinity < 20%), then permission will be sought to test the sheepshead minnow (*Cyprinodon variegatus*), which is more tolerant to wider water quality ranges). The zooplankton test will be conducted for 48-hr while the crustacean and fish tests will be conducted for 96 hours.
- **Solid Phase (direct whole sediment toxicity)** tests two species: Amphipod (*Leptocheirus plumulosus* or *Ampelisca abdita* based on compatibility with the physical attributes of the test sediment) and epibenthic shrimp (*Americamysis bahia*). Tests will be conducted for 10-days.
- **Bioaccumulation (whole sediment)** tests two species: clam (*Macoma nasuta*) and polychaete worm (*Nereis virens*). Tests will be conducted for 28-days.

Bulk samples will be collected in the field in precleaned pails and not homogenized. Bulk samples will be shipped to the testing laboratory where compositing, homogenization, subsampling, and other sample processing logistics will occur.

2.8 SAMPLE SHIPMENT

All sediment and water samples will be delivered to the testing laboratory in the first stage of SOW/SAP execution. Shipping containers and packaging must be capable of protecting the sample containers from breakage and holding sample temperatures 4 ± 2°C through the collection, to the delivery of samples at the testing laboratory. See Table 3 for a summary of procedures for sample collection, preservation, and storage. Final study samples will be shipped within 1-day of completion of all sampling activities.

For the second stage of the SOW/SAP execution, where elutriate and tissue samples for chemical analyses are generated at the testing laboratory, the testing laboratory is responsible for ensuring that analytical holding times for all sample media for the second stage of distribution are not exceeded, and to coordinate a collection and delivery schedule for all samples with the testing laboratory contact identified below.

Alternatively, shipments may be made by refrigerator truck capable of maintaining temperatures 4 ± 2°C. The completed Chain of Custody must be included with sample delivery regardless of the selected shipment alternative.

2.9 SCHEDULE FOR WORK PERFORMED

Table 4 describes the schedule of work for the sampling and analysis. Since the timing of the commencement of field sampling is not known at this time, the schedule is presented in number of days after field work is completed. It is anticipated that the sampling will be performed in mid to late 2021.

Table 4

Schedule of Work Performed

Estimated Deliverable from Award Date (days)	Responsibility	Task	Duration
0		Receive Notice to Proceed	0
7	Contractor	Prepare a draft Field Sampling Plan (FSP) and Health and Safety Plan (HSP)	7
37	PCCA/USACE/Contractor	Review Field Sampling and Safety Plan, send finalized version to EPA	30
40	PCCA/USACE/Contractor	Hold a pre-field coordination call to review FSP	1
45	Contractor	Mobilize to perform field work	45
50	Contractor	Collect sediment and water samples	5
52	Contractor	Transport sample material to shore and deliver to labs	2
66	Contractor	Submit a post-sampling field report	14
97	Contractor / Laboratory	Sediment Chemical and Bioassay Analysis, Site Water and Elutriate Analysis	45
127	Contractor / Laboratory	Sediment Bioaccumulation Analysis	30
157	Contractor / Laboratory	Bioaccumulation Tissue Analysis	30
217	Contractor	Perform data analysis, modeling and complete draft report	60
247	PCCA/USACE	Regulatory agencies review report	30
277	Contractor	Address comments and finalize report	30

2.10 DELIVERABLES

The following reports must be submitted:

1. Draft Field Sampling and Safety Plan submitted for review and comment. Final report should be sent to EPA for final approval.
2. Field Sampling Plan.
3. Post-Sampling Field Report submitted for review and comment. Final report will be provided for PCCA and USACE.

The following documents/deliverables will be prepared:

1. Draft SAP/FSP/HSP submitted to USACE and EPA review and comment.
2. Final SAP/FSP/HSP submitted to USACE and EPA for signature.
3. Sediment chemistry data and recommendations for tissue chemistry. The contractor will summarize sediment chemistry results and prepare a technical memo with tissue chemistry recommendations for USACE and EPA review and approval.

4. Sediment testing report to include all elements and required formats specified by USACE and EPA Region 6, including:
    - A report narrative addressing all aspects of field sampling and laboratory analysis, a discussion of laboratory results, a review of all laboratory quality of control, and Automated Dredging and Disposal Alternative Modeling System model results
    - Copies of all field paperwork including sediment field logs, water quality logs, calibration log, composite logs, temperature logs, chains of custody forms, and daily QC reports
    - Laboratory results provided in condensed data tables
    - Maps of the sampling sites
    - Photographs of the samples as collected

3.0 PROJECT DESIGN

3.1 DESIGN ASSUMPTIONS

The field contractor will collect sediment and water samples from the CCSC Outer Approach Channel, Corpus Christi Channel, and the Harbor Island Junction as outlined in this SOW/SAP and ensure delivery of all collected samples to the analytical provider, as appropriate, within the specified holding times. Procedures for sample collection, required volume, handling, preservation and storage, and shipment are outlined in Section 2.0.

Close coordination by the field contractors, subconsultant, and testing laboratory with PCCA and USACE personnel is an essential component of this SOW/SAP.

If, at the time of sampling and analyzing, conditions require major deviation from the approach outlined in this SOW/SAP, the Contractor must discuss the deviation with the PCCA, with USACE and EPA coordination. USACE will be in contact with the EPA prior to application/implementation.

Should there be a lack of material present at a sampling location, the field contractor, PCCA, EPA, and the USACE will jointly decide how to shift the sample locations. All details of the steps taken to arrive at a decision as to when/how to shift a sampling point will be noted in the field logs and documented in the final report.

3.2 SAMPLE SITES

This SAP will evaluate site surface water, sediment, elutriates, SPP bioassay, direct toxicity bioassay and the bioaccumulation bioassays for new work sediments within the Outer Channel Reach, Harbor Island Junction, and Corpus Christi Channel adjacent to Harbor Island. Surficial samples will be required at the Reference Area.

- DMMUs (CDP-01 through CDP-05): Given that the material will be dredged from the open water in this segment and is expected to be new work material consisting solely of undisturbed base layer geological formations free of impacts from industrial sources or transport mechanisms, samples will be collected to refusal with exact sampling positions recorded for each sample collection.
- DMMUs (CDP-06 through CDP-09): Sample locations for these DMMUs are within the vicinity of Harbor Island, which historically has accommodated oil storage and fabrication facilities, and may be susceptible to contaminant transport mechanisms. As such, samples will be collected to depth with exact positions recorded for each sample location.
- Reference Area (CDP-REF): Surficial samples only are required at the Reference Area.
- New Work ODMDS (CDP-ODMDS): Surficial samples only are required at the New Work ODMDS.

Table 3 provides a summary of the proposed sample collection locations and sample testing. Initial contaminants of concern were selected based upon the 2003 RIA and then refined to be site-specific and project specific.

3.3 SAMPLE VOLUMES AND CONTAINERS

Sample volumes and containers are outlined in Table 3 and Section 2.0.

3.4 CHAIN OF CUSTODY

Appropriate Chain of Custody protocols will be followed. Guidance on appropriate Chain of Custody protocols can be found in EPA (1986), EPA and USACE (1995 and 1998), and Plumb (1981). Shipping and sample distribution to the testing facilities will be managed by PCCA’s subconsultant and the field contractor.

4.0 ANALYTICAL AND REPORTING REQUIREMENTS

4.1 CHEMICAL ANALYSES

The analyses of samples will be as specified in Table 5 for water, elutriate, sediment, and tissue samples, along with required target detection limits (TDLs). Testing and analysis for organotin are required for DMMUs CDP-06 to CDP-09. All analyses will be performed by a laboratory accredited by an accrediting authority recognized by the NELAP for the analytes/analyte groups and matrices to be analyzed. All analyses will be performed within the holding period described in the referenced guidance documents.

Table 5
Target Detection Levels for Analysis by Sample Type

Chemical	Water/Elutriate (ug/L)	Sediment (ug/kg)	Tissue (ug/kg)
METALS[a] AND CYANIDE			
Antimony	3.0 (0.02)[e]	2.5	0.1
Arsenic	1.0 (0.005)[e]	0.3	0.1
Beryllium	0.2	1.0	0.1
Cadmium	1.0	0.1	0.1
Chromium (total)	1.0	1.0	0.1
Chromium (+3)	1.0	1.0	50.0
Chromium (+6)	1.0	1.0	50.0
Copper	1.0	1.0	0.1
Lead	1.0	0.3	0.1
Mercury	0.2	0.2	0.0
Nickel	1.0	0.5	0.1
Selenium	2.0	0.5	0.2
Silver	1.0	0.2	0.1
Thallium	1.0 (0.02)[e]	0.2	0.1
Zinc	1.0	2.0	0.1
Cyanide	0.1	0.1	–
CONVENTIONAL PARAMETERS			
Grain Size	–	1.00%	–
Total Organic Carbon	0.10%	0.10%	–
Total Petroleum Hydrocarbons	0.1 mg/L	5	–
Ammonia	30.0 ug/L	0.1	–
Total Solids/Dry Weight	–	0.10%	–
Total Suspended Solids	1,000 ug/L	–	–
ORGANIC COMPOUNDS			
Phenols/Substituted Phenols			
2-Chlorophenol	0.9	110	–
2,4-Dichlorophenol	0.8	120	–
2,4-Dimethylphenol	10	20	20
4,6-Dinitro-o-Cresol	10	600	20
2,4-Dinitrophenol	10	20	20

Chemical	Water/Elutriate (ug/L)	Sediment (ug/kg)	Tissue (ug/kg)
2-Nitrophenol	2.0	200	–
4-Nitrophenol	5.0	500	–
p-Chloro-m-Cresol	0.7	140	–
Pentachlorophenol	50	100	100
Phenol	10	100	20
2,4,6-Trichlorophenol	0.9	140	–
L Polycyclic Aromatic Hydrocarbons			
Acenapthene	0.8	20	20
Acenapthylene	1.0	20	20
Anthracene	0.6	20	20
Fluorene	0.6	20	20
Naphthalene	0.8	20	20
Phenanthrene	0.5	20	20
H Polycyclic Aromatic Hydrocarbons			
Benzo(a)anthracene	0.4	20	20
Benzo(a)pyrene	0.3	20	20
Benzo(b&k)fluoranthene	0.6	20	20
Benzo[g,h,i]perylene	1.2	20	20
Chrysene	0.3	20	20
Dibenzo[a,h]anthracene	1.3	20	20
Fluoranthene	0.9	20	20
Indeno[1,2,3-c,d]pyrene	1.2	20	20
Pyrene	1.5	20	20
Chlorianted Hydrocarbons			
1,2-Dichlorobenzene	0.9	20	20
1,3-Dichlorobenzene	0.9	20	20
1,4-Dichlorobenzene	0.8	20	20
2-Chloronapthalene	0.8	160	–
Hexachlorobenzene	0.4	10	20
Hexachlorobutadiene	0.9	20	40
Hexachlorocyclopentadiene	3.0	300	–
Hexachloroethane	0.9	100	40
1,2,4-Trichlorobenzene	0.9	10	20
Phthalate Esters			
Bis(2-ethylhexyl) phthalate	2.0	50	20
Butyl benzyl phthalate	4.0	50	20
Diethyl Phthalate	1.0	50	20
Dimethyl Phthalate	1.0	50	20
Di-n-butyl Phthalate	1.0	50	20
Di-n-octyl Phthalate	3.0	50	20
Halogenated Esters			
Bis(2-chloroethoxy) methane	1.0	130	–
Bis(2-chloroethyl) ether	0.9	130	–
Bis(2-chloroisopropyl) ether	0.7	140	–
4-Bromophenyl phenyl ether	0.6	160	–
4-Chlorophenyl phenyl ether	0.4	170	–
PESTICIDES			
4,4’-DDD	0.1	5	10

Chemical	Water/Elutriate (ug/L)	Sediment (ug/kg)	Tissue (ug/kg)
4,4’-DDE	0.1	5	10
4,4’-DDT	0.1	5	10
Aldrin	0.03	3	6
Alpha-BHC	0.03	3	6
Beta-BHC	0.03	3	6
Gamma-BHC (Lindane)	0.1	3	6
Delta-BHC	0.03	3	6
Chlordane and Derivatives	0.03	3	6
Dieldrin	0.02	5	10
Endosulfan and Derivatives	0.1	5	10
Endrin and Derivatives	0.1	5	10
Heptachlor and Derivatives	0.1	3	6
Hexachlorocyclohexane (Lindane) and Derivatives	0.1	3	6
Methoxychlor	0.5	5	10
Toxaphene	0.5	50	50
PCBs			
Total PCBs	0.01	1.0	2.0
Organonitrogen Comounds			
Benzidine	1.0	5	5
3,3-Dichlorobenzidine	3.0	300	–
2,4-Dinitrotoluene	2.0	200	–
2,6-Dinitrotoluene	2.0	200	–
1,2-Diphenylhydrazine	1.0	10	100
Nitrobenzene	0.9	160	–
N-nitrosodimethylamine	0.9	–	–
N-nitrosodi-n-propylamine	0.9	160	–
N-nitrosodiphenylamine	2.1	20	20
ORGANOTIN[b]			
Dibutyltin[c]	0.01[d]	10	10
Monobutyltin[c]	0.01[d]	10	10
Tributyltin[c]	0.01[d]	10	10
MISCELLANEOUS		**mg/kg**	
% Lipids	–	–	0.01%
pH	–	0.1	–
Isophorone	1.0	10	100

[a] Metals shall be expressed as Dissolved values in water samples, except for mercury and selenium, which shall be reported as Total Recoverable.

[b] Organotin TDLs are reported from the EPA and USACE Southeast Regional Implementation Manual (2008). For example, sites with historic sandblasting, shipbreaking, maintenance, and repair would warrant analysis of organotin.

[c] Additional Requirement for DMMUs CDP-06 to CDP-09.

[d] TDL value taken from the EPA and USACE Southeast Regional Implementation Manual (2008).

[e] The values in parentheses are based on EPA “clean techniques”, (EPA 1600 series methods) which are applicable in instances where other TDLs are inadequate to assess EPA water quality criteria.

4.2 LABORATORY QUALITY CONTROL FOR CHEMICAL ANALYSIS

All chemical and physical analyses must include laboratory QC samples; details of the numbers and types of laboratory QC samples can be found below. Documentation of all QC activities performed specifically in conjunction with this project will be furnished along with sample results. Copies of all raw data, lab notes, chromatograms, standard curves, etc. will be furnished upon request. The laboratory will provide a case narrative of the analyses and any deviations or out of specification events that took place during the analyses with each laboratory deliverable.

Documentation of all QC activities performed specifically in conjunction with this project will be furnished along with sample results. Copies of all raw data, lab notes, chromatograms, standard curves, etc. shall be furnished upon request. The laboratory will provide a case narrative of the analyses and any deviations or out of specification events that took place during the analyses.

a. Method Blanks: Shall be performed at a frequency of one per batch of samples, per matrix type, per sample extraction or preparation method.

b. Laboratory Control Samples (Ongoing Precision and Recovery): Shall be analyzed at a minimum of one per batch of 20 or less samples per matrix type, per sample extraction or preparation method, except for analytes for which spiking solutions are not available.

c. Matrix Spike/Matrix Spike Duplicates: Will be performed ***ON PROJECT MATERIAL AND NOT LABORATORY SAMPLES UNRELATED TO THE SITE*** at a frequency of one in 20 samples per matrix type, per sample extraction or preparation method, except for analytes for which spiking solutions are not available.

d. Surrogates: Surrogate compounds must be added to all samples, standards, and blanks for all organic chromatography methods except when the matrix precludes its use or when a surrogate is not available

e. Instrument Performance: Calibration of instrumentation and performance of periodic instrument checks according to the manufacturer and EPA recommendations, and appropriate Standard Operating Procedures (SOPs)

f. Laboratory Performance Evaluation: Participation in performance evaluation and method studies available from EPA, American Society for Testing and Materials, or other agency. Performance evaluation under such a program is to be conducted, at least, on a semiannual basis

g. Laboratory Contamination: Each new shipment or lot of solvent, reagent or adsorbent will be evaluated for purity in accordance with appropriate SOPs

h. Laboratory Standards: Laboratory standards will be prepared and verified in accordance with appropriate SOPs

i. QC Limits: Calculation of QC limits and preparation of control charts will be performed in accordance with appropriate SOPs

j. Deviations: Out of control events, or outlier data will be noted, and corrective action will be taken in accordance with appropriate SOPs

Chemical analysis of water and elutriate samples will be performed according to analytical methods in:

- USACE (1995). QA/QC Guidance for Sampling and Analysis of Sediments, Water and Tissues for Dredged Material Evaluations (Chemical Evaluations). EPA-823-B-95-001;
- EPA and USACE (1998). Evaluation of Dredged Material Proposed for Discharge in Waters of the U.S. – Testing Manual. ITM;
- EPA and USACE (1991). Evaluation of Dredged Material Proposed for Ocean Disposal. Testing Manual. ("Green Book"). EPA 503/8-91/001; and
- EPA and USACE (2003). RIA for the Ocean Dredged Material Disposal Program. EPA Region 6 and USACE, Galveston District. July 2003.

Sediment results will be compared to published sediment screening values where appropriate. These levels are the Threshold Effects Level and the ERL. The Threshold Effects Level represents the concentration below which adverse effects are expected to occur only rarely, and the ERL is the value at which toxicity may begin to be observed in sensitive species (Buchman, 2008). Comparisons will be used for reference only, not for any regulatory decisions. In addition, the results will be evaluated for samples which exceed the laboratory reporting limit, and the corresponding tissue samples will be analyzed for the compounds where the sediment exceedances occurred.

Elutriate and site water results will be compared to the EPA National Recommended Water Quality Criteria Critical Maximum Concentration and the acute Texas State Water Quality Standards. The Critical Maximum Concentration is an estimate of the highest concentration of a pollutant in saltwater to which an aquatic community can be exposed briefly without resulting in an unacceptable effect (EPA, 2002a). The Texas State Water Quality Standards provides a similar comparison for contaminants within Texas, specifically.

Tissue chemistry results will be compared to reference values and U.S. Food and Drug Administration (FDA) action levels (FDA, 2020). For tissue results above reference, ecological effects threshold and North Gulf of Mexico background concentrations will be used for comparison.

Results will be evaluated for the following:

- All results and information presented in the data tables will be compared to the electronic reports from the laboratories and original field sheets.
- All chemical results will be compared to the target detection or reporting limits shown in tables 4, 5, and 6 to ensure that the limits were met. If the laboratory's detection limits do not meet the TDLs, the affected data will be flagged in the table and discussed in the QA/QC section of the

report. All chemical laboratory QCs will be compared to the criteria specified in the Galveston Chemical Quality Assurance Report.

- All toxicological results will be compared to the criteria specified below and the Chemical Quality Assurance Report. Any failures to meet the specified criteria can usually be evaluated sufficiently early in the project to allow re-analysis within holding time. These comparisons will include the following:
    - Evaluation of control sediment against acceptance limits.
    - Comparison of project sediment to reference material.
    - Review of statistical calculations including 50% mortality, 50% development, and student t-test summaries.
    - Review of supplemental information, including daily hydrographic measurements as well as ammonia and sulfide concentrations, to meet project and regulatory guidelines.
    - If required, the Automated Dredging and Disposal Alternative Modeling System model will be run, and results will be compared to the sample's limiting permissible concentration (LPC) to determine if the material will meet offshore disposal criteria.
- All calculations, including statistical comparisons of project tissues to reference tissues, will undergo an independent review to ensure that the correct values are presented.

4.3 WATER COLUMN BIOASSAY, SOLID PHASE BIOASSAY/BIOACCUMULATION

All tests described below shall be performed by the analytical provider with documented QA/QC to validate the bioassay testing. Procedures for performing these tests can be found in the resources listed below. Project specific details are summarized in Table 6.

- RIA (EPA and USACE, 2003);
- The “Green Book” (EPA and USACE, 1998);
- Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms (EPA, 2002b); and
- Methods for Assessing the Toxicity of Sediment-Associated Contaminants with Estuarine and Marine Amphipods (EPA, 1994).

Table 6

Summary of Marine Bioassay Testing and Evaluation Criteria[1]

Parameter	Suspended Particulate Phase (Elutriate) Toxicity *Americamysis bahia* (zooplankton, invertebrate), *Menidia beryllina* or *Cyprinodon variegatus*[2]	Solid Phase Bioassay *Americamysis bahia* and amphipod *Leptocheirus plumulosus* or *Ampelisca abdita*	Bioaccumulation *Macoma nasuta* and *Nereis virens*
Test Procedures	OTM, ITM (EPA and USACE, 1991; 1998; RIA, 2003)	OTM, ITM (EPA and USACE, 1991; 1998; RIA, 2003)	OTM, ITM (EPA and USACE, 1991; 1998; RIA, 2003)
Test Type/Duration	static/48 or 96 hours	static/10 days	static renewal/28 days
Replicates/Treatment	5	5	5
Organisms/Replicate	10	20	1 gram wet tissue per 200 grams wet sediment (target: 65 grams)
SPP Concentrations	100, 50, 10%	N/A	N/A
Water Type	reconstituted seawater	reconstituted seawater	reconstituted seawater
Water Renewal	none	none	3 times weekly
Test Temperature	20 ± 1°C	*L. plumulosus*: 25 ± 1°C; *A. bahia* and *A. abdita*: 20 ± 1°C	*M. nasuta*: 15 ± 1°C; *N. virens*: 20 ± 1°C
Test Photoperiod	16L:8D	amphipods: continuous light *A. bahia*: 16L:8D	16L:8D
Endpoint	survival	survival	tissue residues
Acceptability Criteria	≥ 90% survival in control	≥ 90% survival in control	residue analysis
Feeding Requirements	*A. bahia*: twice daily; *M. beryllina*: at 48-hours	*L. plumulosus*/*A. abdita*: none; *A. bahia*: daily	none
Salinity	30 ppt ± 2 ppt	*L. plumulosus*/*A. abdita*: 20 ppt ± 2 ppt; *A. bahia*: 30 ppt ± 2 ppt	30 ppt ± 2 ppt
Dissolved Oxygen	≥ 40% saturation	≥ 40% saturation	≥ 40% saturation

°C = degrees Centigrade; OTM = Ocean Testing Manual; ppt = parts per thousand

4.3.1 Suspended Particulate Phase (Elutriate) Toxicity Data Analysis

Survival in each of the undiluted (100%) dredged material elutriate treatment will be compared to survival in the dilution water treatment(s). If survival is greater than or equal to survival in the dilution water treatment, the SPP will meet the guidelines for placement under the water column evaluation. If survival in the dredged material treatments is less than survival in the dilution water treatment, but the difference does not exceed 10%, the SPP will meet the guidelines for placement under the water column evaluation.

However, if the difference in survival between the sediment elutriate and the dilution water exceeds 10% then survival in the 100% dredged material elutriate treatment will be statistically compared to survival in the dilution water. Statistical analyses will be performed as described in the OTM and ITM (EPA and USACE, 1991; 1998). If the 100% dredged material elutriate treatment is not statistically different from the dilution water, the SPP is not predicted to be acutely toxic and will meet the guidelines for placement under the water column evaluation.

If mortality is greater than 10% in the control treatment or in the dilution water treatment for a particular test species (30% mortality/abnormality for zooplankton), the test should be rejected, and the bioassay repeated.

If survival in the 100% dredged material elutriate treatment is statistically lower than the dilution water, the LPC will be calculated. If survival is >50%, then the LPC will be calculated as the 100% elutriate multiplied by an appropriate application factor. If survival is <50%, then a Lethal Concentration (LC50) value will be calculated and the LPC will be determined as the LC50 multiplied by an appropriate application factor. While the default application factor is 0.01, regulations state that alternative factors may be used when there is reasonable scientific evidence on a specific material to justify the use of an alternative application factor to calculate the LPC (MPRSA 103, 40 CFR 227.27(a)(3), NAS (1972)). If an alternative factor is used, justification will need to be provided to the USACE and EPA prior to its application to the study data.

The numerical model, STFATE, will then be required to determine compliance with the LPC (EPA and USACE, 1991). The modeled concentrations of the dredged material in the water column outside the boundary of the disposal site during the 4-hour initial mixing period and the maximum concentration in the water column in the marine environment after the 4-hour mixing period will be compared with the LPC to determine compliance. If both modeled concentrations are less than the LPC, compliance for the SPP will have been met. If either of the modeled concentrations exceeds the LPC, compliance for the SPP will not have been met and placement of the dredged sediment cannot be conducted without appropriate management.

4.3.2 Solid Phase (Sediment) Bioassay Data Interpretation

Two conditions are required to designate sediment as potentially toxic based on survival in whole sediment toxicity (solid phase) testing:

1. Mortality that is more than 10% greater for the mysid shrimp or 20% greater for the amphipod than mortality in the reference; and
2. A statistically significant reduction in survival compared to survival in the reference sediment (EPA and USACE, 1991; 1998).

If dredged material mortality exceeds reference mortality by the magnitude describe in condition 1 above, dredging sediment toxicity data will be statistically compared to data from reference sediments as described in the OTM and ITM (EPA and USACE, 1991; 1998). If both conditions are met, the sediment fails to meet the LPC and the dredged material will be deemed unsuitable for open water placement. If one or both of these conditions are not met, the sediment will have met the LPC for whole sediment toxicity (solid phase).

If greater than 10% mean mortality occurs in the control sediment, the test should be repeated.

4.3.3 Bioaccumulation Test Data Interpretation

For bioaccumulation tests, tissue residues will be conservatively compared to the FDA action levels (where available and appropriate) using the 95th UCL of the mean of the data distribution. If concentrations of one or more contaminants statistically exceed the FDA action level, then the sediment does not meet the LPC for open water placement.

If tissue concentrations do not exceed the FDA action levels, then the tissue residue levels will be statistically compared to tissue concentrations of organisms exposed to reference sediment. In cases where tissue residues are less than detection limits, half the detection limit will be applied to statistical comparisons as recommended by Clark (1998). If tissue concentrations in organisms exposed to sediment from the dredging site do not statistically exceed the contaminant concentrations in tissues exposed to the reference sediment, adverse effects are not likely, and the sediment will have met the LPC for bioaccumulation.

If tissue concentrations are statistically greater in organisms exposed to sediment from the dredging site than in organisms exposed to the reference sediment, further evaluation will be required by assessing the eight factors described in the 2003 RIA. The factors are assessed in a weight of evidence approach for determination of LPC compliance.

If a compliance decision still cannot be reached following evaluation of these eight factors, further actions will be developed and agreed upon by both the EPA and the USACE.

Further details on bioassay protocols for each test type can be found in Appendix C.

4.4 DATA SUBMITTAL

A report compliant with this SAP will be submitted by USACE to PCCA at completion of the dredge material characterization and evaluation. The report will synoptically summarize the key points as appropriate from the SOW/SAP, cross reference to study documents and at a minimum, include:

1. Sample collection: sampling sites and locations (water and sediment); tabulated and plotted on figure showing locations and the dredging prism; summarized and cross referenced to study documents as needed

2. Field procedures: synoptic summaries and cross referenced to provided project documents; including compositing, physical observations (e.g. odor, stratification, etc.) and other field procedures, observations, deviations as appropriate
3. QC (field): described and cross referenced to project documents, as needed
4. Analyses: description of what was analyzed, methodologies etc.
5. Results and discussion: discuss data and proceed by environmental medium and within each medium, by analyte category. Similarly, discuss and proceed through each bioassay and within each bioassay by test organism. Prior to issuance of the final report, the report will also discuss any of the applicable subparts and sections of 40 CFR Parts 227 and 228 listed in the RIA.

A report containing the finding of the toxicity and bioaccumulation studies will be provided. The report will include an executive summary, introduction, methods and results section. The report will include test endpoint tables providing means, standard deviations for survival, tissue mass, etc. Water quality analysis tables will include mean, standard deviation, N, and range of values for each endpoint measured.

One (1) hard copy and an electronic PDF version of the report will be provided. Experimental data will be provided in an Excel Electronic Data Deliverable.

5.0 REFERENCES

Buchman, M.F. 2008. NOAA Screening Quick Reference Tables (SQuiRTs), NOAA OR&R Report 08-1, Seattle WA, Office of Response and Restoration Division, National Oceanic and Atmospheric Administration. https://response.restoration.noaa.gov/sites/default/files/SQuiRTs.pdf.

City of Port Aransas. 2006. Planning and Zoning Department. Existing Land Use Map.

Environmental Protection Agency (EPA). 1986. Test Methods for Evaluating Solid Waste (SW846): Physical/Chemical Methods. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC.

______. 1987. Quality Assurance/Quality Control (QA/QC) for 301(h) Monitoring Programs: Guidance on Field and Laboratory Methods. EPA 430/9-86-004. Prepared by Tetra Tech, Inc., Bellevue WA, for the U.S. Environmental Protection Agency, Office of Marine and Estuarine Protection. NTIS Number PB87-221164.

______. 1994. Methods for Assessing the Toxicity of Sediment-Associated Contaminants with Estuarine and Marine Amphipods. EPA 600/R-94/025. U.S. Environmental Protection Agency, Office of Research and Development, Washington, DC, 20460.

______. 2002a. National Recommended Water Quality Criteria: 2002. EPA-822-R-02-047. November 2002.

______. 2002b. Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms. Fifth Edition. U.S. Environmental Protection Agency. EPA-821-R-02-012. October 2002. https://www.epa.gov/sites/default/files/2015-08/documents/acute-freshwater-and-marine-wet-manual_2002.pdf.

Environmental Protection Agency and U.S. Army Corps of Engineers (EPA and USACE). 1990. Specifications and Guidance for Obtaining Contaminant-Free Sampling Containers. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Directive #9240.0-05, April 1990.

______. 1991. Evaluation of Dredged Material Proposed for Ocean Disposal (Testing Manual) ("Green Book"). U.S. Environmental Protection Agency. EPA 503/8-91/001. https://www.epa.gov/sites/default/files/2015-10/documents/green_book.pdf.

______. 1995. QA/QC Guidance for Sampling and Analysis of Sediments, Water, and Tissues for Dredged Material Evaluations - Chemical Evaluations. EPA 823-B-95-001. U.S. Environmental Protection Agency and U.S. Army Corps of Engineers, Washington, D.C.

______. 1998. Evaluation of Dredged Material Proposed for Discharge in Waters of the U.S. Testing Manual, Inland Testing Manual. EPA-823-B-98-004. February 1998. https://www.epa.gov/sites/production/files/2015-08/documents/inland_testing_manual_0.pdf.

______. 2003. Regional Implementation Agreement for Testing and Reporting Requirements for Ocean Disposal of Dredged Material off the Louisiana and Texas Coasts under Section 103 of The Marine Protection, Research and Sanctuaries Act. U.S. Environmental Protection Agency, Region 6 and U.S. Army Corps of Engineers, New Orleans District. July 2003.

______. 2008. Southeast Regional Implementation Manual (SERIM). Requirements and Procedures for Evaluation of the Ocean Disposal of Dredged Material in Southeastern U.S. Atlantic Gulf Coast Waters. August 2008. https://www.epa.gov/sites/default/files/2016-05/documents/r4_serim_final_august_2008.pdf.

Ford, J.G. 2013. Harbor Island Once Bustling. Port Aransas South Jetty. July 11, 2013.

U.S. Food and Drug Administration (FDA). 2020. Guidance for Industry: Action Levels for Poisonous or Deleterious Substances in Human Food and Animal Feed. August 2020. https://www.fda.gov/regulatory-information/search-fda-guidance-documents/guidance-industry-action-levels-poisonous-or-deleterious-substances-human-food-and-animal-feed.

Freese and Nichols, Inc. 2021. Corpus Christi New Work Ocean Dredged Material Disposal Site Proposed Expansion, Unconfined Open Water Disposal New Work Dredged Material Sediment Fate Numerical Modeling. Prepared for the Port of Corpus Christi Authority. March 2021.

Guthrie, K. 1986. History of San Patricio County (Austin: Nortex, 1986). Frank Wagner, ed.,

National Oceanic and Atmospheric Administration (NOAA). 1989. Standard Analytical Procedure of the NOAA National Analytical Facility. 2nd ed., NOAA Technical Memoranda NMFS F/NWC-92, 1986-89. NOAA National Status and Trends Program, NOAA N/OMA32, Rockville, MD.

Plumb, R.H., Jr. 1981. Procedure for Handling and Chemical Analysis of Sediment and Water Samples. EPA/CE-81-1. Prepared by State University College at Buffalo, Great Lakes Laboratory, Buffalo, N.Y. U.S. Environmental Protection Agency and U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.

Tetra Tech. 1986a. Analytical methods for U.S. EPA priority pollutants and 301(h) pesticides in estuarine and marine sediments. Final Report prepared by Tetra Tech, Inc., for U.S. Environmental Protection Agency under Contract No.69-01-6938.

Tetra Tech. 1986b. Bioaccumulation monitoring guidance: 4. Analytical methods for U.S. EPA priority pollutants and 301(h) pesticides in tissues from estuarine and marine organisms. Final Report prepared by Tetra Tech, Inc., for U.S. Environmental Protection Agency under Contract No. 68-01-6938.

U.S. Army Corps of Engineers (USACE). 1995. QA/QC Guidance for Sampling and Analysis of Sediments, Water and Tissues for Dredged Material Evaluations (Chemical Evaluations). EPA-823-B-95-001; Basic Document: http://el.erdc.usace.army.mil/dots/pdfs/epa/qaqc.pdf.

______. 2003. Corpus Christi Ship Channel Improvement Project, Corpus Christi Ship Channel. Final Feasibility Report and Final Environmental Impact Statement. Volume 1. U.S. Army Corps of Engineers, Galveston District. April 2003.

______. 2018. Sampling, Chemical Analysis, and Bioassessment in Accordance with MPSRA Section 103 for Corpus Christi Ship Channel (CCSC) Improvement Project, Entrance Channel and Extension, Corpus Christi, TX. U.S. Army Corps of Engineers, Engineer Research and Development Center. http://www.swg.usace.army.mil/Missions/Navigation/HydrographicSurveys/CorpusChristi.aspx.

______. 2021. Hydrographic Survey Corpus Christi Ship Channels. U.S. Army Engineer District, Galveston, Texas. April 7, 2021.

Appendix A

Corpus Christi Ship Channel, Texas
Channel Improvement Project (2003)

U.S. Army Corps
of Engineers

Galveston District
Southwestern Division

Corpus Christi Ship Channel, Texas
Channel Improvement Project

Volume I

Final Feasibility Report
and
Final Environmental Impact Statement

April 2003

CORPUS CHRISTI SHIP CHANNEL
CHANNEL IMPROVEMENTS PROJECT
CORPUS CHRISTI AND NUECES BAYS
NUECES AND SAN PATRICIO COUNTIES, TEXAS

FINAL
ENVIRONMENTAL IMPACT STATEMENT

U.S. Army Corps of Engineers
Galveston District

April 2003

ABSTRACT

FINAL
ENVIRONMENTAL IMPACT STATEMENT

Corpus Christi Ship Channel Channel Improvements Project
Corpus Christi and Nueces Bays
Nueces and San Patricio Counties, Texas

The responsible lead agency is the U.S. Army Engineer District, Galveston. The responsible cooperating agency is the U.S. Environmental Protection Agency.

Abstract: The Galveston District has reviewed the Port Aransas-Corpus Christi Ship Channel (45-Foot Project) and other reports to determine the feasibility of modifying the Corpus Christi Ship Channel (CCSC) to improve commercial navigation. The plan of improvements is described in the accompanying Feasibility Report and Final Environmental Impact Statement (FEIS). The CCSC and La Quinta Channel are navigation channels that connect the harbor facilities in Corpus Christi and Ingleside-On-The-Bay, San Patricio and Nueces Counties, Texas with the Gulf of Mexico. Ship sizes have increased resulting in the need for light loaded vessels to traverse the present waterway. The current channel depth requires that large crude carriers remain offshore and transfer cargo into smaller crude tankers for the remainder of the voyage. Ship delays are experienced as well due to the 400-foot channel width versus the needed 530-foot channel width and from the lack of barge lanes. Crude petroleum imports and petroleum product imports are expected to increase 50% and 500% by 2056, respectively. Twenty-three alternatives were evaluated. Based on the environmental impacts, engineering feasibility, and economic considerations, the recommended plan consists of deepening the CCSC to 52 feet and widening to 530 feet with modifications to turning basins; addition of 12-foot-deep, 200-foot-wide barge lanes on either side of the 530-foot channel for 9.6 miles in the upper Corpus Christi Bay; extension of La Quinta Channel for 1.4 miles at a depth of 39 feet and width of 300 feet; and a dredged material management/beneficial use plan.

THE OFFICIAL CLOSING DATE FOR THE RECEIPT OF COMMENTS IS 30 DAYS FROM THE DATE ON WHICH THE NOTICE OF AVAILABILITY OF THIS FINAL EIS APPEARS IN THE *FEDERAL REGISTER*.

If you would like further information on this statement, please contact:

Ms. Carolyn Murphy
U.S. Army Engineer District, Galveston
2000 Fort Point Road
Galveston, Texas 77550
Commercial telephone: 409/766-3044

NOTE: Information, displays, maps, etc., discussed in the Feasibility Report and Appendices are incorporated by reference in the FEIS.

April 2003

SUMMARY

Major Conclusions and Findings

Major factors affecting formulation of the Corpus Christi Ship Channel – Channel Improvements Project, Texas, were effects on water quality, sediment quality, bay system hydrology, estuarine resources, socioeconomic, and cumulative impacts. Contaminant studies demonstrated that new work and maintenance dredged material from all sections of the channel, with the exception of the Inner Harbor, is acceptable for offshore disposal, beneficial uses in the bay or ocean, or upland disposal. Because there have been contaminant problems with sediments in the Inner Harbor in the past, this material will be placed in existing, nearby upland sites to remove it from the system. The Hydrodynamic and Salinity Model demonstrated that minimal impacts on water exchange, inflow, and salinity would occur. Tidal amplitude may increase up to 0.06 feet and changes in salinity may seasonally and locally decrease by up to 4 parts per thousand (ppt). Shoreline erosion was studied without the beneficial use sites and it was concluded that neither the existing or proposed conditions had consistently positive or negative impacts on shoreline erosion. Several of the beneficial use sites are located to provide erosion protection to areas of concern for erosion.

The Beneficial Uses Workgroup of the Regulatory Agency Coordination Team developed a dredged material management/beneficial use plan that utilizes dredged material in an environmentally sound and economically acceptable manner and that incorporates other public benefits into its design. Beneficial uses of dredged material investigations identified a plan that will result in the following: creation of 935 acres of shallow water habitat, creation of 15 acres of submerged aquatic vegetation (as mitigation), creation of 26 acres of marsh, construction of 26,400 linear feet of rock breakwater, creation of 1,590 acres of offshore topographic relief, construction of 120 acres of upland buffer zone, construction of 7,500 linear feet of rock revetment, protection of 45 acres of submerged aquatic vegetation, protection of an existing bird island, and protection of 400+ acres of wetlands. Channel enlargement will result in direct permanent and temporary losses to 5 acres of patchy submerged aquatic vegetation, which will be mitigated through creation of 15 acres of submerged aquatic vegetation. The cumulative impact assessment showed that the proposed navigation improvements with the beneficial use plan will result in a net positive environmental effect to the Corpus Christi Bay ecosystem relative to the without project condition.

Recommended Plan

The Corpus Christi Ship Channel – Channel Improvements Project provides navigation safety and efficiency enhancements and environmental restoration via beneficial uses of dredged material. The recommended plan consists of deepening and selective widening of the existing –45 foot MLT deep, 400-ft-wide authorized channel from the Entrance Channel to a point about ½ mile east of the Harbor Bridge. Deepening of the channel will occur along its entire 34 mile length to –52 feet MLT. The existing Entrance Channel will be lengthened 10,000 feet and deepened from its present authorized depth of –47 feet MLT to an authorized depth of –54 feet MLT. The channel will be widened from its present

400-foot width to 530 feet through Upper Corpus Christi Bay. The Lower Corpus Christi Bay reach will be widened from its present 500-foot width to 530 feet. Barge shelves, which will each be 200 feet wide as measured from the toe of the widened channel, will occur along both sides of the channel through Upper Bay. The recommended plan includes the extension of La Quinta Channel approximately 7,400 feet at a width of 300 feet and to a depth of –39 feet MLT.

The Dredged Material Management/Beneficial Uses Plan outlines the placement of dredged material from construction of the project improvements. Eight existing confined upland sites, an existing offshore placement site, and eight existing, unconfined bay sites will be utilized to confine both new work and maintenance dredging material. An additional upland placement site for the La Quinta Channel Extension and seven new open-water beneficial use sites will be established; two offshore, and the remainder in Lower Corpus Christi Bay. Additional beneficial use project features for erosion protection that will benefit the coastal environment will be constructed without the use of dredged material.

Other Major Conclusions and Findings

This Environmental Impact Statement has been prepared to satisfy the requirements of all applicable laws and regulations using the Council of Environmental Quality's National Environmental Policy Act regulations (40 CFR Part 1500) and the Corps of Engineers regulation ER 200-2-2 (33 CFR 230). The following is a brief summary of the effects of the recommended plan on the significant environmental resources of Corpus Christi Bay.

Water Quality

A Hydrodynamic and Salinity Model for Corpus Christi Bay, developed by the Texas Water Development Board, evaluated water exchange and salinity impacts. The model results concluded that changes in tidal amplitude of 0.06 feet or less are expected in the project area, and that changes in salinity may seasonally and locally decrease by up to 4 ppt or increase up to 0.38 ppt. Testing of maintenance material elutriates with chemical analyses and water column bioassays has indicated no cause for concern. No significant increase or decrease in ballast water introductions is expected. As a result, no net adverse direct or indirect impacts from water quality are expected as a result of the recommended plan.

Sediment Quality

The results of sediment analyses demonstrated that new work and maintenance dredged material are acceptable for beneficial uses with two exceptions. Sediments from the Inner Harbor will be placed in several upland confined placement areas, and the fine material from the Upper Bay will continue to go into open-bay, unconfined placement areas.

Community Types

Five acres of submerged aquatic vegetation will be directly impacted by the recommended plan. This loss will be mitigated by planting 15 acres of seagrass within a 200-acre shallow water beneficial use site. The beneficial use plan will protect and create submerged aquatic vegetation habitat areas, wetlands, and coastal shore areas.

Fish and Wildlife Resources

No significant adverse impacts to finfish, shellfish, recreational and commercial species, aquatic communities, essential fish habitat, and wildlife resources are expected to occur from the recommended plan. Temporary impacts to fish and wildlife resources may be experienced from dredging and resulting suspended solids (turbidity). However, the beneficial use plan will create new habitat to be used by these species.

Threatened and Endangered Species

Identification of all Federally listed threatened or endangered species in the project area and any impacts the project may have on these species has been completed. A Biological Assessment of impacts on threatened, endangered, and candidate species in the area has been prepared and coordinated with the U.S. Fish and Wildlife Service and National Marine Fisheries Service. The Galveston District has determined that the recommended plan will not have any significant adverse effect on the listed species and the FWS has concurred (Appendix C). The NMFS's Biological Opinion is also included in Appendix C.

Hazardous, Toxic, and Radioactive Waste

A review of a regulatory agency database information search, an aerial photographic review, interviews with regulatory officials, and a site reconnaissance were conducted to determine the impacts of the recommended plan on or from existing hazardous, toxic, and radioactive waste. Areas identified in the Inner Harbor will not cause an impact because dredged materials will go to upland confined placement areas. Petroleum pipelines occur within the channel and will be relocated. No impacts to oil and gas wells are expected.

Historic Resources

All project impact areas have been evaluated for potential effects to historic properties including multiple marine remote-sensing surveys and diver assessments. The recommended plan will impact one significant historic property, the wreck of the SS *Mary* (41NU252) and mitigation will be done in coordination with the State Historic Preservation Officer. No terrestrial cultural resources will be impacted.

Air Quality

Minor, temporary impacts on air quality from the recommended plan would result during construction dredging activities while air quality from maintenance dredging and ship operations should be similar to those now occurring. Changes in air quality may occur due to the increase in traffic in the La Quinta Channel extension because of the proposed La Quinta Gateway Container Facility. This impact is not a result of the recommended plan and is expected to occur regardless of the deepening and widening of the main channel.

Noise

Minor, temporary impacts to the noise environment from the recommended plan would result during construction while maintenance dredging activities should be similar to those now occurring. Noise is not expected to increase significantly.

Socioeconomic Resources

Implan Professional, a computer-based modeling program, was used to predict indirect and induced effects from the recommended plan. Industry and employment data from the Nueces and San Patricio counties was used in the analyses. No adverse effects to socioeconomic resources are expected to occur from the recommended plan but beneficial economic impacts are expected.

Cumulative Impacts

Nine past, present, and reasonably foreseeable future projects and their impacts upon the project area were evaluated. The cumulative impact assessment concluded that the recommended plan has a net positive environmental effect on the project area relative to the without project (existing CCSC).

Areas of Controversy and Unresolved Issues

A draft Fish and Wildlife Coordination Act Report (CAR) is under revision by the FWS and will not be ready for inclusion in this document. The Final CAR for this project is included with the FEIS. Other resource agencies submitted comments on the recommended plan and the beneficial uses sites discussed in the 50-year disposal plan.

Relationship to Environmental Requirements

The recommended plan is in full compliance with the environmental requirements applicable to this stage of the planning process. A discussion of the applicable laws can be found in Section 7.0 of the FEIS.

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1.0 NEED FOR AND OBJECTIVES OF ACTION

1.1 STUDY AUTHORITY AND LOCATION

A congressional resolution was adopted 1 August 1990 by the committee on Public Works and Transportation, U.S. House of Representatives, which authorized the U.S. Army Corps of Engineers (USACE) to review the reports on the Port Aransas-Corpus Christi Ship Channel, Texas (45-foot project), published as House Document 99, 90th Congress, Second Session, and other pertinent reports to determine the feasibility of modifying the Corpus Christi Ship Channel (CCSC) system from the current depth of 45 to 50 feet to accommodate large vessels, increase shipping efficiency, and enhance navigation safety. The Port of Corpus Christi Authority (PCCA), non-Federal sponsor of the existing channel system, began consideration of additional channel improvements upon the 1989 completion of the 45-foot deepening project. The USACE completed the reconnaissance study in 1994 concluding that the benefits of channel improvements would be 2.5 times greater than the project cost. Thus began a Feasibility Study (FS), Corpus Christi Ship Channel – Channel Improvement Project (CCSCCIP), to determine whether the Federal navigation project is justified and to provide documentation needed to request Congressional authorization and funding for construction of the project. In 1999, the USACE and PCCA signed an agreement to conduct an FS, including an Environmental Impact Statement (EIS). The project is being led by the USACE, but cost is shared with PCCA, with the U.S. Environmental Protection Agency (EPA) as a cooperating agency.

The study area for the CCSCCIP encompasses Corpus Christi Bay, including the southern section of Redfish Bay and the northernmost section of the Laguna Madre, Nueces Bay, the lower Nueces River (12 miles), Inner Harbor, Viola Channel, La Quinta Channel, and the watershed surrounding these water bodies up to roughly ½ mile inland from all shorelines (Figure 1-1). The coastline of this area extends across Nueces and San Patricio counties and is adjacent to the cities of Corpus Christi, Portland, Ingleside-On-The-Bay, and Port Aransas.

The CCSC is located in Corpus Christi Bay on the south-central portion of the Texas coast, 200 miles southwest of Galveston and 150 miles north of the mouth of the Rio Grande River. This channel ranks seventh in the nation for tonnage shipped on oceangoing vessels, and, in Texas, only the Houston Ship Channel handles more tonnage.

1.2 PURPOSE AND NEED

The purpose of the project includes improvement in the efficiency and safety of the deep-draft navigation system, and protection of the quality of the area's coastal and estuarine resources. Safety improvements would address problems identified below and contribute to economic efficiency. Economic efficiency would result from the passage of large ships through the CCSC that previously had to remain offshore and transfer cargo into smaller crude tankers for the remainder of the voyage. Vessel delays and the potential for accidents would also be reduced. Protection of the area's coastal and estuarine resources would be associated with reduced potential for accidents and oil spills.

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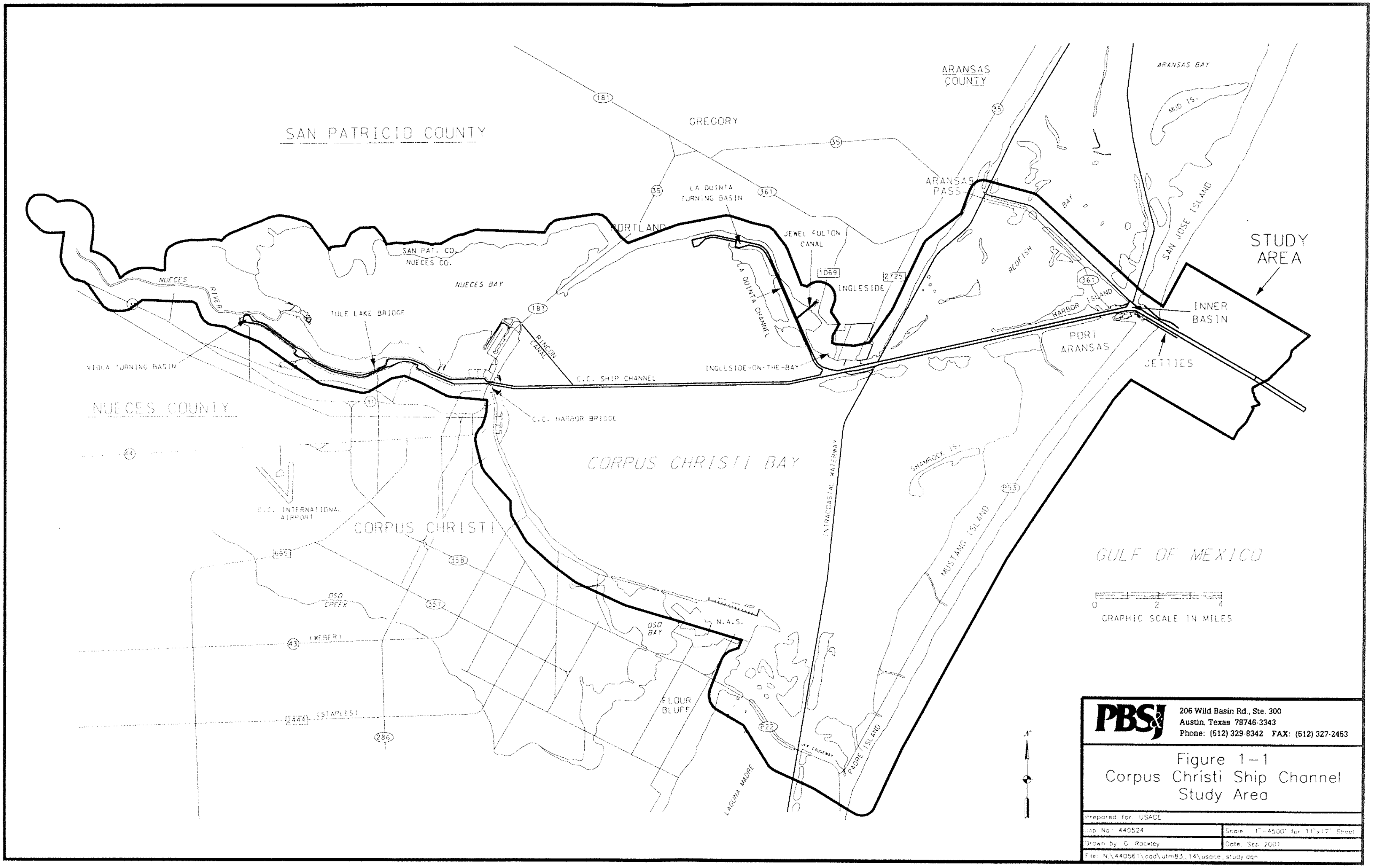

PBS&J
206 Wild Basin Rd., Ste. 300
Austin, Texas 78746-3343
Phone: (512) 329-8342 FAX: (512) 327-2453

Figure 1-1
Corpus Christi Ship Channel
Study Area

Prepared for: USACE
Job No.: 440524
Scale: 1"=4500' for 11"x17" Sheet
Drawn by: G. Rockley
Date: Sep 2001
File: N:\440561\cad\utm83_14\usace_study.dgn

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The channel reach between the Corpus Christi Harbor Bridge and the La Quinta Channel is only 400 feet wide and, since it is in an open-bay area, is subject to strong crosswinds and currents. At present, ships wait offshore and time their entrance into the CCSC to pass in the 500-foot reach since they cannot pass in the 400-foot reach, rather than incur the expense to obtain tug assistance to moor and wait with a pilot on board as well as tugs standing by to release them from the moorings. Widening the 400-foot reach is needed to increase the safety factor for this area and to reduce shipping delays, especially since shipping trends indicate a movement toward use of larger vessels.

Presently, few crude oil vessels are loaded to more than 41 feet because general policy requires vessels to have 3 feet of underkeel clearance. Therefore, the current channel depth requires that large crude carriers remain offshore and transfer their cargo into smaller crude tankers for the remainder of its voyage. Lightering also increases the potential of a collision, oil spill, or fire, leading to adverse environmental consequences. Channel deepening is needed to avoid both inefficiency and risk of adverse impacts from lightering.

Channel widening and deepening are also needed since several of the major petrochemical industries are currently undergoing major expansions, which will result in an increase in crude oil imports. As these imports increase, the number of lightering vessels and product carriers will also increase, adding to shipping delays and congestion. Since the most frequent shipping accidents result from collisions between ships and inland tows, the towing industry and channel industries are concerned that restrictions may be placed on the tows to limit these costly and environmentally damaging events. The proposed project would reduce delays, and the inclusion of barge shelves will reduce the risk of ship-tow collisions.

1.3 EXISTING PROJECT

The CCSC, formerly known as the Port Aransas – Corpus Christi Waterway, is a consolidation of past improvements of Port Aransas and the channel from Aransas Pass to Corpus Christi. The CCSC project channel system also includes La Quinta Channel, Jewel Fulton Canal, and Rincon Canal. The history of Federal Involvement in navigation improvements in the Corpus Christi Bay area began with the Rivers and Harbors Act of June 18, 1878. In August 1968, authorization of major improvements to the CCSC included increasing existing channels and basins to a 45-foot depth, a deep-draft turning area, a deep-draft mooring area and mooring facilities, and widening of the channels and basins at certain locations. The undredged northward extension of the Inner Basin at Harbor Island and the undredged west turnout between the La Quinta Channel and the main channel of the waterway was deauthorized. The 45-foot project was completed in 1989.

The existing authorized Federal navigation project consists of channels and turning basins suitable for oceangoing vessels and rubble-stone jetties. The channel begins at deep water in the Gulf of Mexico about 4.3 miles offshore, passes through the jettied inlet, and extends about 21 miles westward to Corpus Christi. Continuing west, the channel extends about 8.5 miles through the harbor area before terminating at the Viola Turning Basin. The north and south jetties are 11,190 and 8,610 feet long and extend into the Gulf from San Jose (formerly St. Joseph's) and Mustang islands, respectively, and stabilize the natural inlet of Aransas Pass. The stone dike on San Jose Island connects with the north jetty and extends 20,991 feet up the island. The La Quinta Channel extends off of the CCSC near Ingleside, Texas, and runs parallel to the eastern shoreline of Corpus Christi Bay for 5.5 miles to the La Quinta Turning Basin.

1.4 PROBLEMS, NEEDS, AND PUBLIC CONCERNS

Existing water resource problems and needs in Corpus Christi Bay were identified through coordination with Federal and State agencies, area residents, waterway users, and the USACE and PCCA. Most of the identified problems are not unique to Corpus Christi Bay but are common to many of the bays and estuaries in Texas. It should be noted that the following include all of the problems and concerns raised at a series of public meetings. Some have no relevance to this project and are general concerns raised by the citizens of the area. Many are concerns that cannot or will not be addressed in a project-specific EIS. However, all of the concerns raised by agencies and persons at those meetings are discussed in this section. As a consequence of the way the questions, comments, and concerns were collected, some are vague. However, they were reproduced as nearly as possible in this document, without embellishment. Concerns pertinent to the proposed project are addressed in this FEIS.

1.4.1 Navigation/Commerce

The CCSC was the first waterway in Texas to be completed to a 45-foot depth. Since the completion of the 45-foot project, the size of ships using the waterway has steadily increased, and vessels currently have to be light-loaded to traverse the waterway.

The channel reach between the Corpus Christi Harbor Bridge and Ingleside is only 400 feet wide and is subject to strong crosswinds and currents, while the reach between Ingleside and the jetties is 500 feet wide and is semi-protected by emergent Dredged Material Placement Areas (PAs) (Figure 1-2). As part of the 45-foot project, a mooring area was constructed near Ingleside. This facility consists of six mooring dolphins and ten mooring anchors. It was designed to hold inbound ships at Ingleside while other large ships were crossing the open water area from the Harbor Bridge to Ingleside. This facility has not functioned as designed, is in poor repair, and will soon be removed. Shippers prefer to wait offshore and time their entrance to pass in the 500-foot reach rather than incur the expense to obtain tug assistance to moor and wait with a pilot on board and tugs standing by to release them from the moorings. Widening the upper bay reach would increase the safety factor for this area and would reduce shipping delays, especially since shipping trends indicate a movement toward use of larger vessels. The ultimate size of vessels using the channel is restricted by the 138-foot vertical clearance of both the Harbor Bridge and the Tule Lake Lift Bridge. However, the clearance is sufficient to accommodate the present fleet of vessels using the project.

The 45-foot channel deepening project became operational in the late eighties and, at that time, crude oil tankers with loaded drafts up to 45 feet mean low tide (MLT) were not uncommon. MLT is 1 foot lower than National Geodetic Vertical Datum 29 (NGVD 29) (i.e., 0 feet MLT is equivalent to –1 NGVD 29) as used by the Galveston District of the USACE. Presently, few crude oil vessels are loaded to more than 41 feet. Examination of vessel records shows that some petroleum coke vessels are

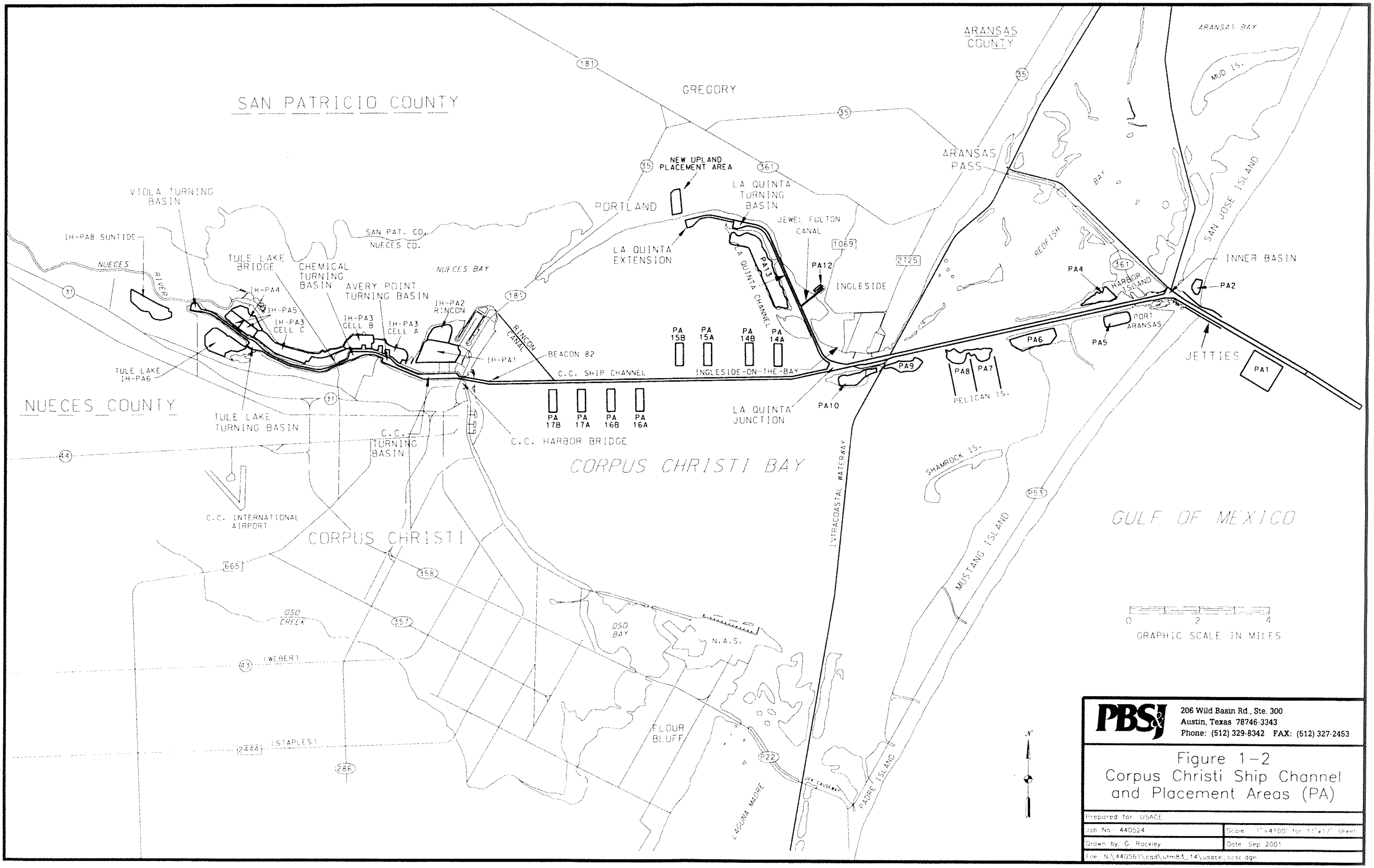

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Figure 1-2
Corpus Christi Ship Channel and Placement Areas (PA)

Prepared for USACE
Job No: 440524
Scale 1"=4100' for 11"x17" Sheet
Drawn by: G. Rockley
Date Sep 2001
File N:\440561\cad\utm83_14\usace_ccsc.dgn

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presently loaded to depths of up to 45 feet MLT. Some pilots have allowed dry cargo, such as petroleum coke, to be loaded to deeper depths than liquid cargo. The general policy requires vessels to have 3 feet of underkeel clearance. Examination of 1996-1999 transit records shows that loaded drafts over 41 feet are infrequent, particularly for liquid cargo. In comparison, 1990 traffic data compiled for the 1994 reconnaissance report reveals that 1 foot of underkeel or less was not uncommon for liquid cargoes during the early 1990s.

The current channel depth requires that large crude carriers remain offshore and transfer their cargo into smaller crude tankers for the remainder of its voyage. This lightering operation takes place in the Gulf where the two ships, the mother ship and the lightering ship, come together to transfer the cargo. Although this operation has been occurring for years, the possibility for a collision, oil spill, fire, or other adverse environmental consequence is always present.

Several of the major petrochemical industries are currently undergoing major expansions which will result in an increase in crude oil imports. As these imports increase, the number of lightering vessels and product carriers will also increase, adding to shipping delays and congestion. Since the most frequent shipping accidents result from collisions between ships and inland tows, the towing industry and channel industries are concerned that without the proposed project, restrictions may be placed on the tows to reduce the potential for these costly and environmentally damaging events occurring.

Other issues of concern associated with navigation include those related to erosion and siltation. Shoreline erosion is occurring along the ship channel in the Port Aransas area. Ship wakes may be contributing to this problem, and an evaluation of the erosion problem was requested for inclusion in this study. The channel area in Corpus Christi Bay near the Harbor Bridge has a high siltation rate.

The remaining capacity of existing upland placement sites as well as the continued suitability of bay placement areas was suggested as requiring further study. It was suggested that a bay-wide plan which encourages the use of dredged materials for beneficial uses (BU) should be developed in the future.

1.4.2 Environmental

Many of the problems, such as pollution, are caused by human activities around the bay system and in the contributing watershed, while others, such as shoreline erosion, are a result of both human activities and natural processes, including normal wind-generated waves and hurricanes. The environmental concerns identified during meetings with the public and resource agencies in the reconnaissance study included the following items:

The increasing potential for environmental harm resulting from shipping accidents is a major concern. In the absence of adequate channel widening, one-way traffic will increase as a means to reduce this threat. One-way traffic has already been imposed when combined beam widths of meeting vessels would exceed 251 feet in the existing 400-foot-wide channel.

Oil spill recovery and definition of the liabilities associated with the clean-up are important to both the environmental community and the oil shipping industry. This understanding is necessary to ensure that cleanup activities are started immediately and are completed as quickly as possible to minimize damages.

Sediment quality in the Inner Harbor has been questioned by members of the RACT and environmental groups. See sections 3.2.3.5, 3.3.1, 3.3.2.5, 4.1.3, and 4.2 for an explanation of how these sediments will be handled.

The ship channel and open-bay placement areas could impact circulation and salinity levels within the bay. In addition, open-bay placement may present problems for the benthic community, circulation, and recreational and commercial fisheries, and may produce a need for future maintenance dredging.

During public scoping meetings and resource agency workshops, several areas of concern were raised that could possibly receive some type of action as a result of channel modifications or mitigation of the unavoidable impacts. It was suggested that water interchange between Corpus Christi Bay and the Laguna Madre could be improved, specifically in the vicinity of the John F. Kennedy (JFK) Causeway and the Gulf Intracoastal Waterway (GIWW). Impacts to wetlands, submerged aquatic vegetation (SAV), and shallow water were a concern as well. Suggested beneficial actions include construction of oyster reefs in and around the Corpus Christi area, enhancement of Redfish Bay, creation of wetlands, SAV, and unvegetated shallow water, and development of bird rookery islands in Nueces Bay.

1.5 PLANNING OBJECTIVES

The planning objectives of the Federal navigation project include improvement in the efficiency and safety of the deep-draft navigation system, and maintenance or enhancement of the quality of the area's coastal and estuarine resources. Safety improvements would address problems identified and contribute to economic efficiency. Economic efficiency would result from the passage of large ships through the CCSC that previously had to remain offshore and transfer cargo into smaller crude tankers for the remainder of the voyage. Economic benefits could also be realized from the proposed container terminal adjacent to the La Quinta Channel extension. Vessel delays and the potential for accidents would also be reduced.

Maintenance and enhancement of the area's coastal and estuarine resources would be associated with reduced potential for accidents and oil spills; beneficial uses of dredged material; minimization of effects to oyster beds, seagrasses, and other valuable habitats; and avoidance of areas with known cultural resource sites.

1.6 NON-FEDERAL SPONSOR AND COORDINATION

The Galveston District, USACE, is responsible for the general management of this FEIS. The PCCA is the non-Federal sponsor and has been an active participant during the reconnaissance phase and FS. As non-Federal sponsor for the waterway, the PCCA has the overall responsibility of acquiring PAs. Generally, the feasibility phase is cost-shared equally between the non-Federal sponsor and the Federal government through the General Treasury. Management has been coordinated between the USACE and the non-Federal sponsor.

EPA is a cooperating agency (40 CFR Part 1501.6) in the EIS process pursuant to its specific programs and responsibilities, including: 1) Section 309 of the Clean Air Act in review of the EIS in compliance with NEPA; 2) the Marine Protection, Research, and Sanctuaries Act in the designation of feasible and environmentally acceptable ocean dredged material disposal sites; and 3) Section 404 of the Clean Water Act in consideration and evaluation of impacts on wetlands and waters of the United States in coordination with the USACE and FWS.

The FS involves multidisciplinary studies to determine the specific improvements needed and the benefit-cost ratios of various alternatives. The Regulatory Agency Coordination Team (RACT), established by the PCCA and the USACE, provides guidance and wise counsel on matters relating to the evaluation of environmental impacts of this project. Members include PCCA, USACE, National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service (FWS), Texas Parks and Wildlife (TPWD), U.S. Environmental Protection Agency (USEPA), Texas Natural Resource Conservation Commission (TNRCC), Railroad Commission (RRC), Texas Water Development Board (TWDB), Texas Department of Transportation (TxDOT), and Texas General Land Office (GLO).

Several technical work groups composed of members of the RACT have been established to focus on specific environmentally related areas of the project, with some overlap between workgroups. These groups have helped define the scopes of work for certain studies as well as review study results (Table 1.6-1). Workgroups include Shoreline Erosion Workgroup (SEW), Cumulative Assessment Workgroup (CAW), Hydrodynamic and Salinity Modeling Workgroup (HSMW), Contaminants Workgroup (CW), Mitigation Workgroup (MW), and Beneficial Uses Workgroup (BUW).

The SEW was created to evaluate the relationship and relative contribution of the project on shoreline erosion in the project area and provide information to guide shore stabilization, erosion protection, project impact assessment or mitigation, and beneficial use alternatives analysis.

The CAW was created to collect information from past changes in bay water salinity patterns, bay bottom losses and disturbances, wetland losses, and water and sediment quality changes, and future projections of the cumulative impact based on reasonably foreseeable development within the project area.

The HSMW was created to identify the model scenarios, which should be addressed to evaluate environmental and biological effects potentially associated with the project.

The CW evaluated water and sediment quality associated with the proposed project, including characterization of existing conditions in the project area and the results of any physical, chemical, and biological analysis.

The MW was created to identify methods to assess direct effects of the proposed project and evaluate environmentally compatible design measures to mitigate adverse effects on fish and wildlife resources.

TABLE 1.6-1

CORPUS CHRISTI SHIP CHANNEL – CHANNEL IMPROVEMENTS PROJECT
WORKGROUP PARTICIPANTS
1998 – MAY 14, 2002

U.S. Army Corps of Engineers

Frank Garcia
Bob Bass
Bob Heinly
Terry Roberts
Carolyn Murphy
Rob Hauch
Gary Ray, WES
Doug Clark, WES
Carl Anderson
Wade Williams
Carlos Tate
Jon Plymale
John McManus
Dale Williams
Rick Medina
Rao Vemulakonda, WES
Ed Reindl
Mike Kieslich
George Alcala

U.S. Environmental Protection Agency

Mike Jansky
Monica Young
Tim Landers

U.S. Fish and Wildlife Service

Johnny French
Clare Lee
Tom Schultz
Tom Shearer
Pat Clements
Mary Orms

National Marine Fisheries Service

Bill Jackson
Rusty Swafford

Texas Department of Transportation

Raul Cantu
Amy Link
Melissa Gabriel
Paul Douglas
Scott Sullivan

Texas General Land Office

Ray Newby
Tom Calnan
Kim Halbrook
Heidi Wadzinski

Texas Natural Resource Conservation Commisson

Bruce Moulton
Mark Fisher
Rene Mariscal
Chris Caudle
Robert Burgess

Texas Parks and Wildlife Department

Smiley Nava
Jim Tolan
Mary Ellen Vega
Beau Hardegree
Kay Jenkins

Texas Railroad Commission

Mary McDaniel
Don Gault
Bill Meyer

Texas Water Development Board

Gary Powell
Junji Matsumoto
Barney Austin
Mark Wetzel

Port of Corpus Christi Authority

Greg Brubeck
David Krams
Paul Carangelo
Stacey Bryant
Sandy Escobar

Coastal Bend Bays and Estuary Program

Leo Trevino

PBS&J

Martin Arhelger
Gary Galbraith
Kari Jecker
Kathy Calnan

Pacific International Engineering

Vladimir Shepsis
Hugo Bermudez

Olivarri and Associates

Leah Olivarri
Kelly Billington

The BUW was created to identify potential beneficial uses of dredged materials and to develop a Dredged Materials Management Plan for the use of these materials. A goal of the BUW was to develop a plan that would provide a net environmental benefit (gain) for the ecosystem. One type of in-bay beneficial use site would be developed by using the dredged material to establish a "platform" of varying elevation, which would provide a mosaic of habitat conducive for colonization by seagrass and emergent vegetation. Most BU sites are multiple-use sites and are located to provide, for example, erosion protection for an area and human recreation opportunities. The offshore sites will provide topographic relief to attract marine organisms to the site. The BU sites represent the beneficial use of new work material lending itself to a purpose of a net benefit to the ecosystem. Monitoring of the sites will not occur; however, the BUW would remain organized throughout the life of the project to participate in the design of the BU sites, monitor the sites during and after construction, and provide recommendations to the project sponsors to repair or renourish the sites, as needed, during future maintenance dredging operations so that the sites function as viable habitat for the ecosystem. The maintenance material varies from silt to sand and its use will be determined by each site's purpose as determined by the BUW.

The RACT and workgroups evaluated alternatives and various studies including engineering design, ship simulations, barge shelf studies, hydrodynamic and salinity modeling, ballast water studies, and benefit and cost analysis, as well as many others.

1.7 RESOURCE MANAGEMENT ACTIONS

Resource management actions are primarily, but not limited to, beneficial uses (BUs) of dredged material, as outlined below.

The BUW and RACT developed a dredged material management/beneficial use plan (DMM/BU Plan) that utilizes dredged material in an environmentally sound and economically acceptable manner and that incorporates, to the extent possible, other public benefits into its design. The estimated amount of dredged material generated would be approximately 41 million cubic yards (mcy) of new work material, and approximately 208 mcy of maintenance material over the next 50 years, from the Entrance Channel, Lower Bay, La Quinta Channel and extension, Upper Bay, and Inner Harbor.

While developing the DMM/BU Plan, the PCCA and the BUW have solicited information from the public to identify the BUs. Categories considered included shoreline protection; erosion protection; habitat development, including creation of marshes, bird islands, underwater berms, shallow water unvegetated and vegetated areas, seagrass areas, reef structures and ecological stimulation; beach nourishment; waterfront development; construction materials; seagrass protection; recreation use; maximization of benefits from freshwater inflows; and increasing the capacity of existing PAs. Seventy-seven sites were originally derived from several public meetings and then, in December 2000, consolidated into nine categories that contained similar suggestions (PCCA, 2001a). These ideas were fully considered further by the BUW during development of the DMM/BU Plan, including the beneficial use sites described below. Within the DMM/BU Plan, eleven sites have been proposed for new habitat development and/or protection areas as described below (Figure 1-3). New work material (16.7 mcy) will be utilized to create two offshore sites, one upland site, and five open-water sites (Table 1.7-1). There are no plans to use dredged material from maintenance dredging at this time in the BU sites although, as at

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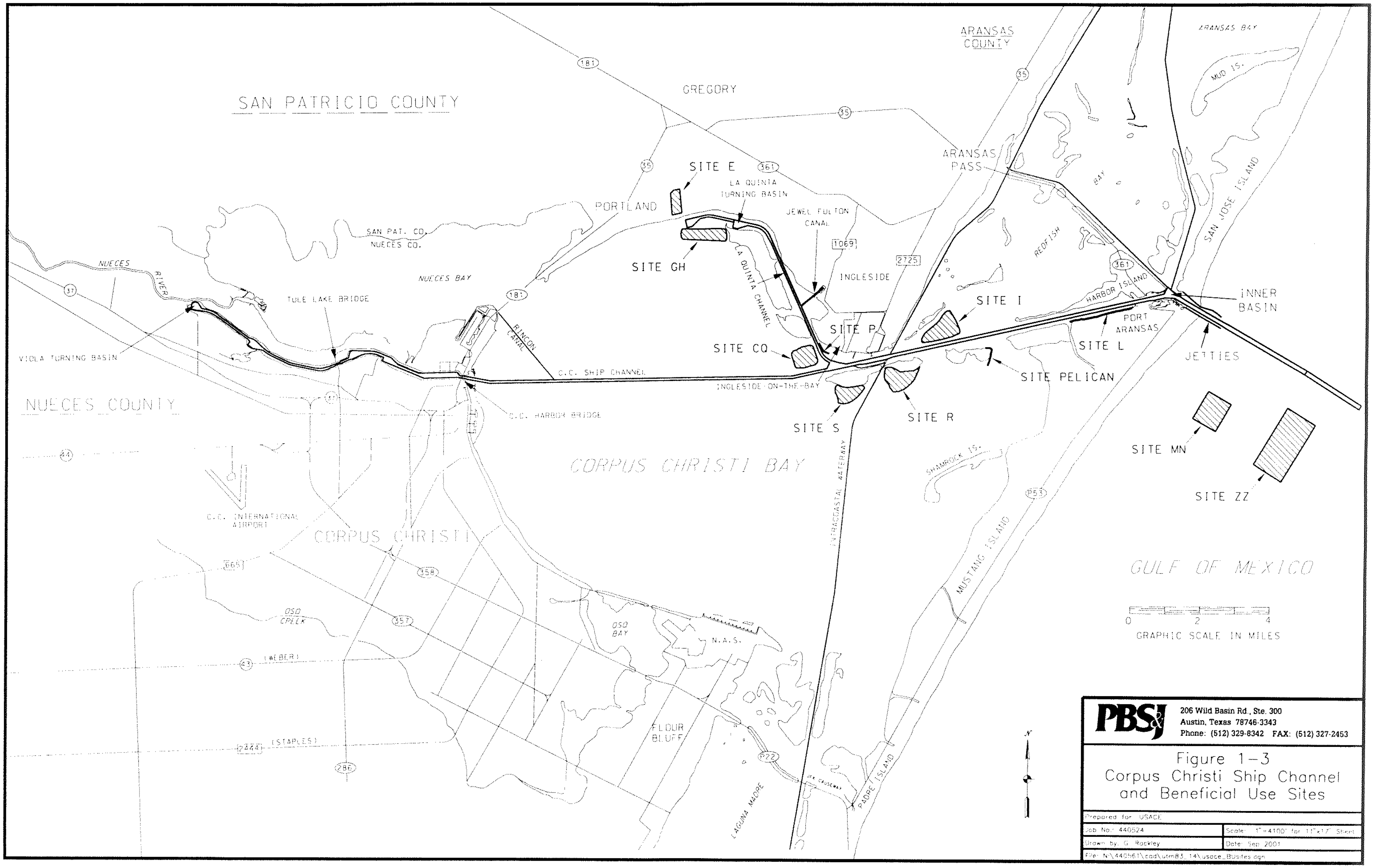

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Figure 1-3
Corpus Christi Ship Channel
and Beneficial Use Sites

Prepared for USACE

Job No.: 440524	Scale: 1"=4100' for 11"x17" Sheet
Drawn by: G. Rockley	Date: Sep 2001

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TABLE 1.7-1
BENEFICIAL USE SITES

	New Work Dredge Material Used at Site		Description of Creation or Protection	
Site	Type	Amount	Approximate Amount	Type
GH	Dense sand and hard clay	2.5 mcy	Creates 200 acres Creates 15 acres Creates 7,500 LF Creates 6 acres	Shallow water habitat SAV Rock breakwater Marsh
CQ	Dense sand	2.9 mcy	Creates 250 acres Creates 8,000 LF Creates 5 acres	Shallow water habitat Rock breakwater Marsh
P	None; imported rock	n/a	Creates 2,400 LF Protects 45 acres	Rock breakwater SAV
I	Dense to very dense sand	2.1 mcy	Creates 163 acres Creates 7,000 LF Creates 15 acres	Shallow water habitat Rock breakwater Marsh
R	Dense to very dense sand	2.4 mcy	Creates 201 acres	Shallow water habitat
S	Dense to very dense sand	1.5 mcy	Creates 121 acres	Shallow water habitat
Pelican	None; existing bird island	n/a	Protects Existing Creates 1,500 LF	Rookery habitat Rock breakwater
L	None; imported rock	n/a	Creates 7,500 LF Protects 400+ acres	Rock revetment Wetlands
E	Hard clay and dense sand	1.0 mcy	Creates 120 acres	Future buffer zone
ZZ	Soft silty and soft sandy clays	2.6 mcy	Creates 1,150 acres	Offshore topographic relief
MN	Soft clays with primarly dense sands	1.7 mcy	Creates 440 acres	Offshore topographic relief
	TOTALS	16.7 mcy of new work dredged material	Creates 935 acres Creates 15 acres Creates 26,400 LF Creates 26 acres Creates 1,590 acres Creates 120 acres Creates 7,500 LF Protects 45 acres Protects existing Protects 400+ acres	Shallow water habitat SAV Rock breakwater Marsh Offshore topographic relief Future buffer zone Rock revetment SAV Bird Island Wetlands

* Maintenance dredged material may also be used to augment BU Sites CQ, R, S, and I, if determined to be needed in the future and maintenance material available at the correct grain size.

present, some maintenance material may be used beneficially, but only after coordination with BUW members.

Proposed BU Site GH is a rectangular site located in open water adjacent to the south side of the La Quinta Channel extension and west of PA 13 at the terminus of the existing La Quinta Channel. After construction, the site will be protected from wave erosion on two sides and contain approximately 200 acres of shallow water high and low marsh aquatic and estuarine habitat. The shallow water would have an approximate mudline from –1 to –2 feet MLT developed from the existing depth of –6 to –12 feet MLT. Approximately 15 acres of submerged aquatic vegetation (SAV) will be planted within this site as mitigation for project impact. BU Site GH will be bordered on the south and west by hydraulically filled embankments protected by geotubes and riprap to elevation +6 feet MLT to protect the shoreline and enhance vegetation colonization. A single row of *Spartina* would be planted along the inside (north side) of the wave-protection levee creating approximately 6 acres of marsh. The area would be ±7,200 to 9,000 feet long running east to west and 1,500 feet wide from north to south. The northern edge of the area would be located approximately 1,500 feet from the existing shoreline. The project provides for deposition of 2.5 mcy of new work dredged material to create the shallow water habitat.

BU Site CQ is located north of the ship channel and west of the La Quinta Channel. Site CQ will be a rectangular open water site, partially enclosing approximately 250 acres of newly created shallow water and emergent island habitat with 6 to 10 mounds of material placed in a northwest to southeast direction to decrease wind fetch inside the site. The new work material would be allowed to flow freely in the deeper eastern half of the site to fill to depths shallow enough to support seagrass. There may be some deeper holes that would not support seagrass, but these areas would provide a mosaic of habitats for marine life. The mounds would be about +3 to +5 feet MLT, and the perimeter of the emergent mounds would be fringed with *Spartina* spaced at 5-foot intervals to hasten vegetation growth and erosion protection, creating 5 acres of marsh. An armored levee for wave protection and to help contain dredged material would be created around the site on the west, south, and east boundaries with geotubes or rock breakwaters to elevation +6 feet MLT, placed over hydraulically filled base. The existing bottom is –3 to –10 feet MLT and would be raised to –1 to –2 feet MLT. This site would be approximately 4,600 feet across. The project provides for the deposition of approximately 2.9 mcy of new work dredged material to create the habitat.

BU Site P is approximately 2,400 feet long and located along the east bank of the La Quinta Channel and Ingleside-On-The-Bay. This site will function as a breakwater to minimize bank erosion and provide protection to about 45 acres of existing seagrass beds. The wave barrier would consist of a rock breakwater to elevation +6 feet MLT. The existing seagrass habitat to be protected at this site is 0 to–3 feet MLT. Dredged material will not be placed at this site.

BU Site I is located adjacent to and north of the ship channel between Dagger Island and Pelican Island, and west of the GIWW. One of the goals of BU Site I formulated by the BUW is to partially protect Dagger Island from ongoing shoreline erosion. Site I is a proposed triangular-shaped open water site, partially enclosing approximately 163 acres of shallow water habitat, including a 10- to 15-acre island in the southeast corner of the site filled to an elevation of +8 to +10 feet MLT and about 20 mounds scattered across Site I filled to an elevation of about +3 feet MLT. The site will be bordered on the south and east sides by a hydraulically filled embankment protected on the exterior slopes by riprap and geotubes to +6 feet. The west and north sides will remain open to provide circulation between the site and the surrounding bay. A mixture of open water, shallow water, and suitable habitat for emergent and high marsh would be created at this site. A fringe of *Spartina* would be planted around the edge of the mounds and the larger island (a single row with 5-foot centers) creating approximately 15 acres of marsh. The existing bottom is at an elevation of –6 to –9 feet MLT. The project provides for the deposition of approximately 2.1 mcy of new work dredged material.

BU Site R is a proposed triangular-shaped open water site, partially enclosing approximately 201 acres of newly created shallow-water habitat. The shallow water would have an approximate mudline from –1 to –2 feet MLT developed from the existing depth of –6 to –10 feet MLT. It is located adjacent to and south of the ship channel, south of PA 9, and east of the GIWW. It will be bordered on the south and west sides by a hydraulically filled embankment, protected by riprap and geotubes on the exterior slopes to an elevation of +5 feet MLT. The project provides for the deposition of approximately 2.4 mcy of new work dredged material to create the shallow water habitat.

BU Site S is a proposed triangular-shaped open water site, partially enclosing approximately 121 acres of newly created shallow-water estuarine habitat. The shallow water would have an approximate mudline from –1 to –2 feet MLT developed from the existing depth of –6 to –10 feet MLT. It is located south of the ship channel, south of PA 10, and west of the GIWW. It will be bordered on the east side by a hydraulically filled embankment, protected by riprap and geotubes to an elevation of +5 feet MLT. The project provides for the deposition of approximately 1.5 mcy of new work dredged material to create the shallow water habitat.

A short stretch of channel(s) may have to be dredged in some of the shallower areas to allow a barge to bring rock and equipment into the area to armor the levee around Sites R and S. The dredged material from the channel(s) would be sidecast along the channel. No plantings are proposed for Sites R and S.

BU Site Pelican is a proposed open water site, located adjacent to and south of the channel, on the east side and south of Pelican Island (PAs 7 and 8). New work material will not be used at this site per se, but approximately 0.3 mcy of suitable quality new work material will be used to fill the geotubes. In the past, maintenance dredged materials have been placed on the south side of the island and allowed to flow out into the open water as a part of the ongoing rookery island enhancement, and this practice will continue. Rock revetment (1,500 feet) on the northeast corner of the island that was constructed previously to protect that part of the island from erosion will be replaced. The armoring has been lost over the years to erosion flanking the rock. Approximately 2,200 linear feet of hydraulically filled embankment, protected by geotube and riprap, will extend bayward from the east end of the island. The purpose of this hydraulically filled embankment is to contain the dredged maintenance material flowing off the south side of the island to maintain an open-water channel between Pelican and Mustang Islands, thereby preventing land bridge access to Pelican Island from Mustang Island by predators. This embankment will also protect the island from shoreline erosion.

BU Site L is located on the south bank of the channel between Piper Channel and the public Fishing Pier just west of Port Aransas. The rock revetment at this site is intended for a marsh/ecosystem protection site and will not use dredged material. The rock revetment will follow the shoreline with 3,400-foot, 500-foot, and 3,600-foot sections from west to east, respectively. A gap will be left between each section to allow for storm tide exchange. The existing ground elevation is +5 feet.

BU Site E is located on PCCA-owned land just north of the turning basin for the La Quinta Channel Extension. New work material at Site E would create a 120-acre upland buffer between lands to the west and the La Quinta Gateway Project. The existing site comprises uplands which include brushland. Approximately 1.0 mcy of new work dredged materials will be placed in this area to serve as a future source of landscaping for a tree-lined greenbelt separating public use lands to the west and industrial sites to the east. Best management practices on site will keep air concerns to a minimum.

Offshore placement of the new work material from the entrance channel extension is being coordinated with EPA for BU Site ZZ, the old U.S. Navy Homeport Ocean Dredged Material Dumping Site (ODMDS), under Section 404 guidelines. In this plan, approximately 2.6 mcy of new work material dredged from the entrance channel extension will be placed in the approximately 1,150-acre site, located approximately 15,300 feet southeast of the Aransas Pass South Jetty. The BUW and the RACT concurred that this Beneficial Use is preferable to general ocean placement. BU Site ZZ will provide topographic relief to the deeper offshore bay bottom, thereby enhancing the marine ecosystem in the area.

BU Site MN is approximately 440 acres and is located just outside the 30-foot contour outside the surf zone 10,000 feet south of the project channel centerline. Approximately 1.7 mcy of new work dredged material will be placed into this area, providing topographic relief to the nearshore Gulf bottom, thereby enhancing the marine ecosystem in the area.

2.0 ALTERNATIVES

2.1 HISTORY AND PROCESS FOR FORMULATING ALTERNATIVES

For the preparation of the CCSCCIP, alternatives were analyzed during the Initial Plan Formulation Phase to identify the alternative that maximized National Economic Development (NED) benefits. Twenty-three alternatives, including combinations, were analyzed during this initial stage. The Feasibility Report, to which this FEIS is attached, provides details of the Alternatives Analysis. Only a brief summary is included below.

The Planning, Environmental, and Regulatory Division of the Galveston District (PER) provided channel depths for analysis. Channel widths were determined by design economic vessels and ship simulations based on information from Aransas-Corpus Christi Pilots and the U.S. Army Engineer Research and Development Center (ERDC). Non-Federal sponsor requests were also evaluated.

An economic evaluation of project modifications to the Corpus Christi and La Quinta channels was conducted by calculating project benefits based on reductions in transportation costs. Benefits were evaluated for the following alternatives: Corpus Christi depths of 48, 50, and 52 feet; deepening the existing Federal portion of the La Quinta Channel; extension of the La Quinta Channel Federal project; and widening the Corpus Christi Bay Channel 400- and 500-foot reaches to 530 feet. In addition to widening of the bay channel, benefits were evaluated for barge shelves in the 400-foot reach. The shelves would extend 200 feet from the toe of the proposed 530-foot-wide channel on either side.

2.2 ALTERNATIVES SCREENING

An initial screening analysis of the plan alternatives was completed in early 2000. The results of the initial screening were presented at the 4 April 2000 Feasibility Scoping Meeting (FSM). The initial screening showed that a Corpus Christi channel depth of 52 feet produced the highest net excess benefits for the deepening plans evaluated for the main channel. The screening analysis suggested that additional studies were necessary to determine whether widening of the bay reach and extension of the La Quinta channel was within Federal interest. An additional recommendation of the FSM was to further investigate deepening of the La Quinta Channel beyond the existing project depth of 45 feet. In regard to channel widening, the non-Federal sponsor and pilots association expressed a strong interest in widening the bay reach due to safety concerns and associated vessel delays and self-imposed vessel meeting restrictions. The recommendation for widening the entire bay reach to 530 feet was based on the USACE Waterways Experiment Station (WES) findings and the safety interest of Aransas-Corpus Christi Pilots. The pilots presently limit vessel meetings to combined beam width up to 251 feet in the 400-foot reach and a combined loaded draft limit of 80 feet.

The USACE conducted the FSM to discuss the twenty-three alternatives with preliminary benefit-cost (BC) ratios providing justification for reducing the alternatives to six. Mitigation was not required to be considered during this initial screening process. Cost factors such as levee construction, dredging, and pipeline relocations were included in the cost analysis. The essence of the initial screening process was to put all the alternatives on an equal basis without the mitigation costs. Costs were developed for all 23 alternatives, but benefits were determined to be needed only on certain alternatives (48-, 50-, and 52-foot depths in the main channel and 400- and 500-foot widths).

The outcome of this initial screening resulted in six alternatives to be analyzed further. The following briefly describes each alternative:

- Deepen to 52 feet from the Gulf of Mexico to Viola Turning Basin and widen across Corpus Christi Bay (maximum net excess benefits)
- Deepen to 50 feet from the Gulf of Mexico to Viola Turning Basin and widen across Corpus Christi Bay
- Widen only across Corpus Christi Bay (Sponsor Request)
- Deepen La Quinta Channel to 50 feet (Sponsor Request)
- Extend La Quinta Channel
- Provide Barge Lanes across the Upper Bay in Corpus Christi Bay

The initial screening indicated that added depth was not needed on La Quinta Channel and channel extension. Reynolds Metals and Oxychem stated that they did not need additional depth in La Quinta Channel. Despite the 0.6 Benefit Cost Ratio, the widening-only alternative was also evaluated further for additional benefits that could change the ratio.

While not part of the initial screening, alternatives also arose for offshore placement of dredged material, including ocean placement pursuant to Marine Protection Research and Sanctuaries Act and beneficial use pursuant to Section 404 of the Clean Water Act. To ensure maximum use of the dredged materials in a beneficial way, the BUW determined that disposal of materials beneficially was the preferred disposal option (BU Site ZZ; see Section 1.6).

2.2.1 Channel Deepening Benefit Summary

Channel deepening benefits were calculated for Corpus Christi crude petroleum, petroleum products, and grain cargoes. The transportation savings benefits were calculated using a Federal discount rate of 6⅞ percent and using fiscal year 2000 hourly operating costs. Transportation costs were calculated for 45- to 52-foot channel depth alternatives (see economic appendix for details).

Projected deepening will result in a decrease in the cost per ton for both the shuttles associated with offshore lightering and for vessels associated with direct shipments. Nearly all crude oil shipped from the Mideast is lightered and will continue to be lightered in the future, and nearly all oil shipped from Mexico and Venezuela is currently shipped direct and will continue to be in the future. Lightering and lightening costs are presently costs slightly less than direct shipment cost for movements from Africa and the North Sea. The deepening project will reduce the differential between direct shipping cost and lightering cost and the reduction in this differential will make direct shipment more likely for movements from Africa and the North Sea. The cost differential reduction is expected to result in a slight increase in direct shipment for Africa and North Sea crude oil imports.

Although lightering would not be eliminated, there would be an overall decrease in the number of vessels needed to transport a given volume of petroleum products. The percentage of tonnage by trade route and method of shipment is displayed in the economic appendix.

The purpose of the spill analysis was to identify accident and spill frequencies for the Corpus Christi Ship Channel project area. The affected area primarily includes the offshore entrance, the bay channel, La Quinta, and the Inner Harbor. Lightering occurs in international waters. A literature search was conducted of national spills. Over one-half of the mother vessels associated with Corpus Christi's offshore transfers operate in the international waters offshore from Galveston. The remainder of crude is transferred in the international waters off of Corpus Christi.

2.2.2 Channel Widening Benefits

Benefits were calculated for widening the Corpus Christi Bay Channel 400- and 500-foot reaches to 530 feet. In addition to widening the bay channel, benefits were evaluated for a barge shelf in the 400-foot reach. The barge shelf would extend 200 feet from the toe of the proposed 530-foot channel.

The benefits associated with widening the bay reach to 530 feet were calculated based on the probability of vessel meetings and potential delays. The Aransas-Corpus Christi Pilots vessel meeting criterion is that vessels with combined beam widths of 251 feet or more cannot meet in the 400-foot reach. An additional criterion is that meetings are not permitted between vessels with combined loaded drafts in excess of 80 feet. The pilots noted that the 80-foot combined draft limit was invoked in the early 1990s.

Benefits for widening the bay reach were calculated based on reductions in delays due to the combined beam width restriction. Benefits were not calculated for easement of the underkeel clearance policy, as the pilots indicated there would be no change in the policy to maintain 3 feet of underkeel clearance.

National data reviewed for the Corpus Christi study showed that for the period 1973–93, there were 38,778 spills in the waters monitored by the USCG and falling in the category of "outer continental shelf and inland regimes." Twenty percent of these spills involved tank ships. The associated volume spilled was 66 million gallons. Two percent of the 66 million gallons was associated with lightering operations. Corpus Christi project data obtained from the USCG for the period 1992-99 was evaluated for the Corpus Christi study. Analysis of the USCG data records showed that pollution incidents, collisions, and allisions most frequently occur in the project area between the Inner Harbor and Viola Turning Basin, where channel widening and barge lanes will reduce the probability of collisions (see economic appendix for details).

2.2.3 Deepening of the Existing La Quinta Federal Project

Examination of the vessel sizes and trade routes associated with tonnage transported through the existing 45-foot channel showed that only a small number of vessels were loaded to drafts in excess of 40 feet. Additional analyses indicated that port depths at shipping and receiving ports were and would continue to remain a constraint. Comparison of the project construction costs for deepening the existing channel to depths over 45 feet with potential reductions in transportation costs associated with more deeply loaded vessels did not produce a BC ratio above unity, which is typically required for a Federal deep-draft navigation project (refer to Feasibility Report – Economic Criteria).

2.2.4 Extension of the Existing La Quinta Federal Project

Determination of the Federal interest in the extension of the existing limits of the La Quinta Channel was evaluated based on the results of a multiport analysis. The purpose of the analysis was to determine whether the La Quinta Channel extension to a proposed container terminal offered a competitive advantage over existing and anticipated container facilities such as the Port of Houston's Barbours Cut and Bayport projects and the Texas City Shoal Point project. It was determined that it would, that the BC ratio was greater than one, and that it would be in the Federal interest.

2.3 RECOMMENDED ALTERNATIVE

The study area has been divided into five reaches for discussion in this document: the Entrance Channel, Lower Bay, La Quinta Channel, Upper Bay, and Inner Harbor (Figure 2-1). Information for the Gulf Intracoastal Waterway (GIWW) across Corpus Christi Bay is also discussed but is not considered a reach since there are no improvements to it associated with this project. The Entrance Channel includes that area from the Gulf of Mexico through the Aransas Pass jetties to the Inner Basin (Station -38+00 to 310+00). The Lower Bay includes the area from the Inner Basin to La Quinta Junction (Station 12+55 to 54+00). La Quinta is the channel from the La Quinta Junction north (Station 309+51 to 382+00). The Upper Bay includes the area between the La Quinta Junction and Beacon 82 (Station 54+00 to 1050+00). Between Beacon 82 and Viola Turning Basin lies the Inner Harbor reach (Station 1050+00 to 1561+00).

2.3.1 No-Action

In the absence of Federal actions to improve the CCSC, the existing Federal project will continue to be maintained at its current dimensions and the dredged materials will be disposed of in a manner very similar to existing practices. It is also expected that industrial expansion in the area will continue and that shipping will likewise increase. The No-Action Alternative is discussed more fully under the various affected resource categories in Section 4, Environmental Consequences.

2.3.2 Preferred Alternative

The following plan is based on the economic, engineering, and environmental factors and is the USACE-recommended and PCCA-preferred alternative for the CCSCCIP. The preferred alternative includes deepening of the CCSC from Viola Basin to the end of the jetties in the Gulf of Mexico to 52 feet, deepening of the remainder of the channel to 54 feet, widening of the Upper Bay and Lower Bay reaches to 530 feet, construction of barge lanes across the Upper Bay portion of the CCSC, and extension of the La Quinta Channel at 39 feet.

The land locked portion of the Entrance Channel will be deepened to 52 feet plus 2 feet of advanced maintenance. The area of the Entrance Channel in the open waters of the Gulf will be dredged to a 54-foot authorized depth with an additional 2 feet of advanced maintenance to insure safe vessel

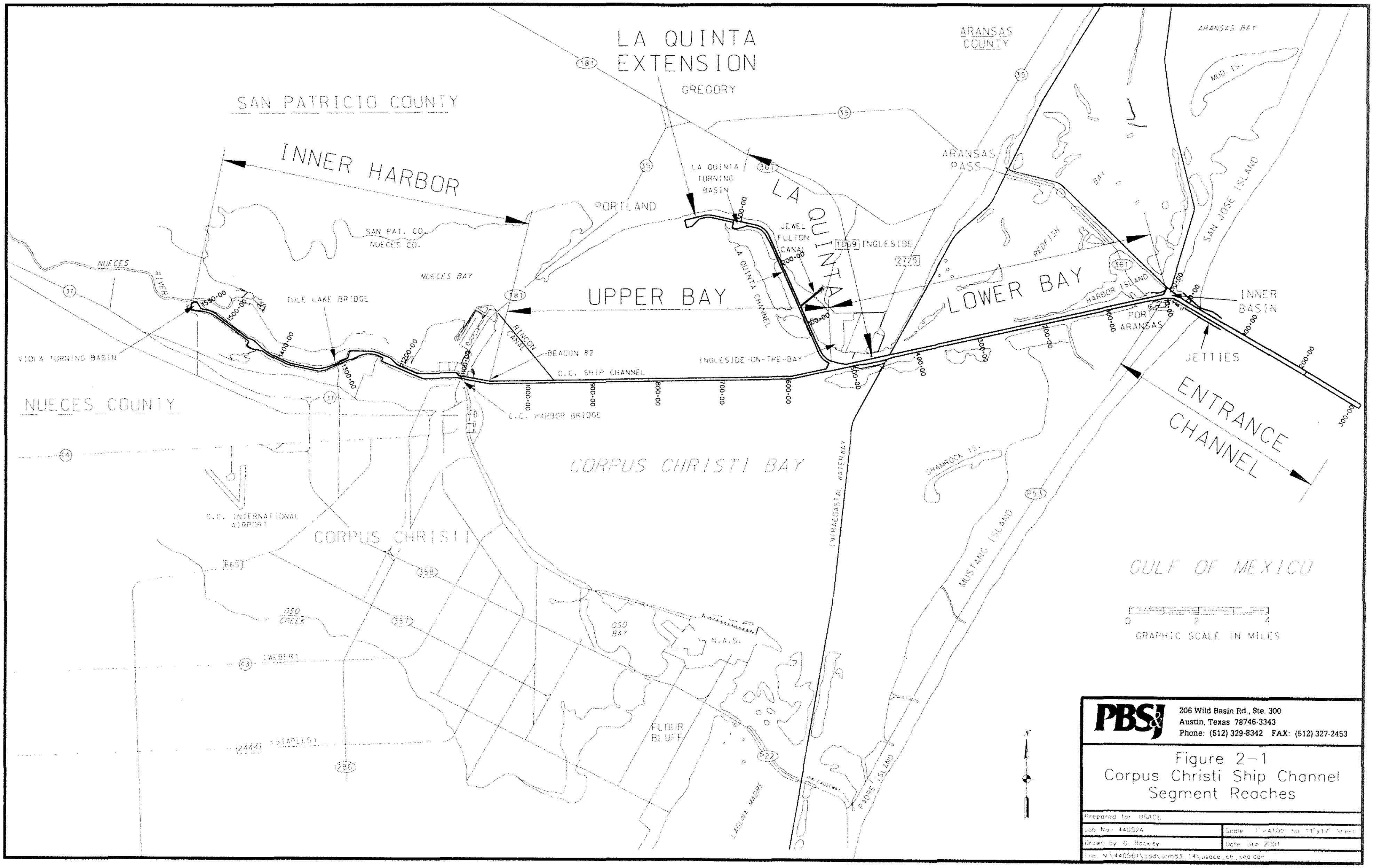

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Figure 2-1
Corpus Christi Ship Channel
Segment Reaches

Prepared for USACE

Job No : 440524	Scale 1"=4100' for 11"x17" Sheet
Drawn by G. Rockey	Date Sep 2001

File: N:\440561\cad\utm83_14\usace_ch_seg.dgn

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passage in a high wave energy environment. The existing channel will be extended an additional 10,000 feet into the Gulf in order to reach a 54-foot natural depth. Minor widening is necessary in a 100-foot-wide area on the northern side of the channel from in the Inner Basin to allow for a better turning radius when entering the Gulf or the Lower Bay portion of the channel.

The Lower Bay will be deepened from 45 feet to 52 feet plus 2 feet of advanced maintenance. The eastern portion of this channel segment is currently wider than the selected 530 feet and no widening will be necessary in this reach. The western half is approximately 500 feet in width and will be widened to 530 feet.

The Upper Bay is currently 400 feet wide and 45 feet in depth. This reach will be deepened to 52 feet with 2 feet advanced maintenance and widened to 530 feet. Barge lanes will be constructed on both sides of the channel and will extend 200 feet from the toe of slope of the main channel and will be dredged to a depth of 12 feet with 2 feet of advanced maintenance.

The Inner Harbor will be deepened to 52 feet plus 2 feet of advanced maintenance. The channel width will range between 300 and 400 feet. Several minor modifications will be made to the turning basins to ensure that they meet USACE navigation requirements. One basin, the Avery Point Basin, will not meet USACE width criteria due to the presence of industry on the shoreline of the channel. In the vicinity of the Tule Lake Lift Bridge, because the bridge may be removed and/or replaced, the channel width in this area will be authorized at 400 feet. This width is consistent with the remainder of the Inner Harbor channel segment. Making the channel width consistent in this area, should the bridge be removed, will allow safer passage through the channel for all ship traffic. Should the bridge remain at the time of project construction, construction will be limited to 200 feet to ensure no impacts to the bridge supports. This 200-foot width is sufficient to allow all expected traffic access beyond the bridge and will not prevent the realization of project benefits.

The La Quinta Channel at the current depth of 39 feet will be extended approximately 7,400 feet beyond its current limit. The channel will measure 300 feet wide at the toe and a second turning basin with a 1,200-foot radius will be constructed. No changes will be made to the existing channel.

New work material will be dredged to deepen the channel from the –56-foot isobath in the Gulf to the Inner Harbor. A complete description of the texture and quality of the new work material and the existing maintenance material can be found in Sections 3.3.1 and 3.3.2 of the FEIS, respectively. Table 2.3-1 provides the quantities, by reach, of the new work and maintenance material expected from the preferred alternative. All dredged material will come from widening, deepening, and subsequent maintenance of the CCSC and the La Quinta Channel.

The project has identified eight existing confined upland sites, one existing offshore (open-water) site, and eight existing bay (open-water) sites for meeting the capacity requirements for the placement of both new work and maintenance dredging materials, as described below. However, the project may utilize all existing upland sites as needed during the life of the project to maintain operational flexibility.

TABLE 2.3-1

QUANTITIES OF NEW WORK AND MAINTENANCE DREDGED MATERIAL (mcy)

Reach	New Work Material	Maintenance Material (50 years)
Entrance Channel	4.337	62.0
Lower Bay	8.754	11.7
Upper Bay	14.419	82.2
Inner Harbor	6.916	24.1
La Quinta Channel	6.257	28.0
Barge Lanes	0.271	NA

The existing offshore PA 1, 510 acres in size, is located approximately 2 miles offshore and 1,000 feet south of the channel centerline. This site was designated by the EPA as the Corpus Christi Ship Channel ODMDS pursuant to Section 102(c) of MPRSA in 1989, but USACE terminology is PA 1. The reader should note that these two are the equivalent names for the same site. It is proposed that this site be used to place approximately 62.0 mcy of maintenance dredging materials (over a 50-year period) from the Entrance Channel portion of the project. Modeling was conducted which determined that PA 1 would be able to accommodate the additional volume of maintenance material, included with the proposed project, without exceeding the mounding requirements of the ODMDS Site Management Plan (Appendix A). Designation of the ODMDS by the EPA does not constitute approval by the EPA for placement of materials at the site. Prior to each placement event, the concurrence by the EPA must be given after determination that the materials meet all environmental criteria and regulatory requirements pursuant to MPRSA (40 CFR 220-228). The EPA and USACE, Galveston District, have established a Regional Implementation Agreement (RIA) for testing and reporting requirements for ocean disposal of dredged materials that outlines dredged material characterization and evaluation requirements.

PA 2 is partially confined on the beach and dune area just north of the San Jose Island jetty, which protects the CCSC Entrance Channel near Port Aransas. Effluent flows from the site, over the beach, and into the Gulf of Mexico.

Suntide PA (IH-PA 8) is a 306-acre UCPA located just west of the terminus of the Inner Harbor reach of the project channel in Corpus Christi. It will be used to contain approximately 1.2 mcy of new work dredged materials, and 1.0 mcy of future maintenance dredged materials for the project.

The Inner Harbor PA 1 (IH-PA 1) is a 350-acre upland confined placement area (UCPA) located just north of the inner harbor area in Corpus Christi. IH-PA 1 is subdivided into two cells (A and B), and will be used to contain approximately 800,000 CY of material from new work dredging and 10.6 mcy from maintenance dredging over a period of 50 years.

The Rincon PA (IH-PA 2) is a 230-acre UCPA located adjacent to and just north of PA 1. It will be used to contain approximately 900,000 CY of new work material and 5.2 mcy of future maintenance material.

South Shore (IH-PA 3) is a UCPA located on the south shore of Nueces Bay at Corpus Christi, just west of IH-PA 1 and north of the CCSC. It is divided into 3 cells, A, B, and C. Cell A is 200 acres in size and Cell B is 183 acres. Cell C is not proposed for use to meet capacity requirements under this project, but will continue to be available should it be needed. Cell A of IH-PA 3 will be used to contain approximately 1.0 mcy of new work material and is not planned for any future maintenance material. Cell B will be used to contain approximately 1.0 mcy of new work material and 1.0 mcy of future maintenance material.

IH-PA 6 is a 360-acre upland confined placement area which is south of the ship channel, as shown on Plate F-42 in the Feasibility Report. IH-PA 6 will be used to contain approximately 1.6 mcy of new work material and 1.1 mcy of future maintenance dredged material. Although this placement area is an existing placement area that has been used for material disposal in the past, it is not specifically provided or used under the present authorized 45-foot project. Consequently, IH-PA 6 will have to be acquired for the improved channel to satisfy storage capacity needs.

PA 6 is a 304-acre UCPA, located on the northern point of Mustang Island, south of and adjacent to the CCSC between Port Aransas and the La Quinta junction. It has been used once in the past as a placement area, but currently is in a state of disrepair. Its utilization will require major renovation of the perimeter levees and drop structure. PA 6 will be used to contain approximately 2.7 mcy of new work material from the channel. The project does not include the use of PA 6 for future maintenance dredging of the channel.

PAs 7 and 8 (Pelican Island) form a 360-acre UCPA located to the west of PA 6, south of the CCSC. PAs 7 and 8 will not be used for new work material but will continue to be used periodically to receive 11.7 mcy of future maintenance material over the 50-year life of the project.

PA 10 is a 196-acre UCPA located on the south side of the CCSC across from Port Ingleside. It will not be used for the placement of any new work dredged materials, but will be used to contain approximately 2.8 mcy of future maintenance dredged material over the 50-year life of the project.

PA 13 is a 750-acre UCPA located in the northeast corner of Corpus Christi Bay on the west side of the La Quinta Channel, near Port Ingleside. PA 13 will be used to contain approximately 3.7 mcy of new work dredged materials, and 25.2 mcy of future maintenance dredged materials over the 50-year life of the project.

PAs 14-A, 14-B, 15-A, 15-B, 16-A, 16-B, 17-A, 17-B, open water placement areas, are considered to have unlimited capacity for placement of dredged materials. They are located on either side of the ship channel across Corpus Christi Bay, These areas will be used for containment of approximately 11.8 mcy of new work dredged materials, and 87.4 mcy of future maintenance dredged materials over the 50-year life of the project.

New work material from the outer half of the Entrance Channel will be used beneficially in BU Site ZZ (Appendix A) and maintenance material will be placed in PA 1. New work material from the inner half of the Entrance Channel will be placed in BU Site MN; from the Lower Bay in BU sites I, R, and S and PA 6; from the La Quinta Channel extension in Sites E and GH and a portion stockpiled in PA 13 for future levee renovation at PA 13; from the Upper Bay in BU Sites R, S, CQ, and PAs 14a – 17b; and from the Inner Harbor in a series of UCPAs. Maintenance material from the jetty channel will be placed in offshore PA 1 and/or in PA 2 for beneficial use (only from a section of the Lower Bay), if it is of the correct grain size; from the Lower Bay at Pelican Island for rookery enhancement, BU Sites S and R, and PA 10; from the La Quinta Channel in PA 13; from the Upper Bay in PAs 10 and 14a-17b; and from the Inner Harbor in a series of UCPAs.

The following PAs are designated for placement of dredged maintenance material from the CCSC authorized 45-foot deepening project. While not scheduled for use at this time, these areas are available for the 52-foot project future, if needed.

Inner Harbor PAs 4 and 5 (IH-PA 4 and IH-PA 5) are privately owned, but are potentially available for use through an agreement with the land owner or by navigation servitude. IH-PA 4 and IH-PA 5 were last used 23 years ago during the CCSC 45-foot deepening project.

PA 4 is a confined site located north of the CCSC on Harbor Island. It has not been used since the 45-foot deepening project for the placement of new work dredged material. It is owned by the PCCA and may be available for use by the proposed project.

PA 5 is an upland unconfined site located on the south side of the CCSC west of Port Aransas. It has not been used since before the CCSC was deepened to 45 feet and may be available for use by the proposed project through navigation servitude.

PA 9 is an unconfined emergent placement area located south of the CCSC and east of the GIWW crossing. It has not been used in the past 23 years. It was last used for placement of new work material during the 45-foot deepening project.

PA 18 is an unconfined open-water placement area that is configured as two narrow, parallel placement corridors oriented perpendicular to the CCSC. PA 18 is available for use, but has not been used recently because of concerns that it could accelerate filling of the small-boat channels near the Corpus Christi City Marina.

Creation of all BU sites will cover roughly 935 acres of unvegetated deep bay bottom and 120 acres of upland. The area of the offshore BU Site MN and the topographic relief feature further offshore at BU Site ZZ depends on the exact placement methods and equipment and height of the berms, but will cover approximately 1,590 acres of Gulf of Mexico bottom. Offshore PA 1 is the only site currently in use offshore. It should be noted that the site where BU Site ZZ is located was not originally designated as a BU site, but as the ODMDS for virgin and maintenance material from the U.S. Navy Homeport project (see Section 5.3.3). The physical location of BU Site ZZ and the ODMDS for the Homeport project coincide. Physical examination of the materials proposed for placement in BU Site ZZ indicated that additional testing would be required to determine suitability for placement at the site pursuant to MPRSA (i.e., ocean dumping). However, the BUW determined that beneficial use of these materials is the preferred option and disposal of these materials at the site beneficially is evaluated under Section 404 of the Clean Water Act (Appendix A) and under the Fishery Conservation and Management Act.

All BU sites, except BU sites E, MN, and ZZ, will be located in deep, unvegetated bay bottom. BU Site E will be located upland. BU Site MN will be located in 20 to 40 feet of Gulf water, whereas BU Site ZZ will be located in approximately 50 feet of Gulf water. The maintenance PAs are currently being used to receive maintenance material dredged from the CCSC and La Quinta Channel. The BU sites will be constructed during widening and deepening of the CCSC, creation of the barge lanes, and extension of the La Quinta Channel. Maintenance will be ongoing. Only hydraulic pipeline dredges will be used inshore of the jetties. The entrance channel will be dredged with an oceangoing hopper dredge. The completed elevation of most BU sites will be approximately –1 to –2 feet MLT, to promote the growth of seagrasses. Most BU sites include breakwaters to an elevation of +6 feet MLT and most have fringes around the inside of the breakwaters with a design elevation of around +2 feet MLT for *Spartina* growth. Sites I and CQ include interior islands to an elevation between approximately +3 to +10 feet MLT. Site MN and the offshore topographic relief feature at site ZZ will likely have elevations around 6 feet above the Gulf bottom.

The new work material will range from mostly hard clay in the Inner Harbor and La Quinta Extension to mostly soft clay in the Upper Bay and mostly medium-to-dense sand in the Lower Bay to very dense sand in the jetty channel portion of the entrance channel and soft-to-firm clay in the outer portions of the entrance channel. The maintenance material is silt or sandy silt in the Inner Harbor, Upper Bay, and La Quinta Channel; fine or silty sand and silt in the entrance channel; and a mixture of silt or sandy silt, fine or silty sand, and sand in the Lower Bay.

This project was coordinated with State and Federal resource agencies. Their recommendations have been considered and are expected to be implemented. Any unavoidable resource losses have been identified by the RACT/MW and will be mitigated. The BU sites, including the offshore sites, are designed to lead to an overall increase in the productivity and diversity of habitat in the project area.

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3.0 AFFECTED ENVIRONMENT

3.1 ENVIRONMENTAL SETTING

The study area for the CCSCCIP encompasses Corpus Christi Bay, including the southern section of Redfish Bay and the northern section of the Laguna Madre, Nueces Bay, the lower Nueces River (12.379 miles), Inner Harbor, La Quinta Channel and the watershed surrounding these water bodies up to roughly 0.5 mile inland from all shorelines. The coastline of this area extends across Nueces and San Patricio counties and is adjacent to the cities of Corpus Christi, Portland, Ingleside-On-The-Bay, and Port Aransas.

3.1.1 Physiography

The study area is characterized by interconnected natural waterways, restricted bays, lagoons, estuaries, narrow barrier islands, and dredged intracoastal canals and channels. The surface topography of the study area is mainly flat to gently rolling and slopes to the southeast. The Nueces River drains areas to the west of the study area and discharges into Nueces Bay. A few short, low-gradient streams drain directly into Nueces and Corpus Christi bays. Vegetation is sparse at most places, but there are oak clusters and other vegetation in more sandy areas and in the uplands along streams. Broad areas of coastal prairies, chaparral pastureland and farmland occur inland from the bays. On the Gulf side of Mustang Island, and for a short distance inland, sand dunes break the flatness of the terrain.

The Nueces and Corpus Christi bay systems are relatively low-energy environments protected on the seaward side by barrier islands. Water depths in Corpus Christi Bay range from a maximum of approximately 13 feet in the central part of the bay to less than 6 feet along the bay margins (Brown, et al., 1976). Tidal channels, passes, and dredged channels are greater than average depth. Water exchange between the bay and the Gulf is normally limited to natural and artificial tidal passes through the barrier island. Fresh water is supplied to the bays by the Nueces River and by small streams that drain local areas adjacent to coastal uplands. The bay systems were formed when rising sea levels inundated and flooded the older Nueces River Valley. The arcuate shoreline of Nueces Bay is a relict of meanders of the old river valley.

The primary physiographic environments of the study area include fluvial-deltaic systems, bay-estuary-lagoon systems, barrier island-strandplain systems, locally distributed marsh-swamp systems, and eolian (wind) systems (Brown et al., 1976). The Coastal Zone within the study area is underlain by sedimentary deposits that originated in ancient, but similar, physiographic environments. These ancient sediments were deposited by the same natural processes that are currently active in shaping the present coastline such as long shore drift, beach wash, wind deflation and deposition, tidal currents, wind-generated waves and currents, delta outbuilding, and river point-bar and flood deposition (Brown et al., 1976).

3.1.2 Geology

Pleistocene age fluvial and deltaic sediments of the Beaumont Formation surround much of Nueces and Corpus Christi bays. These sediments were deposited in both marine and nonmarine environments. Recent alluvium present in the western portion of the study area is associated with the Nueces River and deposits in the eastern portion are related to Mustang Island.

The geologic units consist primarily of mixtures of sand, silt, clay, mud and shell deposited within the last one million years. Exposed sediments are composed primarily of interdistributary mud and lesser amounts of distributary and fluvial sands and silts. The majority of the outcropping Beaumont Formation within the study area consists predominantly of stream channel, point bar, natural levee, and back swamp deposits and, to a lesser extent, coastal marsh, mud flat, lagoonal and sand dune deposits. The Beaumont consists of mainly beach and relict barrier island deposits along a north-south trending belt parallel to the Laguna Madre-Redfish Bay system. These deposits are mostly fine-grained sand and shell, and are probably part of the laterally extensive Pleistocene age Ingleside barrier island system.

Sediment distributions within the bay system consist chiefly of terrigenous clastics. Clean quartz sands can be found in some PAs along parts of the mainland shoreline and in the wind-tidal flats areas. Muddy sands occur adjacent to dredged material placement mounds, in the shallow bay margin areas next to the mainland shore and at the edge of the wind-tidal flats. Muddy sand distribution is not depth controlled, rather it is related to hurricane washovers, dredging activities, and reworking of relict sediment (McGowen and Morton, 1979).

3.1.3 Climate

The coastal climate within the study area may be described as subhumid to semiarid. Major climatic influences are temperature, precipitation, evaporation, wind, and tropical storms/hurricanes. This area is subject to extreme variability in precipitation with rainfalls averaging about 29 inches in the Corpus Christi vicinity, with the greatest concentration falling in the spring and fall months. However, there is an average annual deficit of 12 to 16 inches when evapotranspiration is taken into account. The peak rainfall in late summer and fall coincides with the tropical storm/hurricane season. Rainfall totals decrease toward the southern coastline and inland to the west. The temperatures in the area are fairly high with an average in the lower 70s, punctuated with occasional killing freezes.

The persistent wind is from the southeast from March to September and the northeast from October to February. The hurricane season spans June through November with the greatest number occurring in the area in August and September. Wind velocities may be at least 74 miles per hour (mph), with wind gusts exceeding sustained wind speeds by up to 50 percent (Dunn and Miller, 1964). The winds are important agents in eroding and reworking sediments and sands as well as affecting water levels and circulation patterns depending on the velocity and duration of the wind. The direction and intensity of persistent winds control the orientation and size of wave sequences approaching the shoreline, ultimately eroding or depositing sediment along the shoreline (Brown et al., 1976).

3.2 WATER QUALITY

3.2.1 Water Exchange and Inflows

There are two principal types of water exchanges in the Corpus Christi Bay system: one is bidirectional, involving the tidal exchange of the bay system with the Gulf of Mexico and between components of the bay system, and the other is unidirectional, involving freshwater flow into the system and through-flow to the Gulf.

Tidal influence in the Gulf of Mexico is dominated by the 12.4-hour semidiurnal and the 24.8-hour diurnal lunar tides and the 13.6-day cycle in the magnitude of the declination of the moon (Ward 1997). Because of the constriction provided by the Corpus Christi Jetty Channel, the diurnal tide is severely dampened and the semidiurnal tide is dampened even further. Ward (1997) notes that because of its longer period, the "quasi-periodic" semi-annual rise and fall of Gulf waters pass into the bays with almost no attenuation, leading to high water levels in the spring and fall and low water levels in the winter and summer.

Frontal passages can also cause changes in water levels and exchanges between the bays and the Gulf. As the front approaches from the north, onshore airflow increases, forcing water from the Gulf into the bays. With frontal passage, the wind direction shifts, forcing water from one bay to another for short-lived, low energy fronts and from the bays into the Gulf for longer-duration fronts.

Freshwater flow into the bay system is dominated over the long term by the Nueces River and, to a lesser extent, by other freshwater inputs into the system from runoff. The long-term average freshwater replacement time for the Corpus Christi Bay system (bay volume divided by average inflow rate) is around 50 months (Ward 1997). Ward (1997) notes that while on the long term, diversions of freshwater from entering the bay system for human uses have been "non-negligible but minor when compared to natural watershed inflows and evaporative losses."

3.2.2 Salinity

The mean salinity in the upper 1 meter of the various segments of Corpus Christi Bay, for the period of record (1958 – 1993) examined by Ward and Armstrong (1997) ranges from 26.1 parts per thousand (ppt), near the mouth of Nueces Bay, to 31 ppt in the center of the Bay. This compares to an average mean salinity, based on latitudinal sections of Corpus Christi Bay, from 27°44′N to 27°50′N, which ranges from 28.96 to 29.24 ppt (USACE, 1999a). Ward and Armstrong (1997) note that there is little vertical gradient to the salinity profile and no apparent correlation between salinity and the presence of the ship channels; i.e., no salt wedge, as is apparent in, for example, Galveston Bay. Therefore, changes in channel depth will not cause salinity impacts like those that would be expected in a bay system with a strong salt wedge. The gradient that is evident from the data of Ward and Armstrong (1997) and USACE (1999a) is an increase in salinity from north to south from reduced freshwater inflow and increased evaporation to the south. However, both Corpus Christi Bay and Nueces Bay show almost no gradient from west to east, as one moves farther from the source of freshwater inflow.

Ward and Armstrong (1997) do note that there is a long-term increase in salinity in Corpus Christi Bay of about 0.1 ppt per year. They favor the hypothesis that long-term decreases and changes in the timing of fresh water inflow are the cause for this increase in salinity.

3.2.3 Water and Elutriate Chemistry

The CW determined that both Tier I and Tier II evaluations according to EPA and USACE guidance was to be conducted for both water and sediment quality. To this end, contaminants of concern were identified and all current and historic data were compiled and presented to the CW in both graphical and tabular format (Tier I) for both Gulf areas (covered by the Ocean Dumping Manual (EPA/USACE, 1991) or the Green Book) and inland areas (covered by the Inland Testing Manual (EPA/USACE, 1998) or the ITM). Water and elutriate data were compared with Water Quality Standards and past water column toxicity compliance was determined (Tier II). For those areas where the CW felt there were insufficient data (e.g., the BU Site ZZ), additional data were collected and analyzed (Tier II). After analysis of the data, the CW concluded that there would be no adverse impacts to the waters of the U.S. from the project and that additional testing, including toxicity testing, was not required (Tier II). This information is discussed in this section and in Section 3.3.

Ward and Armstrong (1997) noted a general improvement in water quality in the Corpus Christi Bay system over the 25 years preceding their study. Their study area was much broader than the CCSCCIP study area, as was the scope of their determination. For the present document, concerns are with the channel improvements and beneficial uses included in the CCSCCIP. Therefore, the emphasis will be on areas in and near the CCSC. This need is met by an examination of the data collected at regular intervals by the USACE. For a more general discussion of water and sediment quality in the overall Corpus Christi Bay system, the reader is referred to Ward and Armstrong (1997).

The data collected by the USACE since 1981 were analyzed to determine the water quality of Corpus Christi Bay. Also included below is a discussion of the elutriate, which provides information on those constituents that are dissolved into the water column during dredging and placement. Since the elutriate represents the dissolved concentrations that would be expected in the water column, they are compared to the Texas Surface Water Quality Standards (TWQS) provided by the Texas Natural Resource Conservation Commission (TNRCC, 2000) for the protection of aquatic life and EPA water quality discrete criteria. Since the values are from samples, not long-term composites or averages, and are from a marine environment, the acute marine TWQS are used (there are no TWQS for barium, but the Gold Book Criterion (U.S. Environmental Protection Agency (EPA), 1986, as revised) is 1,000 micrograms per liter (µg/L) barium for domestic water supplies. No value exceeded 1,000 µg/L barium). The CW has reviewed selected-screening criteria and concurs with these findings.

3.2.3.1 Entrance Channel

Water quality tables referred to in this section are contained in Appendix B (tables 3.2-1 through 3.2-11). Historical water and elutriate data for detected compounds from 1984, 1990, and 1999 are presented in Table 3.2-1. No constituents were found in 1990, although detection limits were high; in 1984, however, a few constituents were found despite higher detection limits. Some constituents detected in 1999 could not have been detected with either 1984 or 1990 detection limits. Of the metals, arsenic and copper were found above detection limits in 1984. In 1999, arsenic, barium, cadmium, and zinc concentrations were found above detection limits for water and elutriate samples; nickel was detected in water samples; and chromium and copper were found only in elutriate samples. Elutriate concentrations in 1999 were consistently higher than ambient water concentrations, including Reference samples, for barium and cadmium, but the opposite was true for zinc. All samples were well below the TWQS, except for copper in the elutriate samples from station CC-J-84-01 (0+00). Looking at the other 1984 copper data and those from 1999 (which are in the range of 1.3 to 4 µg/L), the elutriate value of 30 µg/L for CC-J-84-01 may be in error. Consequently, there are no apparent temporal trends in the data; since copper was the only compound detected in more than 1 year, trends for compounds other than copper could not be determined.

Oil and grease were detected in 1984 for water and elutriate samples. No organics were detected in the 1990 or 1999 data for any medium, except for total organic carbons (TOC) and total petroleum hydrocarbons (TPH).

Two sets of elutriate bioassays have been conducted on samples collected from the Entrance Channel (Southwest Research Institute (SWRI), 1980 and EH&A, 1985). The results of these tests are presented in Table 3.2-2, an examination of which indicates that in all tests, survival of organisms exposed to the liquid phase (LP, elutriate) and suspended particulate phase (SPP, unfiltered elutriate) of sediments from the Corpus Christi Entrance Channel was greater than 50 percent. Therefore, no 96-hour LC_{50} (that concentration of a substance which is lethal to 50 percent of test organisms after a continuous exposure time of 96 hours) could be calculated. This indicates that no acute toxicity to water column organisms could be expected from dredging the Entrance Channel or placement of Entrance Channel sediments.

There is no indication of water or elutriate problems in the Entrance Channel.

3.2.3.2 Lower Bay

This reach of the CCSC is not dredged often due to scouring and, therefore, very little data have been collected. Historical water and elutriate data for detected compounds from 1988 and 1991 are presented in Table 3.2-3. No metals were detected for the 1988 and 1991 data for water and elutriate. This is not surprising since the material is 72 to 97 percent sand.

TOC was above detection limits in water and elutriate samples for two stations in 1991, at roughly the same range for both media. No other organics were detected in 1991 and no organics were reported in 1988 for water or elutriate samples.

Water and construction sediment samples were collected for the proposed U.S. Navy Homeport project, for which an EIS was prepared in 1988 (U.S. Navy, 1987). The concentrations of detected compounds can be found in Table 3.2-4. No TWQS were exceeded in the water or elutriate samples. Most noticeable about Table 3.2-4 is the increase in oil and grease and TOC in the elutriate samples, relative to the corresponding water sample. The elutriate oil and grease concentrations are not high, relative to other reaches (there are no other oil and grease data for the Lower Bay Reach), but the elutriate concentrations in the water samples are much lower than in other reaches. For TOC, the values for the water samples are comparable to the other reaches but the elutriate values are much higher. U.S. Navy (1987) indicates no water or elutriate quality problems.

Toxicity testing has been conducted on elutriate samples made with maintenance material from this reach of the project area (Tereco, 1981) and is presented in Table 3.2-5. While the survival of mysids (*Mysidopsis almyra*) exposed to the LP from Station IB-1 was low, it was not significantly less than control survival (97 percent) at the 95 percent confidence level. Since the LP is a subset of the SPP, the low survival in the LP versus the high survival of mysids exposed to the SPP from Station IB-1 is enigmatic. Also, survival in no bioassay was less than 50 percent. Therefore, no 96-hour LC_{50} could be calculated. This indicates that no acute toxicity to water column organisms could be expected from dredging the Lower Bay Channel or placement of Lower Bay Channel sediments.

There is no indication of water or elutriate problems in the Inner Basin to La Quinta Junction Reach.

3.2.3.3 La Quinta

Historical water and elutriate data for detected compounds from 1985, 1990, and 2000 are presented in Table 3.2-6. Arsenic was the only metal found above detection limits in 1985, and it was found in all water and elutriate samples. Although arsenic was not detected in 1990, copper was found in all water and elutriate samples, and nickel was detected in all elutriate samples, indicating a release of nickel with dredging and placement. However, all elutriate values were less than TWQS. In 2000, arsenic was found in most water but no elutriate samples; barium and zinc were detected in all water and elutriate samples; cadmium was found in most water and elutriate samples; lead was found in one water sample at the detection limit; and selenium was found in most elutriate and some water samples near the detection limit. No trends indicated whether elutriate or water concentrations were higher. Moreover, TWQS were not exceeded by any metal, and barium concentrations were well below 1,000 µg/L (ppb). No temporal trends could be determined, since there were no detected chemicals common to more than one data set.

Oil and grease were detected in all samples in 1985, and elutriate concentrations were consistently higher than water concentrations. TOC was above detection limits for elutriates for all stations and most water samples, and were consistently higher in elutriate samples in 1990. No organics, including TOC, were detected in 2000 water and elutriate samples.

Toxicity testing has been conducted on elutriate samples made with maintenance material from this reach of the project area (Tereco, 1982); the results are presented in Table 3.2-7. While the survival of silverside minnows (*Menidia beryllina*) exposed to the LP from Station LQ-1 and grass shrimp (*Palaemonetes pugio*) exposed to the SPP from Station LQ-1 was low and significantly less than the respective control survival (97 percent for both) at the 95 percent confidence level, survival in no bioassay was less than 50 percent. Therefore, no 96-hour LC_{50} could be calculated. Tereco (1982) concluded that, with judicious management, no toxicity to water column organisms could be expected from dredging the La Quinta Channel or placement of La Quinta Channel sediments.

Overall, there is no indication of water or elutriate problems in the Channel to La Quinta Reach.

3.2.3.4 Upper Bay

Historical water and elutriate data for detected compounds from 1981, 1983, 1985, 1987, 1988, 1989, 1991, 1994, 1995, 1997, and 1998 are presented in Table 3.2-8. Arsenic was found above detection limits in 1983 and 1985 (water and elutriate samples), 1994 (water only), and from one reference station in 1998 (elutriate only), with the highest concentrations in 1983. Barium, for which analyses were not conducted before 1994, was detected for both water and elutriate in 1994, 1995, 1997, and 1998 (highest concentrations in 1995); chromium in both media in 1994 and for water only in 1997; mercury at only two of 15 stations in the elutriate in 1998; and nickel in both media in 1988. Copper was also detected in 1981, 1985, 1988, 1991, 1994, 1997 (water only), and 1998, with higher concentrations in 1988 and 1994 than in 1998. Zinc was detected in 1985 at one station each for water and elutriate, in 1987, 1988 (water only), 1989, 1991, 1994, 1997, and 1998, and was only high in 1987 when the TWQS was exceeded in 13 of 19 water samples and one elutriate sample. For that one elutriate sample, the concentration in the water was higher than in its corresponding elutriate sample. Barium concentrations are generally higher in elutriate than in water. Concentrations of zinc in the elutriate samples were less than in water samples in 1987 and 1998, but in 1989, the opposite was generally true.

TOC was not measured until 1991 and was above detection limits for water and elutriates for most stations in 1991, 1994, 1995, and 1998 (one station) (Table 3.2-8). Detected concentrations in the historic data for TOC were similar in value for all water and elutriate samples. Oil and grease were detected in 1981, 1983, 1985, 1987, and 1988 for water and elutriate samples. All oil and grease values were similar for water and elutriate; however, there were increased concentrations in 1981 and 1988 when compared with the other historical data.

As noted above, the only metal found above TWQS was zinc in 1987, and no trends indicated increasing concentrations with time.

Toxicity testing has been conducted on elutriate samples made with maintenance material from this reach of the project area (Tereco, 1982); the results are presented in Table 3.2-9. While the survival of mysids exposed to the LP from Station MT-1 was low, it was not significantly less than the control survival (90 percent) at the 95 percent confidence level. Since the LP is a subset of the SPP, the low survival in the LP versus the high survival of mysids exposed to the SPP from Station MT-1 is enigmatic. Also, survival in no bioassay was less than 50 percent. Therefore, no 96-hour LC_{50} could be calculated. This indicates no acute toxicity to water column organisms could be expected from dredging the Lower Bay Channel or placement of Lower Bay Channel sediments.

3.2.3.5 Inner Harbor

All material from this reach will be placed in Upland Confined Placement Areas (UCPA). Elutriates are, thus, of key interest in this reach, since the elutriate most nearly represents discharge from the UCPAs.

Historical water and elutriate data for detected compounds from 1983, 1988, 1991, 1994, 1997, and 2000 are presented in Table 3.2-10. Of the metals, arsenic, barium, cadmium, chromium, copper, nickel, and zinc were found above detection limits in water and elutriate samples. Arsenic was detected in both media at all stations in 1983; not detected in 1988, 1991, 1997, and 2000; and detected in water only at two stations in 1994. Barium was found above detection limits in 1994, 1997, and 2000 (there was no analysis for barium in 1983, 1988, or 1991), as was chromium in 1994 and 1997, nickel in 1988, and zinc in 1988, 1991, 1997, and 2000 for both water and elutriate samples. For 1988, copper was detected in both water and elutriate samples; however, it was only found in water samples for 1994 and 1997. Cadmium was only found in 1997 at two stations in elutriate samples. In 1997, station CC-TB-97-09 (1500+00) had an elevated barium concentration when compared to other stations of the same year and to previous years, but all concentrations were less than 1,000 μg/L. Interestingly, zinc concentrations were lowest (i.e., not detected) in 1994 when sediment concentrations were the highest in the data set, and were similar to other years in 1997 when sediment zinc concentrations were also high. Copper levels were generally lower in 1997 than in 1994; none was detected in 2000. All concentrations for both media and for all years were less than the TWQS.

TOC was above detection limits for water and elutriates for most stations in 1991 and 1994 (it was not determined in 1988) (Table 3.2-10). Oil and grease were detected in 1983 and 1988 for water and elutriate samples. Oil and grease were replaced by TPH after 1988 but TPH was not detected in any water or elutriate samples until 2000, when it was found in all water and elutriate samples from channel stations, PAs, and Reference sites. Concentrations of TPH in water were numerically higher than in the elutriates at all stations.

There is no indication of water or elutriate problems in the Beacon 82 to the Viola Turning Basin Reach.

3.2.3.6 GIWW Across Corpus Christi Bay

Most of the GIWW across Corpus Christi Bay is in water deeper than 12 feet and, therefore, does not require maintenance dredging. However, on the south side of the Bay, where the Upper Laguna Madre begins, the water shoals and maintenance dredging is conducted. This section discusses the data from that portion of the GIWW, roughly USACE channel stations 0+000 to 10+000.

Historical water and elutriate data for detected compounds from 1983, 1990, and 1993 are presented in Table 3.2-11. Of the metals, arsenic was found above detection limits for 1983 for water and elutriate samples, but was not detected in 1990 or 1993. Barium was detected for both water and elutriate at all stations in 1993, but was not included in the analyses in 1983 or 1990. No TWQS were exceeded.

Oil and grease were detected in 1983 at one station in the elutriate. Also in 1983, hexachlorocyclohexane (the gamma isomer of which is lindane) was detected in all water and elutriate samples below or equal to the TWQS (Table 3.2-11). TOC was above detection limits for water and elutriate samples for all stations in 1990 and 1993. No other organics were detected in 1990 or 1993 for either medium.

Since no evidence of hexachlorocyclohexane has been present since 1983 and all other constituents were below TWQS (or the EPA criterion, for barium), there is no indication of water or elutriate problems in the GIWW across Corpus Christi Bay.

3.2.4 Brown Tide

A major water quality concern since the early 1990s has been the phytoplankton, brown tide (*Aureoumbra lagunensis*) (De Yoe et al., 1997). Although brown tide has been and continues to be in general decline throughout the study area, there are sporadic patches of algal blooms throughout the area, generally in canals and near developments (Villareal and Dunton, 2000). However, Dr. Tracy Villareal reported in May 2000 (Villareal, 2000) that brown tide counts at Marker 53, roughly 2 miles south of the JFK Causeway, were similar to those in the long brown tide bloom from 1989 to 1997.

There are several potential impacts of algal blooms to estuarine ecosystems. Buskey et al. (1996) estimates that brown tide has caused a recent loss of 10 square kilometers (2,471 acres) of seagrass coverage in the Upper Laguna Madre and has also contributed to impacts such as decreased abundance, biomass, and diversity of benthic fauna, and reduced larval fish populations. Stockwell (1993) suggests that the persistent brown tide has temporarily changed the phytoplankton/seagrass production ratio and altered nutrient cycles within the Laguna Madre. Barrera et al. (1995) report that under normal conditions, turbidity is minimal and seagrass meadows are extensive in the Laguna Madre, but the persisting brown tide bloom has caused serious problems to the seagrasses of the Laguna Madre.

3.2.5 Ballast Water

The National Invasive Species Act of 1996 (NISA) calls for a variety of measures to reduce the risk of exotic species invasions associated with release of ballast water by ships. Ballast water is carried by ships to provide stability and adjust a vessel's trim for optimal steering and propulsion. The use of ballast water varies among vessel types, among port systems, and according to cargo and sea conditions. Ballast water often originates from ports and other coastal regions which are rich in planktonic organisms. It is variously released at sea, along coastlines, and in port systems. As a result, a diverse mix of organisms is transported and released around the world with ballast water of ships (Smithsonian Environmental Research Center [SERC], 1998).

Today, ballast water appears to be the most important vector for marine species transfer throughout the world. Ballast water transfers have been identified as a potential source of non-indigenous invasive species (NIS) (Carangelo, 2001). Refer to Table 3.2-12 for the Gulf of Mexico Program list on non-indigenous marine species, a list generated in a cooperative program between the EPA's Gulf of Mexico Program and the Gulf Coast Research Laboratory Museum of the University of Southern Mississippi. It has been estimated that as few as 5 to 10 percent of the vessels worldwide represent 80 to 95 percent of the risks on non-native species introductions through ballast water (Carangelo, 2001).

Although the effects of many introductions remain unmeasured, it is clear that some invaders are having significant economic and ecological impacts as well as human-health consequences. These organisms have the potential to become aquatic nuisance species (ANS). ANS may displace native species, degrade native habitats, spread disease, and disrupt human social and economic activities

TABLE 3.2-12

GULF OF MEXICO NON-INDIGENOUS MARINE SPECIES

Common Name	Scientific Name
Shrimp Viruses	
Infectious Hypodermal and Hematopoietic Necrosis Virus (IHHNV)*	
Taura Syndrome Virus	
White Spot Baculovirus complex	
Yellow Head Virus	
Bacteria	
	Mycobacterium marinum (C)
Cholera	*Vibrio cholerae*, serotype Inaba, biotype El Tor*
	Vibrio parahaemolyticus (including O3:K6 strain*)
Tunicates	
A sea squirt	*Botryllus niger* (C)
A sea squirt	*Botryllus schlosseri**
A tunicate	*Diademnium perleucidum**
A sea squirt	*Styela plicate**
Bryozoans	
A bryozoan	*Conopeum* "seurati" (C)
A bryozoan	*Cryptosula pallasiana**
A bryozoan	*Sundanella sibogae**
A bryozoan	*Victorella pavida**
A bryozoan	*Watersipora subovoidea**
A bryozoan	*Zoobotryon verticillatum* (C)
Coelenterates	
A hydroid	*Cordylophora caspia**
Orange-striped anemone	*Diadumene lineata**
A scyphoid jellyfish	*Phyllorhiza punctata**
Flatworms (Phylum Platyhelminthes)	
Eurasian strigeid trematode	*Bolbophorus confusus**
Marine blackspot	*Cryptocotyle lingua**

TABLE 3.2-12 (cont'd)

Common Name	Scientific Name
A flatworm	*Taenioplana teredini*
Roundworms (Phylum Nematoda)	
Eel parasite	*Anguillicola crassus**
Segmented Worms (Phylum Annelida)	
A polychaete worm	*Boccardiella ligerica**
A polychaete worm	*Hydroides elegans**
Mollusks	
Lake Merrit cuthona	*Cuthona perca*
A California nudibranch	*Ercolania fuscovittata*
An Indo-Pacific shipworm	*Lyrodus medilobatus*
European salt-marsh snail	*Ovatella myosotis**
Brown mussel	*Perna perna**
Green mussel	*Perna viridis**
Black-lipped pearl oyster	*Pinctada margaritifera*
Atlantic rangia	*Rangia cuneata*
Striped falselimpet	*Siphonaria pectinata*
Giant clam	*Tridacna crocea**
Giant clam	*Tridacna maxima**
Crustaceans	
Striped barnacle	*Balanus amphitrite**
A barnacle	*Balanus reticulatus**
A barnacle	*Balanus trigonus**
A copepod	*Centropages typicus**
Portunid crab	*Charybdis hellerii**
An amphipod	*Chelura terebrans**
Chinese mitten crab	*Eriocheir sinensis**
Potted bumblebee shrimp	*Gnathophyllum modestum*
An isopod	*Ligia exotica**
An isopod	*Limnoria pfefferi* (C)
An isopod	*Limnoria saseboensis* (C)
Pacific white shrimp	*Litopenaeus vannamei**
Jumbo tiger prawn	*Penaeus monodon**

TABLE 3.2-12 (cont'd)

Common Name	Scientific Name
Serrated swimming crab; Somoan crab	*Scylla serrata**
A wood-boring isopod, gribble	*Sphaeroma terebrans**
An isopod	*Sphaeroma walkeri**
A tanaid	*Zeuxo maledivensis**
Fishes	
Spotted seatrout	*Cynoscion nebulosus*
Spotted seatrout x orangemouth corvina	*Cynoscion nebulosus x C. xanthulus**
Sheepshead minnow	*Cyprinodon variegatus*
Gulf killifish	*Fundulus grandis*
Naked goby	*Gobiosoma bosc*
Spot	*Leiostomus xanthurus*
Atlantic croaker	*Micropogonias undulatus*
White bass	*Morone chrysops*
Wiper	*Morone chrysops x M. saxatilis*
Striped bass	*Morone saxatilis*
Coho salmon	*Oncorhynchus kisutch*
Rainbow trout	*Oncorhynchus mykiss*
Chinook salmon	*Oncorhynchus tshawytscha*
Rainbow smelt	*Osmerus mordax*
Gulf flounder	*Paralichthys albiguttata*
Pacific batfish	*Platax orbicularus**
Amazon molly	*Poecilia formosa*
Sailfin molly	*Poecilia latipinna*
Black drum	*Pogonias cromis*
Blackdrum x red drum	*Pogonias cromis x Sciaenops ocellatus*
Atlantic salmon	*Salmo salar*
Red drum	*Sciaenops ocellatus*
Algae	
A green tropical alga	*Caulerpa taxifolia*
A red alga	*Prionitis* sp.

* Exotic
C Cryptogenic

Source: Gulf of Mexico Program, 2000.

that depend on water resources (U.S. Coast Guard (USCG), 2000). Ballast-mediated introductions, such as the zebra mussel in the U.S. Great Lakes and toxic dinoflagellates in Australia, have had tremendous ecological and economic impacts (SERC, 1998).

The issue of regulating, controlling, or otherwise reducing the risk of ballast mediated introductions is a topic of ongoing national and international debate and investigation. The complexity of the issue led to the development or implementation of various foreign nation, domestic state, port-specific, or species-specific strategies (Carangelo, 2001). The U.S. Coast Guard is responding to these concerns through a comprehensive national ballast water management program.

3.2.5.1 The U.S. Coast Guard Ballast Water Management Program

Purpose of Regulations

The USCG Interim Rule on ballast water management, Implementation of the NISA of 1996, was published in the Federal Register on May 17, 1999. The new regulations amend 33 CFR Part 151, Vessels Carrying Oil, Noxious Liquid Substances, Garbage, Municipal or Commercial Waste, and Ballast Water. These regulations are intended to limit the introduction and spread of aquatic nuisance species into the waters of the United States. Presently, the primary means of preventing this is to replace ballast water taken on in foreign ports with deep ocean water through an at sea ballast water exchange. The new USCG rule establishes voluntary ballast water management guidelines for all waters (except the Great Lakes and sections of the Hudson River) of the U.S. and establishes mandatory reporting and sampling procedures for nearly all vessels entering U.S. waters.

Key Provisions of the USCG Guard Ballast Water Management Program

Voluntary Guidelines & Recommended Practices. These guidelines include suggested practices that should be taken by every vessel to minimize the uptake and release of harmful aquatic organisms, pathogens, or sediments. Additionally, the rule recommends that vessels carrying ballast water into the waters of the U.S. after having operated beyond the Exclusive Economic Zone (EEZ) to employ one of the following ballast water management practices:

- Conduct an exchange of ballast water beyond the EEZ, in an area no less than 200 miles from any shore and where the water depth exceeds 2,000 meters
- Retain the ballast water on board
- Use an alternative method of ballast water management
- Discharge ballast water to an approved reception facility
- Conduct the exchange in an approved Alternative Exchange Zone.

Mandatory Requirements. All vessels calling in a U.S. port must submit a completed Ballast Water Report Form (Appendix to 33 CFR 151, Subpart D) to the Smithsonian Environmental Research Center (SERC). Submission of the International Maritime Organization Ballast Water Reporting Form will also fulfill this reporting requirement. The reports must be kept on board the vessel and available for inspection for 2 years.

3.3 SEDIMENT QUALITY

The data collected by the USACE, on maintenance material, and others since 1981 were analyzed to determine the sediment quality of Corpus Christi Bay. The data presented here are from bulk sediment analyses, which tend to vary, even within duplicates, by a factor of up to five times. The data are compared to one type of Sediment Quality Guidelines (SQG), a co-occurrence type of SQG known as the Effects Range Low (ERL, originated by Long and Morgan, 1990), as given in the National Oceanic and Atmospheric Administration (NOAA) Screening Quick Reference Tables (Buchman, 1999). The CW has reviewed selected parameters of concern and screening criteria for this analysis and have concurred with the findings.

ERLs were developed by assembling a large group of sediment data sets, comprised of samples for which there was both bulk sediment chemistry and exhibition of toxicity. For each chemical in the data set, the concentrations are ranked in ascending order and the ERL is calculated as the lower 10th percentile of the concentrations. However, this approach demonstrates no cause and effect from the chemicals in the data set, since the fact that a chemical was detected does not demonstrate that it was responsible for the toxicity exhibited by the sediment. Not surprisingly, when ERLs derived from sets of data from different areas are compared, the results are inconsistent (WES, 1998). For example, when the ERLs of a number of chemicals were compared using a northern California data set versus a southern California data set, the ERLs differed by a range, from only a factor of three for total polychlorinated biphenyls (PCB) to a factor of 2,689 for p,p'-DDE. Since the ERLs are not based on cause and effect data, one would expect them to exhibit low predictive ability and to give a high number of false positives, both of which are true (WES, 1998). ERLs could only be compared to detected compounds. Although some detection limits were greater than ERLs, primarily for acenapthene, chlordane, and DDT, these were not listed as exceedances since there was no way to determine what the true values were.

In Section 3.2.3, it was noted that water and elutriate samples were compared to TWQS, which are regulatory standards, promulgated by the TNRCC (2000), and tied to effects from empirical data presented in the scientific literature. Because of the reasons noted above, the SQG are guidelines with no regulatory authority, used only to determine a "cause of concern".

3.3.1 Surficial Sediments

Surficial sediments have been examined by several studies (Barrera et al., 1995 [U.S. Fish and Wildlife Service (FWS)]; Ward and Armstrong, 1997 [Corpus Christi Bay National Estuary Program (CCBNEP)]; Carr et al., 1997 [CCBNEP], Fugro South, 2000 [PCCA]). Some of these studies encompassed an area greater than the study area for this FEIS, but only data from the study area are discussed here.

Barrera et al. (1995) collected sediment and biota samples from Redfish, Nueces, and Baffin bays; the Upper Laguna Madre; the Nueces River, in addition to samples from Corpus Christi Bay; and the Inner Harbor. The samples were analyzed for PAHs, organochlorine compounds, PCBs, and trace elements (Table 3.3-1). Sediment quality tables referred to in this section are contained in Appendix B (tables 3.3-1 through 3.3-3). Sediment PAHs, organochlorine compounds, and PCBs were below detection limits or were detected at very low concentrations. While Barrera et al. (1995) compared the sediment data to a number of guidelines, including data from other systems and guidelines used in Florida and Puget Sound, the comparison here is with the ERLs noted in Section 3.3 (Table 3.3-1). As an examination of Table 3.3-1 reveals, there were exceedances only in the Inner Harbor. Cadmium, copper, lead, mercury, and zinc samples in the Inner Harbor all exceeded ERLs at one or more stations.

Ward and Armstrong (1997) found that, in general, the highest metals concentrations in sediments were in the Inner Harbor and that these concentrations were often an order of magnitude higher than in other parts of their study area. Aside from the Inner Harbor, other areas found to contain elevated metals in sediments were Corpus Christi Bay for chromium and lead, the Gulf of Mexico near the Entrance Channel for copper and lead, and Nueces Bay and the Upper Laguna Madre for most metals. Note that these elevated concentrations are not relative to any guideline, like ERLs, but to other parts of the Ward and Armstrong CCBNEP study area. Ward and Armstrong also found probable temporal trends in that, for most metals in most of the system, including the Inner Harbor, concentrations are declining. However, zinc shows a possible increasing trend in many parts of Corpus Christi Bay. In contrast to the metals, sediment pesticides are not noticeably high in the Inner Harbor or Nueces Bay (Ward and Armstrong, 1997), except for toxaphene in Nueces Bay. However, they found PCBs to be high in the Inner Harbor and PAHs to be high in both the Inner Harbor and Nueces Bay (some polycyclic aromatic hydrocarbons (PAHs)). They also found a temporal trend of increasing naphthalene in both of these areas.

Carr et al. (1997) used a Sediment Quality Triad (SQT), composed of sediment chemistry, toxicity testing, and benthic invertebrate community analyses, to examine sediment quality near storm water outfalls and other selected sites. The sampling sites included 15 storm water sites, 8 reference areas, and 13 additional sites that the authors felt deserved attention. Based on the SQT results, the stations were ranked from the worst (Station S1, storm water outfall near the L-head in Corpus Christi Marina) to the best (Station 11, in the La Quinta Channel adjacent to industrial activity and dredging operations). Only a few of the stations are in a position to impact or be impacted by the CCSCCIP: Stations 11 and 12, in the La Quinta Channel (ranked 35 and 36, where 36 is the best); Station R3, a reference station near Indian Point (ranked 16); Station 5, in a PA (ranked 23); and Station 3, near the largest discharge into the Inner Harbor (ranked 19).

Construction or new work material will also be included in this section, since some of it (e.g., from channel widening) will be surficial sediments, even though other construction material will be deep sediments. However, none will be maintenance material.

There have been three studies, which evaluated construction material, that are pertinent to the CCSCCIP: U.S. Navy (1987), Fugro (2000), and Tereco (1982).

U.S. Navy (1987) took samples along the Lower Bay reach of the CCSC, from approximately Channel Station 12+55 to Channel Station 521+70. The concentrations of detected parameters are in Table 3.2-4. There are no patterns to the sediment concentrations but ERLs were exceeded for several parameters: arsenic, 8 of 9 stations; cadmium, 4 stations; and mercury, 2 stations.

However, no elutriate concentrations were greater than the TWQS for these, or any other parameters, so the meaning of the ERL exceedances is unclear.

The concentrations of detected parameters from Fugro (2000) are in Table 3.3-2. Two of the Fugro (2000) stations were in the Lower Bay (C-60 and C-67), two were in the Upper Bay (C-71A and C-76), and three were in the La Quinta Extension (L-24, L-27, L-30). The range of values for the samples collected provide such overlap that there is no notable difference among the reaches. For the three stations for which shallower and deeper samples were collected, there is no pattern concerning concentration versus depth. No ERLs were exceeded in any sample.

Tereco (1982) looked at construction material, but the study was concerned with the Inner Harbor area, and all of that material, both construction and maintenance will go into UCPAs. Therefore, elutriate is the medium of concern. Water and elutriate values for detected parameters are included in Table 3.3-3. In general, water and elutriate concentrations are similar except that oil and grease was generally higher in elutriate samples than in the respective water samples, the arsenic in the water sample from IC-1 was high compared to the IC-1 elutriate and all other water and elutriate samples, and zinc was generally lower in elutriate samples. No TWQS were exceeded, indicating that there should be no water quality concerns from the discharge from UCPAs which receive construction material from the Inner Harbor.

3.3.2 Maintenance Material

3.3.2.1 Entrance Channel

Maintenance material concentrations of detected parameters in 1984, 1990, and 1999 are found in Table 3.2-1. Since the RACT, at the recommendation of the CW, agreed that sediment concentrations would be compared to ERLs, they are also included in all tables. Arsenic was the only metal above detection limits in 1984; zinc was detected at all stations, chromium and nickel at three stations, and copper at one station in 1990, all below the ERLs. Of the metals, only mercury (three stations), silver (one station), and selenium (no stations) were not found at all stations in 1999 samples. Only one 1999 sample, CC-J-99-03, exceeded an ERL: mercury at a concentration of 0.20 milligrams per kilogram (mg/kg), versus an ERL of 0.15 mg/kg. Aside from the one exceedance noted, there is no indication of a cause for concern relative to maintenance material quality in the Entrance Channel. Sampling of any future project maintenance material will be routinely conducted to determine sediment quality prior to actual dredging. Additionally, prior to placement of maintenance material in PA 1, the material must meet all of the environmental criteria and regulatory requirements pursuant to MPRSA (40 CFR 220-228). Environmental criteria are based on toxicological and bioaccumulative effects on marine organisms.

Table 3.2-2 also presents the data for solid phase (SP, or sediment) bioassays with Entrance Channel sediments from 1980, 1985, and 1995. These bioassays were conducted according to protocols in both the old (EPA/USACE, 1978) and new (EPA/USACE, 1991) Green Books. The LC_{50} is not pertinent for SP bioassays, but the fact that test survival was not significantly less than Reference Control survival, at the 95 percent confidence level, provides reasonable assurance that no significant undesirable impacts would occur from ocean placement of the maintenance material dredged from the Entrance Channel reach of the CCSC.

3.3.2.2 Lower Bay

Maintenance material concentrations of detected parameters in 1988 and 1991 are found in Table 3.2-3. In 1988, chromium, copper, lead, and nickel were all above detection limits for one station and zinc was detected at all stations. In 1991, cadmium, chromium, copper, nickel, and zinc were found at most stations. The values for chromium, copper, nickel, and zinc for 1988 and 1991 were similar. No organics were detected in sediments, and no ERLS were exceeded. Grain size data indicate the maintenance material in this reach is coarse (72-97 percent sand). There is no indication of a cause for concern relative to maintenance material quality in the Inner Basin to La Quinta Junction Reach. Sampling of any future project maintenance material will be routinely conducted to determine sediment quality prior to actual dredging.

Table 3.2-5 also presents the data for SP bioassays with Lower Bay CCSC sediments from 1981. Test survival was not significantly less than Reference Control survival, at the 95 percent confidence level, providing reasonable assurance that no significant undesirable impacts would occur from open water placement of the maintenance material dredged from the Lower Bay reach of the CCSC.

3.3.2.3 La Quinta

Maintenance material concentrations of detected parameters in 1985, 1990, and 2000 are found in Table 3.2-6. Arsenic, chromium, nickel, and zinc were above detection limits in 1985 at most stations, and arsenic exceeded the ERL at all stations. In 1990, arsenic was not detected but chromium, copper, nickel, and zinc were detected in all sediment samples. The values for nickel were numerically higher in 1990 than in 1985 but by less than a factor of three, and no metal exceeded its ERL. In 2000, arsenic, barium, chromium, copper, lead, nickel, and zinc were detected at all stations, cadmium and mercury were found in two samples near the detection limit, and selenium was found at one station, also near the detection limit. No ERLs were exceeded. Oil and grease was detected in 1985 but was discontinued before 1990. TOC was not detected in 1990 and was the only organic detected, at a range of 2,560 mg/kg to 12,800 mg/kg. The test sediments were mostly sand. Since arsenic was not detected in 1990 and did not exceed the ERL in 2000, there is no indication of a cause for concern relative to maintenance material quality in the Channel to La Quinta Reach. Sampling of any future project maintenance material will be routinely conducted to determine sediment quality prior to actual dredging.

3.3.2.4 Upper Bay

Maintenance material concentrations of detected parameters in 1981, 1983, 1985, 1987, 1988, 1989, 1991, 1994, 1995, 1997, and 1998 are found in Table 3.2-8. Zinc was found above detection limits for all years at all stations. Lead was found at all stations, except in 1985 when it was found at all stations but one, and in all years except 1989. Chromium, copper, and nickel were detected for all years, except 1985, and at all stations, except in 1989 when chromium and copper were found at all but two stations. Arsenic was also detected in 1983, 1985, 1987, 1988, 1997, and 1998; barium in 1994, 1995, 1998, and 1998; cadmium in 1981, 1997, and 1998; mercury at all stations and selenium at one station in

1998. There are sufficient data to determine whether temporal trends exist but, although there are fluctuations, no trends are apparent. However, there are some interesting aspects to the data. For instance, in 1995, chemical concentrations from channel stations are consistently higher than those at the Reference or Placement Area (PA) stations, but for other years (1985, 1998) there is no difference in the ranges from channel stations versus Reference or PA stations. In fact, in 1989, most of the high values were found at the Reference stations. Although the ERL was exceeded for copper for three channel stations, one reference station in 1987, and one reference station in 1989, these values are suspect and may actually be typographical errors: two were reported as 40.00 mg/kg and three were reported as 50.00 mg/kg, whereas the range of all other copper concentrations was 2.20 to 5.60 mg/kg. Nickel (20.92 mg/kg) and zinc (157.9 mg/kg) exceeded their respective ERLs (20.9 and 150 mg/kg) at station CC-B-95-05 (750+00) in 1995.

TOC was above detection limits for all sediment samples in 1997 and 1998. Oil and grease was detected in 1981, 1983, 1985, 1987, and 1988. TOC concentrations in 1998 sediment samples were much higher than compared with previous years, but this is likely due to a change in methodology. Total PAH was found at most stations in 1987, ranging from 0.2 micrograms per kilogram (µg/kg) to 0.4 µg/kg. DDT was also found in 1987 at four stations, ranging from 0.2 µg/kg to 3.1 µg/kg. The latter value exceeded the ERL for DDT of 1.58 µg/kg. Fluoranthene (12 stations, 1.3 – 6.1 µg/kg) and benzo(a)pyrene (5 stations, 1.0 – 1.6 µg/kg) were also found in 1987. These values are questionable since they are below the required detection limit of 10.0 µg/kg for these two compounds in 1987. In any case, there is no ERL for fluoranthene and the ERL for benzo(a)pyrene is 430 µg/kg, so there were no exceedances for these PAHs.

An examination of all data presented above for this reach does not indicate a cause for concern relative to maintenance material quality in the La Quinta Junction to Beacon 82 Reach. Sampling of any future project maintenance material will be routinely conducted to determine sediment quality prior to actual dredging.

Table 3.2-9 also presents the data for SP bioassays with Upper Bay CCSC sediments from 1982. Test survival was not significantly less than Reference Control survival, at the 95 percent confidence level, providing reasonable assurance that no significant undesirable impacts would occur from open water placement of the maintenance material dredged from the Upper Bay reach of the CCSC.

3.3.2.5 Inner Harbor

The CW agreed that there appears to be no significant contaminant concerns with new work and maintenance materials from the CCSCCIP, except in the Inner Harbor. Because of concern with contaminants in the Inner Harbor, the workgroup supports a plan to place any dredged material from this reach in existing upland confined placement areas. Sampling of any future project maintenance material will be routinely conducted to determine sediment quality prior to actual dredging.

Since all material from this reach will be placed in UCPAs, the elutriates (Section 3.2.3.5) are of key interest. The elutriate most nearly represents the discharge from the UCPAs, which will re-enter the Inner Harbor as at present. However, to determine the baseline conditions, maintenance sediment data for this reach will be discussed in this section.

Maintenance sediment concentrations of detected parameters in 1983, 1988, 1991, 1994, 1997, and 2000 are also found in Table 3.2-10. Chromium, copper, lead, and zinc were found above detection limits for all years for all stations. Arsenic was also detected in 1983, 1988, 1997, and 2000; barium in 1994, 1997, and 2000 (it was not determined in 1983-1991); and nickel in 1988, 1991, 1994, 1997, and 2000 for all stations. Cadmium was found in 1983 at one station, in 1997 at all stations, and in 2000 at nine of fifteen stations. Mercury was found only in 1997 at nine of ten stations and in 2000 at all stations. Arsenic concentrations were generally less in 1988 than in 1983, and it was not detected in 1991 or 1994. In 1997, it was detected at a range of 2.2 to 5.9 mg/kg, and in 2000, the range was 4.8 to 9.9 mg/kg. While this could indicate a trend of increasing arsenic in sediment of this reach, without sufficient data with which to conduct statistical analyses, a trend cannot be confirmed. It certainly is not supported by the concentrations of the other sediment metals, most of which were lower in 2000 than in 1994 and 1997. There is also no evidence of a similar trend for arsenic in the other reaches.

ERLs were exceeded by arsenic at four stations in 2000; cadmium at one station in 1983 and all stations in 1997; copper at two stations in 1994 and one station in 1997; lead at one station in 1994; mercury at four stations in 1997 and one reference station in 2000; and zinc at one station in 1983, six stations in 1994, and seven stations in 1997.

Oil and grease was detected in 1983 and 1988 at all stations, but was replaced by TPH, which was not detected until 2000, when it was found in all channel stations, PA samples, and Reference Stations. TOC was above detection limits for all sediment samples in 1994, 1997, and 2000. TOC concentrations were much higher in 2000 than in 1994 and 1997, but this was due to a change in methodology. Fluoranthene and benzo(a,e)pyrene were detected in 1991, 1994, and 1997, and benzo(e)pyrene was also found in 1997. Benzo(a)pyrene (637 μg/kg) exceeded the ERL (430 μg/kg) at one station in 1994.

One can see from the data presented that the detection of constituents of concern is much more prevalent in this reach than in the others. Also, the number of exceedances is much higher for this reach than for the others. Ward and Armstrong (1997) note, "Contaminants such as coliforms, metals, and trace organics show elevated levels in regions of runoff and waste discharge, with generally the highest values in the Inner Harbor..." However, as noted above, all dredged material from the Inner Harbor will be placed in Upland Confined Placement Areas, and the elutriate results discussed in Section 3.2.3.5 show no indications of concerns. The decant water from UCPA in the Inner Harbor will return to the Inner Harbor as currently done with the existing 45-foot project.

No SP bioassays have been conducted with maintenance material from the Inner Harbor reach of the CCSC because this material has not been placed in the past nor intended in the future for aquatic placement.

3.3.2.6 GIWW Across Corpus Christi Bay

Most of the GIWW across Corpus Christi Bay is in water deeper than 12 feet, and therefore, does not require maintenance dredging. However, on the south side of the Bay, where the Upper Laguna Madre begins, the channel shoals and maintenance dredging is conducted. This section discusses the data from that portion of the GIWW.

Sediment concentrations of detected parameters in 1983, 1990, and 1993 are found in Table 3.2-11. Arsenic, chromium, nickel, and zinc were above detection limits at most stations in 1983; chromium, copper, nickel, and zinc in 1990; and barium, chromium, copper, lead, nickel, and zinc in 1993. No ERLs were exceeded.

Oil and grease was detected in 1983 at all stations. Hexachlorocyclohexane was not detected in the sediments in 1983, although it was detected in the water and elutriate samples. In 1993, TOC was detected at station GIC-CBB-93-01 (0+000), but at a concentration below the required detection limit. No other organics were detected.

There is no indication of a cause for concern relative to maintenance material quality in the GIWW reach of Corpus Christi Bay. However, sampling of any future project maintenance material will be routinely conducted to determine sediment quality prior to actual dredging.

3.4 COMMUNITY TYPES

The study area lies within the southeastern portion of the Gulf Prairies and Marshes vegetational region, as described by Gould (1975). This vegetational area is a nearly level plain less than 250 feet in elevation, covering approximately 10 million acres (Hatch et al., 1990). The region is subdivided into two vegetation units: 1) the low marshes with tide water influence (where the study area is located), and 2) the prairies or grasslands farther inland (Hatch et al., 1990). The study area is a highly adaptive community that changes in response to constant environmental fluctuations. The diverse flora of this vegetational region creates a valuable resource for all forms of life. The following paragraphs provide a brief description of the various coastal habitats found within the study area.

3.4.1 Submerged Aquatic Vegetation

SAV includes the true seagrasses such as shoalgrass (*Halodule wrightii*), turtlegrass (*Thalassia testudinum*), manateegrass (*Syringodium filiforme*), and clovergrass (*Halophila engelmannii*), but also includes widgeongrass (*Ruppia maritima*) which is not considered a true seagrass because it grows in freshwater environments as well. Seagrass/SAV meadows typically occur in water shallower than –4 feet MLT. In the study area, they occur both as narrow bands along bay and channel margins and as extensive beds in broad shallow, relatively low energy areas in bays and lagoons (CCBNEP-06A, 1996a). These seagrass communities generate high primary productivity and provide refuge for numerous species including shrimp, fish, crabs and their prey. Animal abundances in seagrass beds can be 2-25 times greater than in adjacent unvegetated areas (Pulich, 1998). All five taxa are found within the study area of Corpus Christi Bay and Redfish Bay/Harbor Island with shoalgrass being the most abundant. Shoalgrass and widgeongrass occur in Nueces Bay (Pulich et al., 1997).

Figure 3-1 depicts SAV coverages for the defined study area as reported by the Texas Parks and Wildlife Department (TPWD) (1994). There are approximately 19,900 acres of seagrass beds in the study area. The net acreage of seagrass in Corpus Christi Bay and Redfish Bay/Harbor Island has remained relatively stable since 1958, although there has been fragmentation of this habitat and some local losses in Redfish Bay/Harbor Island. The acreage of seagrass beds in Nueces Bay fluctuates with inflows, but there has been a net increase since 1958. There have also been increases in seagrass coverage in the Harbor Island and Mustang Island areas.

Several factors may impact seagrass communities. A study by Quammen and Onuf (1993) has suggested that probable causes for shifts in cover of seagrass species in the Laguna Madre include changing salinity regimes (due in part to changes in Bay/Gulf interchange as channels [including ship channel and GIWW] and passes open and/or close), increased turbidity caused by maintenance dredging of the GIWW, and eutrophication resulting from nutrient inputs. Other researchers have suggested that brown tide has played a major role in the alteration of Laguna Madre seagrass communities (Buskey et al., 1996; Stockwell, 1993; Barrera et al., 1995; Pulich, 1998). Recently, the USACE funded an investigation into the potential impacts of open bay disposal of maintenance dredge material from the GIWW on seagrass beds in the Laguna Madre. This study included field verification of predictions made by sediment transport (Teeter, 2000) and seagrass modeling (Burd and Dunton, in press), which indicated no significant difference in seagrass survival or productivity for sites one mile or more from placement sites compared to sites in a non-dredging-and-placement scenario. Even sites that were 100 meters from the disposal event showed full recovery after a 2-week period of decreased biomass.

3.4.2 Coastal Wetlands

The coastal estuarine wetlands of Corpus Christi Bay, Nueces Bay and Redfish Bay/Harbor Island play an important part in sustaining the health and abundance of life within the ecosystem. Coastal wetlands are distinct areas between terrestrial and aquatic systems where the water table is at or near the surface or the land is covered by shallow water with emergent vegetation. They are extremely important natural resources that provide essential habitat for fish, shellfish, and other wildlife (McHugh, 1967; Turner, 1977; Sather and Smith, 1984). Coastal wetlands also serve to filter and process agricultural and urban runoff and buffer coastal areas against storm and wave damage. Coastal wetlands of the study area are shown on Figure 3-2.

3.4.2.1 Salt Marshes/Shrublands

In contrast to the upper Texas coast, only a small percentage of smooth cordgrass (*Spartina alterniflora*) is associated with the salt marshes of the Laguna Madre and Coastal Bend. The more common plant species include saltwort (*Batis maritima*), seashore saltgrass (*Distichlis spicata*), and seashore dropseed (*Sporobolus virginicus*). The estuarine intertidal scrub-shrub category describes coastal wetlands dominated by woody vegetation and periodically flooded by tidal waters. Examples of estuarine intertidal scrub-shrub species in the study area include black mangrove (*Avicennia germinans*) and bushy sea-ox-eye (*Borrichia frutescens*).

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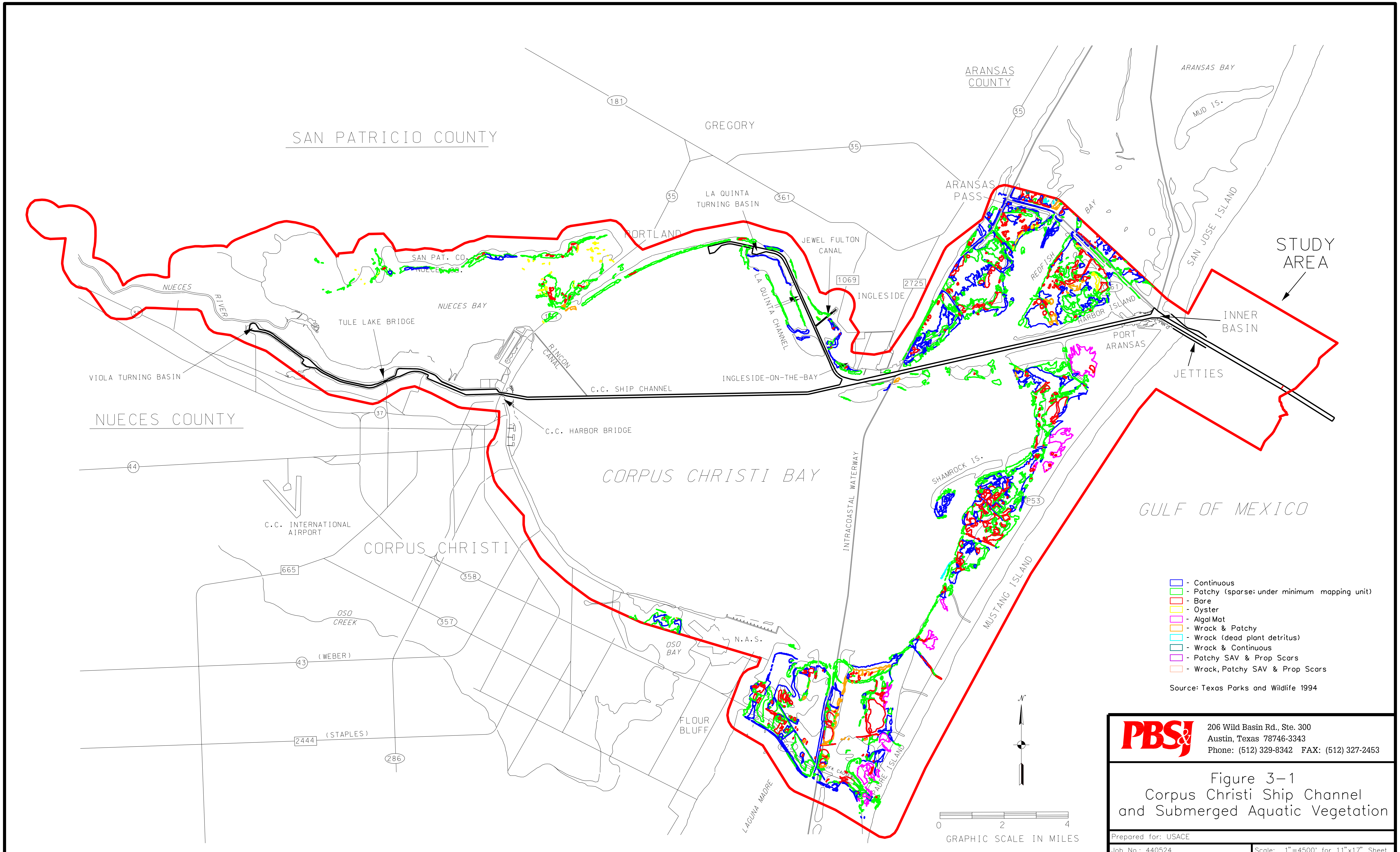

Source: Texas Parks and Wildlife 1994

PBS&J
206 Wild Basin Rd., Ste. 300
Austin, Texas 78746-3343
Phone: (512) 329-8342 FAX: (512) 327-2453

Figure 3-1
Corpus Christi Ship Channel
and Submerged Aquatic Vegetation

Prepared for: USACE

Job No.: 440524
Scale: 1"=4500' for 11"x17" Sheet
Drawn by: G. Rackley
Date: Sep 2001
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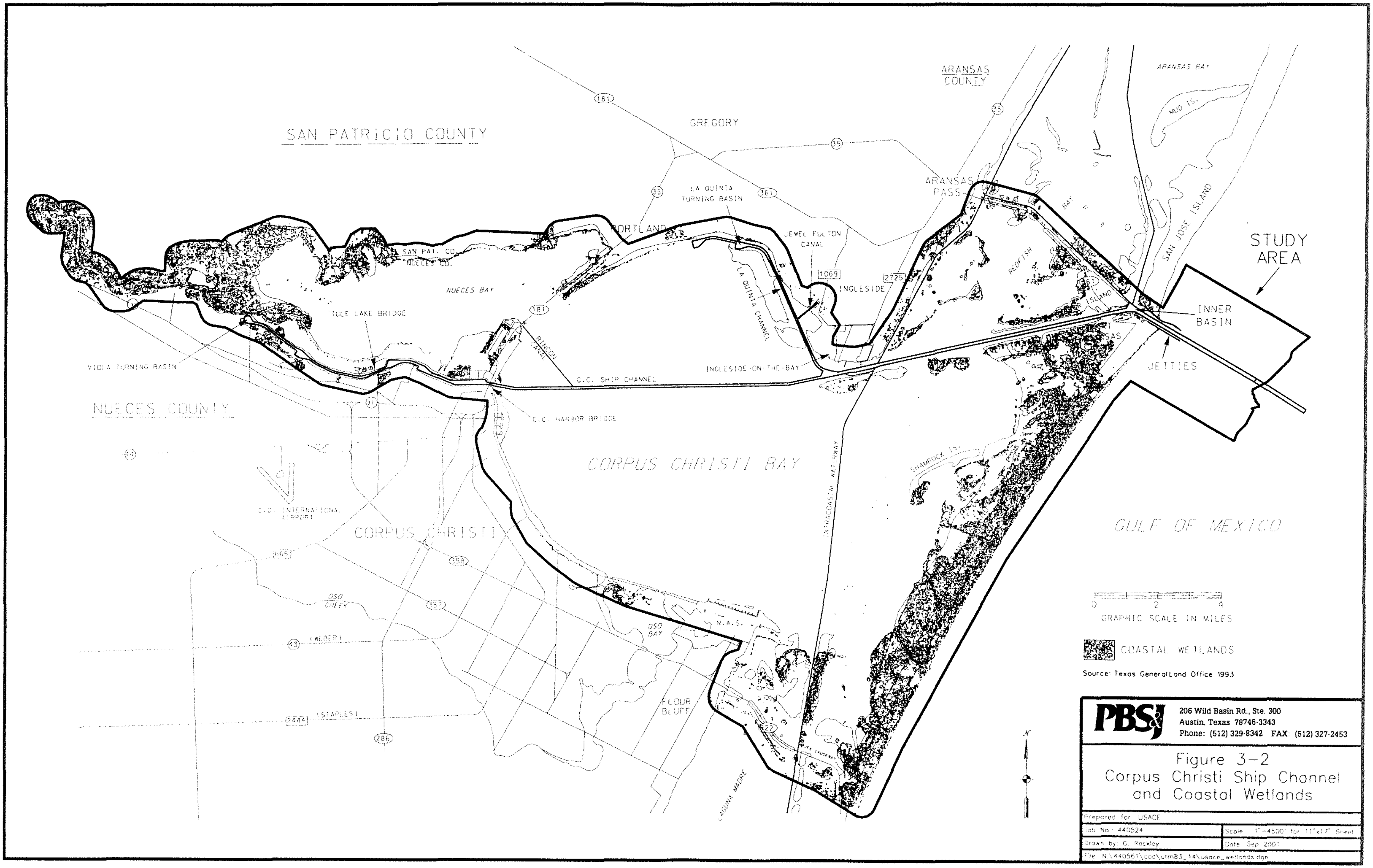

Source: Texas GeneralLand Office 1993

PBSJ
206 Wild Basin Rd., Ste. 300
Austin, Texas 78746-3343
Phone: (512) 329-8342 FAX: (512) 327-2453

Figure 3–2
Corpus Christi Ship Channel
and Coastal Wetlands

Prepared for USACE
Job No: 440524
Scale 1"=4500' for 11"x17" Sheet
Drawn by: G. Rockley
Date Sep 2001
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The estuarine wetlands potentially affected by the proposed dredging would be those in close proximity to the channel itself. There are approximately 12,700 acres of estuarine wetlands (not including flats as described below) in the study area.

3.4.2.2 Estuarine Sand Flats/Mud Flats/Algal Mats

This community type includes coastal wetlands periodically flooded by tidal waters and with less than 30 percent areal coverage by vegetation. This category includes sandbars, mud flats, and other nonvegetated or sparsely vegetated habitats called salt flats. Sparse vegetation of salt flats may include glasswort (*Salicornia* spp.), saltwort, and shoregrass (*Monanthochloe littoralis*). These tidal flats serve as valuable feeding grounds for coastal shorebirds, including the threatened piping plover, fish, and invertebrates. There are approximately 5,100 acres of this category within the study area.

Many of the tidal flats in the study area are considered wind tidal flats because they are exposed primarily by wind and storm tides as opposed to astronomical tides. These areas are generally hypersaline, which prevents or restricts macrophytic vegetation. Blue-green algal mats form in these areas. There are approximately 807 acres of algal mats in Corpus Christi Bay (including Oso Bay) and 87 acres in Redfish Bay/Harbor Island (Pulich et al., 1997).

3.4.3 Open Water/Reef Habitat

Open water areas include the unvegetated, bottom portion (excludes hard substrates such as oyster reefs) of the subtidal estuarine environment. Open water habitats support communities of benthic organisms and corresponding fisheries populations. Approximately 154,000 acres of open water habitat are in the study area.

There are a few scattered reefs of the Eastern oyster (*Crassostrea virginica*) present in some areas of Corpus Christi Bay (1.14 acres), Redfish Bay/Harbor Island (112.6 acres) and Nueces Bay (24.99 acres) (Pulich et al., 1997). According to the Corpus Christi National Estuary report (CCNEP-06C, 1996b), Gatsoff found most oyster reefs in Corpus Christi Bay to be dead; but did find living oyster reefs in Nueces Bay and the intertidal zone. Periodic TPWD surveys since that time also support these early findings.

3.4.4 Coastal Shore Areas/Beaches/Sand Dunes

The coastal shore areas function primarily as buffers protecting upland habitats from erosion and storm damage, and adjacent marshes and waterways from water-quality problems. A variety of birds occur on coastal shores of the Coastal Bend, and few are restricted to one particular habitat (Britton and Morton, 1989). Cranes, rails, coots, gallinules, and other groups can be found on the shorelines and in fringing marshes of the study area.

Beaches along the south Texas and Coastal Bend coastline are dynamic habitats subject to a variety of environmental influences, such as wind and wave action, salt spray, high temperature, and moisture stress. The harsh conditions associated with the beach/dune system support a relatively small number of adapted animals and plants. Sand dunes help absorb the impacts of storm surges and high waves and also serve to slow the intrusion of water inland. In addition, dunes store sand that helps deter shoreline erosion and replenish eroded beaches after storms. The dune complexes are of two types, primary and secondary, each of which supports a unique plant community. The primary dunes are taller and offer more protection from wind and hurricane storm surge. The secondary dunes are leeward (relative to Gulf winds) of the primary dunes, shorter and more densely vegetated. On the barrier islands of the Texas Coastal Bend, typical plant species of the primary dunes include sea oats *(Uniola paniculata*), bitter panicum (*Panicum amarum*), Gulf croton (*Croton punctatus*), beach morning glory (*Ipomea pes-caprae*) and fiddleleaf morning glory *(Ipomea stolonifera*). Secondary dune species include marshhay (*Spartina patens*), seashore dropseed, seashore saltgrass, pennywort (*Hydrocotyle bonariensis*) and partridge pea (*Chamaecrista fasciculata*).

3.5 FISH AND WILDLIFE RESOURCES

3.5.1 Finfish and Shellfish

The study area includes Corpus Christi Bay, Nueces Bay, and small portions of the Upper Laguna Madre, Redfish Bay, and the Gulf nearshore waters at the entrance channel in Port Aransas. Within the study area, environmental fluctuations are extreme and the inhabitant biota reflect and are adapted to this lack of stability in the environment (Warshaw, 1975). Large changes in habitat occur on a daily basis with respect to wind, tidal action, salinity regimes, and freshwater inflow. These ongoing natural processes are coupled with other natural events such as freezes, droughts, hurricanes, and anthropogenic pressures (i.e., management practices and coastal projects) in the study area. Nevertheless, the biological community present in the study area remains diverse and abundant. For example, Tunnell et al. (1996) reports 234 fish species within the CCBNEP study area which includes the study area for this project. The Gulf nearshore fish community includes many species found in both estuarine and offshore oceanic habitats (Tunnell et al., 1996). Most of the species in the Gulf nearshore waters are temperate in biogeographic distribution with a few tropical species (Tunnell et al., 1996).

Although adding pressure to the ecosystem, natural processes and events increase the diversity and abundance of organisms in the study area. The high energy flow in the study area is attributed in part to the shallow water depth with respect to a large surface area and results in high phytoplankton primary production (Tunnell et al., 1996). Higher salinities within the Upper Laguna Madre mean a reduced level of nutrients due to the lack of freshwater inflow, and these also play major roles in increasing the ecological efficiency. This high ecological efficiency found in this portion of the study area results in high abundances of the higher level consumers, such as benthic mollusks and fishes (Tunnell et al., 1996). Salinities within the study area can vary greatly depending on the time of year and location of the system. For example, the Upper Laguna Madre, lacking any river inflow, is a hypersaline lagoon having a much higher salinity than Corpus Christi Bay, whereas Nueces Bay has the lowest salinity of the study area due to inflow from the Nueces River (Tunnell et al., 1996).

A second factor regarding the diversity and abundance of organisms is past and present management strategies. As stated in CCBNEP-06C (1996b), "Management strategies are affected by estimated population densities, biology of target organisms, habitat quality, fishing technology, consumer demand, economic value, and special interest group demands." The competing forces of recreational and commercial fisheries have led to increased management activities along the Texas coast, including the elimination of gillnets in Texas bays and designation of red drum (*Sciaenops ocellatus*) and spotted seatrout (*Cynoscion nebulosus*) as "game species" (CCBNEP-06C, 1996b). Inlets such as Aransas Pass have also played a role in biological productivity by lowering salinity concentrations and providing a means for the ingress/egress of aquatic organisms, including species of red drum and spotted seatrout. In the study area, the Nueces River is one of the major freshwater inputs and is a vital part of the system, providing nutrients and sediment and affecting salinity, nutrient levels, circulation patterns and erosion (Tunnell et al., 1996).

3.5.1.1 Recreational and Commercial Species

The principal finfish harvested by sport-boat anglers in the study area from 1982 to 1992 were spotted seatrout, red drum, Atlantic croaker (*Micropogonias undulatus*), southern flounder (*Paralichthys lethostigma*), sheepshead (*Archosargus probatocephalus*), sand seatrout (*Cynoscion arenarius*), and black drum (*Pogonias cromis*) (Warren et al., 1994). Statistics for the Texas Coastal Fisheries show the Corpus Christi Bay system received bay and pass party-boat fishing pressure of 22 percent and landings of 51 percent of the total from 1991 to 1992, whereas the Upper Laguna Madre received 11 percent of coastwide fishing pressure and 7 percent of total Texas landings from 1983 to 1992 (Warren et al., 1994). Recreational boat landings from 1983 to 1991 for all finfish have shown an increased trend in the Nueces-Corpus Christi Bay and a decreased trend in the Upper Laguna Madre (Tunnell et al., 1996). Offshore, private anglers accounted for 25 percent of landings and 54 percent of the fishing pressure (1982-1992) with sand seatrout, king mackerel (*Scomberomorus cavalla*), and red snapper the most commonly landed finfish (Warren et al., 1994).

The most important commercial finfish species currently reported from the study area are black drum, flounder (*Paralichthyes* spp.), sheepshead, and striped mullet (*Mugil cephalus*) (Robinson et al., 1998). Leading Gulf landings for commercial finfish include grouper and snapper, with lesser numbers of cobia (*Rachycentron canadum*), black drum, and flounder also caught (Robinson et al., 1998). Overall, from 1972 to 1997, black drum, flounder, and sheepshead landings have declined in the study area (Robinson et al., 1998). However, from 1972 to 1993, 48 percent of the finfish in Texas bays were landed in the study area (Tunnell et al., 1996). In 1979, 1983, 1984, 1986, and 1987 in the Nueces-Corpus Christi Bay area, there has been an upward trend in landings, whereas in the Upper Laguna Madre, there has been a downward trend. It is not known if this is due to a shift in abundance of resources, fishing effort among bay systems, or a change in consumer demands (Tunnell et al., 1996).

The main shellfish species in the study area include brown shrimp (*Penaeus aztecus*), pink shrimp (*Penaeus duorarum*), white shrimp (*Penaeus setiferus*), blue crab (*Callinectes sapidus*), and eastern oyster (*Crassostrea virginica*). Within the study area, as with the Texas coast in general, brown shrimp are far more common than the other two penaeid species. The Upper Laguna Madre does not support a significant commercial shellfish industry; however, in the Nueces-Corpus Christi Bay system, shrimp has dominated the commercial harvest since 1975 (Tunnell et al., 1996). In addition, there were no eastern oyster landings reported by TPWD from the study area from 1993 to 1997 (Robinson et al., 1998). The commercial harvest of blue crabs in the Nueces-Corpus Christi Bay system remained low between 1972 to 1984, and from this point on, the harvest has exhibited patterns of increases and decreases. In the Upper Laguna Madre, the blue crab catch has remained low from 1972 to the present (Tunnell et al., 1996).

3.5.1.2 Aquatic Communities

In addition to the finfish discussed above as having high recreational and commercial value to humans, many additional aquatic communities are present in the study area that serve to support the ecological diversity and abundance. Other species found mainly in shallow areas include the longnose killifish (*Fundulus similis*), Gulf killifish (*F. grandis*), and tidewater silverside (*Menidia peninsulae*) (Warshaw, 1975). Inhabitants of seagrass meadows include the pinfish (*Lagodon rhomboides*), silver perch (*Bairdiella chrysura*), sheepshead, and pigfish (*Orthopristis chrysoptera*) (Warshaw, 1975). Species often found in deeper water, including the GIWW, are the Atlantic croaker, Gulf menhaden (*Brevoortia patronus*), and sea catfish (*Arius felis*), while a number of fish occur in abundance in both seagrass meadows and deeper areas, including the bay anchovy (*Anchoa mitchilli*), spot (*Leiostomus xanthurus*), and striped mullet (Warshaw, 1975). A study by Shaver (1984) of surf-zone fish revealed that almost 90 percent of the species sampled were larvae and small juveniles including sardine (*Harengula jaguana*), anchovy, Atlantic croaker, mullet, Gulf menhaden, Atlantic thread herring (*Opisthonema oglinum*), and Florida pompano (*Trachinotus carolinus*).

The entire food chain is dependent on the microscopic plankton which utilizes nutrients and provides an abundant food source. The plankton community consists of small plants (phytoplankton) and animals (zooplankton) that are suspended in the water column. Diverse and abundant plankton communities exist throughout the study area. The abundance of plankton has been directly related to salinity and temperature (Tunnell et al., 1996). Seasonal patterns have also been found with phytoplankton and zooplankton (Tunnell et al., 1996).

The benthic macroinvertebrates of the study area form a highly diverse group of organisms with a wide variety of functions in the aquatic community. Their diversity is related to salinity and, as salinity levels rise, marine species are able to colonize the system. In addition to serving as a major food source for vertebrate predators such as fish, macroinvertebrates have important roles as herbivores, detritivores, and carnivores. Tunnell et al. (1996) reported that benthic macroinvertebrates found in the sediments of the study area were primarily polychaetes, bivalves, gastropods, and crustaceans. In Nueces Bay, polychaetes and bivalves comprised the majority of the benthic macroinvertebrates. Polychaetes composed 60 percent of total abundance in Corpus Christi Bay, and bivalves were seasonally abundant. The abundance of macroinvertebrates in Corpus Christi Bay is highest during the winter and spring (Tunnell et al., 1996). Benthic communities in the Gulf nearshore waters undergo widely fluctuating, dynamic, and harsh physical conditions resulting in a few dominant organisms which are low in species diversity but high in density, including polychaetes, mollusks, and crustaceans (Tunnell et al., 1996).

Benthic fauna found in natural sand mud bottom areas offshore from Corpus Christi (for the Corpus Christi Ship Channel ocean dredged material disposal site study) include polychaetes, gastropods, decapods, bivalves, echinoderms, ribbon worms (*Rhynchocoela*), and peanut worms (*Sipuncula*) (EPA, 1988). Within this EPA document, Science Applications (1984) reported on 1983 EPA findings at the CCSC site and indicated that the sampling locations in natural mixed bottom habitat represented higher numbers of individuals, taxa, and species diversity in comparison to those found in the primarily sand-bottomed disposal sites.

3.5.1.3 Essential Fish Habitat

The proposed Project is located in an area that has been identified by the Gulf of Mexico Fishery Management Council (GMFMC) as Essential Fish Habitat (EFH) for postlarval, juvenile, and subadult red drum, brown shrimp and white shrimp, adult Spanish mackerel (*Scomberomorus maculatus*), and juvenile pink shrimp. Coordination with NMFS has been completed. EFH for these species known to occur in the project area includes estuarine emergent wetlands, estuarine mud, sand and shell substrates, SAV, estuarine water column, non-vegetated bottom, and artificial reefs. Detailed information on red drum, shrimp, and other Federally managed fisheries and their EFH is provided in the 1998 amendment of the Fishery Management Plans for the Gulf of Mexico prepared by the GMFMC. The 1998 EFH amendment was prepared as required by the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) (P.L. 104–297) as amended.

The following describes the preferred habitat of each species and relative abundance of each species based on information provided by GMFMC (1998).

Juvenile brown shrimp are considered abundant within the project area from February to April with a minor peak in the fall. The density of postlarvae and juveniles is highest in marsh edge habitat and SAV, followed by tidal creeks, inner marsh, shallow open water and oyster reefs. Juveniles and sub-adults of brown shrimp occur from secondary estuarine channels out to the continental shelf but prefer shallow estuarine areas, particularly the soft, muddy areas associated with the plant-water interface. Adult brown shrimp occur in neritic Gulf waters (i.e., marine waters extending from mean low tide to the edge of the continental shelf) and are associated with silt, muddy sand, and sandy substrates (GMFMC, 1998).

Juvenile white shrimp are considered abundant within the project area from May through November with peaks in June and September. Postlarval white shrimp become benthic upon reaching the nursery areas of estuaries, where they seek shallow water with muddy-sand bottoms high in organic detritus. As juveniles, white shrimp are typically associated with estuarine mud habitats with large quantities of decaying organic matter or vegetative cover. Densities are usually highest in marsh edge and SAV, followed by marsh ponds and channels, inner marsh, and oyster reefs. As adults, white shrimp move from estuaries to coastal areas, where they are demersal and generally inhabit bottoms of soft mud or silt (GMFMC, 1998).

Red drum occur in a variety of habitats, ranging from depths of 40 meters offshore to very shallow estuarine waters. In the juvenile life stages they are considered common within the project area year-round. They are commonly known to occur in all Gulf estuaries where they are found over a variety of substrates including sand, mud and oyster reefs. An abundance of juvenile red drum has been reported around the perimeter of marshes in estuaries (Perret et al., 1980). Young fish are found in quiet, shallow, protected waters with grassy or slightly muddy bottoms (Simmons and Breuer, 1962). Shallow bay bottoms or oyster reef substrates are especially preferred by subadult and adult red drum (Miles, 1950). Spawning occurs in deeper water near the mouths of bays and inlets and on the Gulf side of the barrier islands (Pearson, 1929; Simmons and Breuer, 1962; Perret, et al., 1980). Larvae are transported into the emergent estuarine wetlands where they mature before moving back to the Gulf.

As juveniles, Spanish mackerel are considered common in relative abundance only during the high salinity season between August and October. Although nursery areas are in emergent estuarine communities, juveniles are found offshore and in beach surf and are generally not considered estuarine dependent. Adult Spanish mackerel are usually found along coastal areas, extending out to the edge of the continental shelf (GMFMC, 1998).

Postlarvae and juveniles of pink shrimp occur in estuarine waters of wide-ranging salinity (0 to >30 ppt). Juveniles are commonly found in estuarine areas with seagrass where they burrow into the substrate by day and emerge at night. Postlarvae, juveniles, and subadults may prefer coarse sand/shell/mud mixtures. Densities are highest in or near seagrasses, low in mangroves, and near zero or absent in marshes. Adults inhabit offshore marine waters with the highest concentrations in depths of 9 to 44 meters. Preferred substrate of adults is coarse sand and shell with a mixture of less than 1 percent organic material (GMFMC, 1998).

3.5.2 Wildlife Resources

The study area lies within Blair's (1950) Tamaulipan Biotic Province. The area is semi-arid and hot, with marked deficiency of moisture for plant growth. The vertebrate fauna of this province includes considerable elements of neotropical as well as grassland species. Wildlife habitats found within the study area include upland prairies, salt marsh and seagrass beds, and tidally influenced lowlands. The coastal wetlands of the bay system are represented by salt marshes (previously defined in Section 3.4) on the delta of the Nueces River and Nueces Bay. The Upper Laguna Madre supports two Audubon sanctuaries, documented migratory/waterbird nesting sites, Padre Island National Seashore, Mollie Beattie Habitat Community and Mustang Island State Park. The Audubon sanctuaries are associated with North and South Bird islands in the Upper Laguna Madre south of the study area.

The Tamaulipan Biotic Province supports a diverse fauna composed of a mixture of species that are common in neighboring biotic provinces. The fauna includes a substantial number of neotropical species from the south, a large number of grassland species from the north and northwest, a few Austroriparian species from the northeast, and some Chihuahuan species from the west and southwest (Blair, 1950).

At least 19 species of lizards and 36 species of snakes occur in the Tamaulipan Biotic Province (Blair, 1950). Reptile species of potential occurrence in the study area include such amphibians as Blanchard's cricket frog (*Acris creptians blanchardi*), Texas toad (*Bufo speciosus*), Great Plains narrowmouth toad (*Gastrophryne olivacea*), and bull frog (*Rana catesbiana*). Terrestrial reptiles of potential occurrence in the study area include the western glass lizard (*Ophisaurus attenuatus attenuatus*), six-lined racerunner (*Cnemidophorus sexlineatus sexlineatus*), keeled earless lizard (*Holbrookia propinqua propinqua*), Texas spotted whiptail (*Cnemidophorus gularis*), western coachwhip (*Masticophis flagellum tesaceus*), ground snake (*Sonora semiannulata*), and western diamondback rattlesnake

(*Crotalus atrox*). Five species of sea turtles are also known to occur within the Gulf of Mexico and associated bays. These sea turtles include the loggerhead sea turtle (*Caretta caretta*), green sea turtle (*Chelonia mydas*), leatherback sea turtle (*Dermochelys coriacea*), Atlantic hawksbill sea turtle (*Eretmochelys imbricata*), and Kemp's Ridley sea turtle (*Lepidochelys kempii*).

The immediate study area and vicinity support an abundant and diverse avifauna. Tidal flats and beaches create excellent habitat for numerous species of gulls, terns, herons, shorebirds, and wading birds. Some common species which occur within the study area include the laughing gull (*Larus atricilla*), ring-billed gull (*Larus delawarensis*), royal tern (*Sterna maxima*), sandwich tern (*Sterna sandvicensis*), great blue heron (*Ardea herodias*), little blue heron (*Egretta caerulea*), sanderlings (*Calidris alba*), least sandpiper (*Calidris minutilla*), roseate spoonbill (*Ajaia ajaja*), and white ibis (*Eudocimus albus*). Thousands of sandhill cranes (*Grus canadensis*) utilize tall grass coastal prairies and fallow agricultural fields throughout the south Texas coast.

Other bird species which are associated with prairies and marshes include many species of raptors, songbirds, and migratory waterfowl. Texas is one of the most significant waterfowl wintering regions in North America with three to five million waterfowl annually (recent years) wintering in the state (Texas Coastal Management Program (TCMP), 1996).

At least 61 mammalian species occur or have occurred within recent times in the Tamaulipan Biotic Province (Blair, 1950). Terrestrial mammals likely to occur in the study area include the black-tailed jack rabbit (*Lepus californicus*), Gulf Coast kangaroo rat (*Dipodomys compactus*), marsh rice rat (*Oryzomys palustris*), fulvous harvest mouse (*Reithrodontomys fulvescens*), common raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), and coyote (*Canis latrans*). Marine mammals are also likely to occur within the study area. The bottle-nosed dolphin (*Tursiops truncatus*) is the marine mammal most likely to be encountered.

3.6 THREATENED AND ENDANGERED SPECIES

The Endangered Species Act (ESA) [16 U.S.C. 1531 et. Seq.] of 1973 as amended, was enacted to provide a program for the preservation of endangered and threatened species and to provide protection for the ecosystems upon which these species depend for their survival. All Federal agencies are required to implement protection programs for these designated species and to use their authorities to further the purposes of the act. The FWS and the NMFS are the primary agencies responsible for implementing the ESA. The FWS is responsible for birds and terrestrial and freshwater species, while the NMFS is responsible for non-bird marine species.

An endangered species is one that is in danger of extinction throughout all or a significant portion of its range in the U.S. A threatened species is one likely to become endangered within the foreseeable future throughout all or a significant portion of its range. State-listed threatened and endangered species, while addressed in this assessment, are not protected under the ESA, nor are Species of Concern (SOC), which are species for which there is some information showing evidence of vulnerability, but not enough data to support a Federal listing. Only those species listed as endangered or threatened by the FWS or NMFS are afforded complete Federal protection. It should be noted that inclusion on the following lists does not imply that a species is known to occur in the study area, but only acknowledges the potential for occurrence. County lists of special species provided by the Texas Parks and Wildlife Biological Conservation Data System (TXBCD, 1999) in addition to the most recent list of threatened and endangered species of Texas by county disseminated by the FWS (2000) were reviewed. TXBCD data files were also reviewed in order to obtain specific species' locations within the study area.

3.6.1 Flora

Table 3.6-1 presents Federally and State-endangered plant species and SOC that may occur in the study area. Texas Parks and Wildlife uses the same listing designations as the FWS for plants. Plants having a geographic range including Nueces and San Patricio counties are briefly discussed.

Three plant species listed by both the FWS and TPWD as endangered may potentially occur within the study area. These plants include south Texas ambrosia (*Ambrosia cheiranthifolia*), slender rush-pea (*Hoffmannseggia tenella*), and black lace cactus (*Echinocereus reichenbachii* var. *albertii*).

South Texas ambrosia is an inhabitant of open prairies in grassland/mesquite-dominated savannah in clay loam to sandy loam soils (FR 59 43648-43652). Much of its original habitat has been converted to cropland or introduced forage species. It is known from Nueces, Kleberg, and Jim Wells counties in the U.S. and Tamaulipas in Mexico. Known stands of this species occur in rights-of-way along highways and railways, where the species is subject to weed-control measures including mowing and herbicide applications (Turner, 1983). This species has a record of occurrence within the study area adjacent to the Nueces River.

The slender rush-pea is known from only four populations in Kleberg and Nueces counties. It is found in barren openings within native grassland and brush in calcareous clay soils (FWS, 1997). Introduction of non-native grasses and conversion of prairies to agriculture are thought to be responsible for its decline. It is of possible occurrence within the study area.

One endangered cactus is known to have a geographic range which includes the study area. The black lace cactus has a range in the south Texas plains which includes Jim Wells, Kleberg, and Refugio counties (Poole and Riskind, 1987). This cactus occurs in brushy, grassy areas along streams in an area where the coastal plain meets the inland mesquite/huisache/blackbrush savannah (Poole and Riskind, 1987). The occurrence of this species within the study area is unlikely due to lack of suitable soils and habitat. Texas Parks and Wildlife includes this species on their Nueces County list of rare species (TXBCD, 1999).

Six plant species identified as SOC by the FWS have records in Nueces or San Patricio counties. These species include: lila de los llanos (*Echeandia chandleri*); Texas windmillgrass (*Chloris texensis*); Thieret's skullcap (*Scutellaria thieretii*); Roughseed sea-purslane (*Sesuvium trianthemoides*); Welder machaeranthera (*Psilactis heterocarpa*); and Mathis spiderling (*Boerhavia mathisiana*). Thieret's skullcap is known from within the study area; lila de los llanos, roughseed sea-purslane, and Texas

TABLE 3.6-1

ENDANGERED, THREATENED, AND SPECIES OF CONCERN POTENTIALLY OCCURRING IN THE PROJECT AREA NUECES AND SAN PATRICIO COUNTIES, TEXAS[1]

Common Name[2]	Scientific Name[2]	Status[3]	
		FWS	TPWD
AMPHIBIANS			
Sheep frog	*Hypopachus variolosus*	--	T
Black-spotted newt	*Notophthalmus meridionalis*	--	T
South Texas siren	*Siren* sp.[1]	--	T
Rio Grande lesser siren	*Siren intermedia texana*	SOC	--
BIRDS			
Brown pelican	*Pelecanus occidentalis*	E	E
Reddish egret	*Egretta rufescens*	--	T
White-faced ibis	*Plegadis chihi*	--	T
Bald eagle	*Haliaeetus leucocephalus*	T/PDL	T
Northern gray hawk	*Buteo mitidus maximus*	SOC	--
White-tailed hawk	*Buteo albicaudatus*	--	T
Ferruginous hawk	*Buteo regalis*	SOC	--
American peregrine falcon	*Falco peregrinus anatum*	--	E
Arctic peregrine falcon	*Falco peregrinus tundrius*	--	T
Black rail	*Lateralus jamaicensis*	SOC	--
Whooping crane	*Grus americana*	E	E
Piping plover	*Charadrius melodus*	T	T
Mountain plover	*Charadrius montanus*	PT	--
Eskimo curlew	*Numenius borealis*	E	E
Sooty tern	*Sterna fuscata*	SOC	T
Black tern	*Chilidonias niger*	SOC	--
Loggerhead shrike	*Lanius ludovicianus*	SOC	--
Cerulean warbler	*Dendroica cerulea*	SOC	--
Texas olive sparrow	*Arremonops rufivirgatus*	SOC	--
Texas Botteri's sparrow	*Aimophila botteri texana*	SOC	T
Sennett's hooded oriole	*Icterus cucullatus sennetti*	SOC	--
Audubon's oriole	*Icterus graduacauda audubonii*	SOC	--
Wood stork	*Mycteria americana*	--	T

TABLE 3.6-1 (Cont'd)

Common Name[2]	Scientific Name[2]	Status[3]	
		FWS	TPWD
FISH			
Opossum pipefish	*Microphis brachyurus*	--	T
MAMMALS			
Southern yellow bat	*Lasiurus ega*	--	T
Maritime pocket gopher	*Geomys personatus maritimus*	SOC	--
Red wolf (extirpated)	*Canus rufus*	E	E
Ocelot	*Leopardus pardalis*	E	E
Jaguarundi	*Herpailurus yagouaroundi*	E	E
West Indian manatee	*Trichechus manatus*	E	E
REPTILES			
Loggerhead sea turtle	*Caretta caretta*	T	T
Green sea turtle	*Chelonia mydas*	T	T
Leatherback sea turtle	*Dermochelys coriacea*	E	E
Atlantic hawksbill sea turtle	*Eretmochelys imbricata*	E	E
Texas tortoise	*Gopherus berlandieri*	--	T
Kemp's Ridley sea turtle	*Lepidochelys kempii*	E	E
Texas diamondback terrapin	*Malaclemys terrapin littoralis*	SOC	--
American alligator	*Alligator mississipiensis*	T/SA	--
Texas horned lizard	*Phrynosoma cornutum*	--	T
Scarlet snake	*Cemophora coccinea*		
Timber/canebrake rattlesnake	*Crotalus horridus*		T
Indigo snake	*Drymarchon corais*	--	T
Northern cat-eyed snake	*Leptodeira septentrionalis*	--	T
Gulf saltmarsh snake	*Nerodia clarkii*	SOC	--
PLANTS			
Black-laced cactus	*Echinocereus reichenbachii* var,	E	E
South Texas ambrosia	*Ambrosia cheiranthifolia*	E	E
Slender rush-pea	*Hoffmanseggia tenella*	E	E
Lila de los llanos	*Echeandia chandleri*	SOC	--
Texas windmill grass	*Chloris texana*	SOC	--

TABLE 3.6-1 (Concluded)

Common Name[2]	Scientific Name[2]	Status[3]	
		FWS	TPWD
PLANTS (Concluded)			
Theiret's skullcap	*Scutellaria thieretii*	SOC	--
Roughseed sea-purslane	*Sesuvium trianthemoides*	SOC	--
Welder machaeranthera	*Psilactis heterocarpa*	SOC	--
Mathis spiderling	*Boerhavia mathisiana*	SOC	--
INSECTS			
Maculated manfreda skipper	*Stallingsia maculosus*	SOC	

[1] According to FWS (1995, 2000), TPWD (1997), and TXBCD (1999).

[2] Nomenclature follows AOU (1998), Collins (1990), Hatch et al. (1990), and Jones et al. (1997).

[3] FWS - U.S. Fish and Wildlife Service; TPWD - Texas Parks and Wildlife Department.

E	Endangered; in danger of extinction E/SA, T/SA - No longer biologically threatened or endangered but because of the similarity of appearance to other protected species, it is necessary to restrict commercial activities of specimens taken in the USA to ensure the conservation of similar species that are biologically threatened or endangered.
T	Threatened; severely depleted or impacted by man.
--	Not listed.
PDL	Proposed delisting.
PT	Federally proposed threatened.
SOC	Species of concern - species for which there is some information showing evidence of vulnerability but not enough data to support listing at this time.

windmillgrass have records of occurrence near the study area, thus the potential for occurrence of these species within the study area exists.

Lila de los llanos occurs on level to gently undulating sites along and somewhat inland from the Gulf Coast of Texas. It prefers full sunlight and grows among prairies and chaparral thickets on heavy clay and loamy clay soils (Poole, 1985). Texas windmillgrass occurs along the Gulf Coast and throughout the northeastern Rio Grande Plains of Texas. It prefers silty and sandy loam soils and is known from Nueces County (Poole et al., 2000). Thieret's skullcap occurs on shell, sand, shell ridges, or sandy meadows usually not far from brackish marshes. It is also found growing in close association within woodlands dominated by honey locust (*Gleditsia tricanthos*) and sugar hackberry *(Celtis laevigata*) in non-disturbed soils (Kral, 1983). Roughseed sea-purslane occurs on dunes of south Texas (Correll and Johnston, 1970) and in brackish swales, marshes and depressions along the coast (Jones, 1977). Poole et al. (2000), show its range occurring only in Kenedy County. Welder machaeranthera occurs in shrub-invaded grasslands and open mesquite-huisache woodlands on mostly gray clays to silty soils overlying the Lissie and Beaumont formations (Texas Organization for Endangered Species [TOES], 1993). It has been documented in both Kleberg and Nueces counties (Poole et al., 2000). Mathis spiderling is recorded in San Patricio and Live Oak counties; however, the greatest known populations are located in Mexico. This small, perennial herb grows on thin soils over limestone, in limestone cracks or rubble in tall thorn shrub, growing in the open and under shrubs (54 FR 27413-27414). No known occurrence of this species has been recorded within or in the vicinity of the study area.

3.6.2 Wildlife

Table 3.6-1 lists wildlife taxa that may occur in the study area that are considered by FWS and TPWD to be endangered, threatened or SOC. Table 3.6-1 is composed of endangered and threatened species that have a geographic range which may include Nueces or San Patricio counties. As with the flora noted above, inclusion on the list does not imply that a species is known to occur in the study area, but only acknowledges the potential for occurrence. The following paragraphs present distributional data concerning each Federally or State-listed species, along with a brief evaluation of the potential for the species to occur within the study area.

3.6.2.1 Amphibians

Four amphibians are listed by the TXBCD and FWS as potentially occurring within the study area counties. Three species that are State-listed as threatened include the sheep frog (*Hypopachus variolosus*), black-spotted newt (*Notophalmus meridionalis*), and South Texas siren (*Siren* sp.). The Rio Grande lesser siren (*Siren intermedia texana*) is identified as a SOC by the FWS. The sheep frog is known to occur in moist burrows of subterranean mammals, under vegetative debris, and around pond edges and irrigation ditches (Garrett and Barker, 1987). This species has been recorded from counties within the study area (Dixon, 1987). The black-spotted newt inhabits heavily vegetated, shallow water lagoons, streams, ditches and swamps (Garrett and Barker, 1987). The black-spotted newt may occur in wetland sites within the study area. The South Texas siren is known to occur in the study area in habitat similar to that occupied by the black-spotted newt. However, the newt requires year-round open water since it cannot aestivate in dry ground like the siren. The Rio Grande lesser siren prefers warm, shallow waters with vegetative cover such as those in ponds, irrigation canals and swamps in permanently to semipermanently inundated areas in counties along the lower coast of Texas and along the Rio Grande (Bartlett and Bartlett, 1999).

3.6.2.2 Birds

Twenty-four endangered, threatened, and SOC bird species are listed by the FWS and/or TXBCD as occurring or potentially occurring in the study area. Several of these are predominantly inland species that are not ordinarily expected on the coast, or are migrants that pass through the region seasonally. Others may occur as breeding birds, permanent residents, or post-nesting visitors. Federally listed species are described below, followed by descriptions of State-listed species and then Federal SOC.

The Federally and State-endangered brown pelican (*Pelecanus occidentalis*) is primarily a coastal species that rarely ventures very far out to sea or inland. In Texas, it occurs primarily along the lower and middle coast, and now common sightings are reported on the upper coast and inland to central, north-central and eastern Texas, usually on large freshwater lakes (Texas Ornithologists Union (TOS), 1995). Brown pelicans are colonial nesters, usually nesting on undisturbed offshore islands in small bushes and trees, including mangroves (National Fish and Wildlife Laboratory (NFWL), 1980; Guzman and Schreiber, 1987). This species is a common resident of the area and is likely to occur in the open water habitat and sand/mud flats in the study area. Pelican Island, located just south of the CCSC, is a major brown pelican nesting site.

The bald eagle (*Haliaeetus leucocephalus*) has recovered sufficiently to be downlisted to threatened throughout its range, and the FWS has proposed to completely delist the species in the near future (64 FR 36453-36363; July 6, 1999). Two subspecies are currently recognized based on size and weight: the northern bald eagle and the southern bald eagle. The northern population nests from central Alaska and the Aleutian Islands through Canada into the northern U.S. The southern population primarily nests in estuarine areas of the Atlantic and Gulf coasts, northern California to Baja California, Arizona and New Mexico (Snow, 1981). Wintering ranges of the two populations overlap. The bald eagle inhabits coastal areas, rivers and large bodies of water as fish and waterfowl comprise the bulk of their diet. Nests are seldom far from a river, lake, bay, or other water body. Nest trees are generally located in woodlands, woodland edges, or open areas, and are frequently the dominant or co-dominant tree in the area (Green, 1985). The 1999 bald eagle nesting survey in Texas identified 82 nesting territories statewide, the southernmost found in Refugio, Goliad, Victoria, and Matagorda counties (Mitchell, 1999). Concentrations of wintering northern eagles are often found around the shores of reservoirs in Texas, with most wintering concentrations occurring in the eastern part of the state. Wintering bald eagles in Texas have been observed as far south as Cameron County (Oberholser, 1974), and are considered to be a rare permanent resident in the Coastal Bend (Rappole and Blacklock, 1985). No nests are known to occur in the study area, nor have any been reported from Nueces County (Mitchell, 1999). The bald eagle should occur in the study area only as a rare migrant or post-nesting visitor.

Each year, the entire breeding population of the Federal and State-endangered whooping crane (*Grus americana*) migrates 2,600 miles from Canada's Northwest Territories and winters in the prairies, salt marshes and bays along a narrow section of the Texas coast centered around the Aransas

National Wildlife Refuge. Rest areas along the migration route include the central and eastern panhandle of Texas (FWS, 1995). In Texas, the principal winter habitat is brackish bays, marshes, and salt flats, and whooping cranes will feed in nearby upland sites characterized by oak mottes, grassland swales, and ponds (Campbell, 1995). In Texas, they eat a wide variety of plant and animal foods, including blue crabs, clams, berries of Carolina wolfberry (*Lycium carolinianum*), acorns, snails, crayfish, and insects (Campbell, 1995). The whooping crane has been recorded from counties within the study area but is generally restricted to the Aransas National Wildlife Refuge in Aransas, Refugio, and Calhoun counties. Though the leeward side and interior of Padre Island provide suitable winter habitat for whooping cranes, they are unlikely to occur in the study area.

The Federally and State-threatened piping plover is a winter resident and spring and fall migrant of the study area. This small shorebird breeds in the northern Great Plains of the U.S. and Canada, along beaches of the Great Lakes, and along the Atlantic coastline from North Carolina to Newfoundland (Haig and Oring, 1987). Post-breeding and wintering sites include the southern U.S. Atlantic coastline; the Gulf of Mexico from Florida to Veracruz, Mexico; and on scattered Caribbean islands (Haig and Oring, 1985). The piping plover can be found along Texas beaches, tidal flats, mud flats, sand flats, dunes, and offshore spoil islands (American Ornithologists Union (AOU), 1998; FWS, 1995) arriving in mid- to late July (Haig and Oring, 1985). The piping plover is a regular migrant and winter resident along the lower Texas coast (Oberholser, 1974; Haig and Oring, 1985). The checklist of birds of Mustang Island State Park lists the piping plover as a fairly common winter resident and a common migrant (Pulich et al., 1985). This species is also known to occur within the Mollie Beattie Habitat Community (Zonick and Ryan, 1996; GLO and FWS, 1998). This species has been documented here as recently as August 2001 (PBS&J, in-house data). As a result of a lawsuit, critical habitat was designated for this species in its nesting and wintering grounds (65 FR 41781-41812, July 6, 2000). Designation of critical habitat became final on July 10, 2001 (66 FR 36038). Portions of the study area, but not the footprint of the project, are within Critical Habitat units TX-6, TX-7, TX-8, TX-9, TX-10, TX-11, TX-12, TX-13, TX-14, and TX-16. Designation of critical habitat became final on July 10, 2001 (66 FR 36038).

The mountain plover (*Charadrius montanus*) was proposed for listing as a Federally threatened species on February 16, 1999 (64 FR 7587). Non-breeding birds prefer short-grass plains, fields, plowed fields, sandy deserts, and sod farms (NatureServe, 2000a). The mountain plover is a rare to uncommon local winter resident on the coastal plains and inland from south Texas through the Edwards Plateau into the South Plains (TOS, 1995). The mountain plover has been recorded from Nueces County (Oberholser, 1974). It is most likely to occur in agricultural areas away from the seashore. This species appears as an uncommon migrant on the checklist for birds of the Corpus Christi area (Audubon Outdoor Club of Corpus Christi (AOCCC), 1994), but is absent from checklists for Mustang Island State Park (Pulich et al., 1985) and the Padre Island National Seashore (Southwest Parks and Monuments Association (SPMA), 1990). This species is unlikely to occur within the study area.

The current status of the Eskimo curlew (*Numenius borealis*) is considered uncertain and possibly extinct (TOS, 1995), but the species is considered Federally and State-listed as endangered. This species was extremely abundant in the nineteenth century, but was subject to extreme hunting pressures. The breeding habitat of the Eskimo curlew was treeless arctic and subarctic tundra (Gill et al., 1998). Non-breeding birds use a variety of habitats, such as grasslands, pastures, plowed fields, and less frequently, marshes and mud flats (AOU, 1983). Spring migration would bring them through Texas and the midwestern U.S. (Gill et al., 1998) from mid-March to late April in Texas (Oberholser, 1974). One record does exist from Galveston, Texas, in 1962, and others since have been reported, but the validity of these records is uncertain (TOS, 1995). The Eskimo curlew is unlikely to occur in the study area due to its extreme rarity and the lack of recent records of occurrence.

The reddish egret (*Egretta rufescens)*, a State-threatened species, typically inhabits saltwater bays and marshes. Its breeding range is restricted to the Gulf Coast where it commonly nests in yucca-prickly pear thickets (Oberholser, 1974). The white-faced ibis (*Plegadis chihi*), State-listed as threatened, is a common resident along the coast. Preferred habitats of the white-faced ibis have been described as ranging from freshwater marshes and sloughs and irrigated rice fields to salt marshes (Oberholser, 1974). Both of these species occur within the study area.

The white-tailed hawk (*Buteo albicaudatus*) is listed as State threatened and is considered an uncommon local resident along the Texas coastal plain (TOS, 1995). The white-tailed hawk could be present in savannah-like, grassland habitats within the study area.

All North American peregrine falcons were delisted from the endangered species list (64 FR 46541-46558, August 2, 1999). The Arctic peregrine falcon (*Falco peregrinus tundrius*), which was listed as endangered due to similarity of appearance (E/SA) was delisted Federally but remains on the TPWD threatened list. The Arctic peregrine falcon winters along the entire Gulf Coast and occurs statewide during migration (FWS, 1995). The American peregrine falcon (*Falco peregrinus anatum*) remains on the State endangered list.

The sooty tern (*Sterna fuscata*), State-listed as threatened and a Federal SOC, is considered a rare local summer resident along the central and lower coast (TOS, 1995). This pelagic bird spends almost its entire life at sea. Many records have been reported on the Texas coast following large tropical storms. Oberholser (1974) shows a breeding and a summer record of the sooty tern in Nueces County. This species is a rare but potential vagrant to the study area.

The Texas Botteri's sparrow (*Aimophila botterii texana*) is an uncommon to locally common summer resident on the lower coastal plain, with isolated breeding records from Duval, Jim Wells, and San Patricio counties (TOS, 1995). This sparrow is an inhabitant of tall bunch grass prairie with widely scattered shrubs and small trees mostly within 20 miles of the Gulf Coast (Oberholser, 1974). The reason for a decline in numbers of this species is attributed mostly to depletion of habitat due to agriculture practices (Oberholser, 1974). Texas Parks and Wildlife considers this sparrow to be State threatened.

The wood stork (*Mycteria americana*) is listed as threatened by TPWD. This bird is an uncommon to common post-breeding visitor to the central and upper coastal prairies and a regular visitor of lakes and reservoirs in central and east Texas. This species has been recorded within the study area counties (Oberholser, 1974; TOS, 1995).

Two additional *Buteo* species, northern gray hawk (*Buteo nitidus maximus*) and ferruginous hawk (*Buteo regalis*), are considered SOC by the FWS. The northern gray hawk is a rare to uncommon local resident in the Lower Rio Grande Valley (TOS, 1995). In Texas, this hawk inhabits mature woodlands of the river valleys and nearby semi-arid mesquite and scrub grasslands (Oberholser, 1974). Oberholser (1974) shows a fall record of the northern gray hawk from Nueces County. This species is unlikely to occur in the study area. The ferruginous hawk ranges the wide open spaces of the dry Great Plains and Great Basin in western North America (Oberholser, 1974). It may occur in the study area as a migrant or winter resident. It is considered locally uncommon on Texas' barrier islands and the central and south coastal plains (TOS, 1995). Two ferruginous hawks are known to overwinter in the study area (Beasley, 1998).

Three additional avian SOC of potential occurrence in the study area include the black rail (*Laterallus jamaicensis*), black tern (*Chlidonias niger*), and loggerhead shrike (*Lanius ludovicianus*). The black rail is a rare migrant and winter resident in the state (Oberholser, 1974) and a potential migrant to the study area. It is primarily a bird of coastal marshes, typically dominated by smooth cordgrass. The black tern is a common migrant in all parts of Texas including offshore waters (TOS, 1995). It breeds in marshy areas of the northern U.S. and Canada, and may migrate through Texas during all months except January, February, and March (Oberholser, 1974). This species occurs within the study area. The loggerhead shrike is an inhabitant of open country with scattered trees and shrubs. It is a rare to common resident throughout the state, except for portions of the South Texas Plains. It is a possible resident/migrant within the study area.

Four songbirds of potential occurrence within the study area are considered SOC by the FWS. These four species are: cerulean warbler (*Dendroica cerulea*), Texas olive sparrow (*Arremonops rufivirgatus*), Sennett's hooded oriole (*Icterus cucullatus sennettii*), and Audubon's oriole (*Icterus gradaucada audubonii*). The cerulean warbler is a rare to uncommon spring migrant in the eastern half of the state, mostly on the coast, and south to the Rio Grande Valley (TOS, 1995) and prefers deciduous or mixed woodlands near stream bottoms. It is likely to occur within the study area only during migration. The olive sparrow is a common resident in south Texas, extending north to Goliad, Karnes, Uvalde, and Val Verde counties (TOS, 1995). This sparrow inhabits dense brushy areas where it spends much of its life on or near the ground. This species is unlikely to inhabit the study area, due to lack of appropriate habitat. Sennett's oriole is a summer resident and rare winter resident in south Texas. It inhabits areas closely associated with towns where it nests in palm (*Washingtonia* sp. and *Sabal* sp.) and pecan (*Carya illinoinensis*) trees (Oberholser, 1974). Audubon's oriole is a rare to uncommon resident in south Texas and is typically found in wooded or brushy areas. During the warmer months, it tends to prefer mesquite woodlands; in winter it can be found in evergreen trees such as live oak (*Quercus virginiana*) along with huisache (*Acacia smallii*) and Texas ebony (*Pithecellobium flexicaule*) (Oberholser, 1974). The presence of either of these orioles in the study area is unlikely.

3.6.2.3 Fish

A candidate species is, as its name implies, a candidate for listing under the ESA. More specifically, it is a species or vertebrate population for which sufficient reliable information is available that a listing under the ESA may be warranted. There are no mandatory Federal protections required under the ESA for a candidate species (NMFS, 2001).

The dusky shark (*Carcharhinus obscurus*), also known as the bronze whaler or black whaler, was added to the NMFS candidate species list in 1997. It has a wide-ranging (but patchy) distribution in warm-temperate and tropical continental waters (NMFS, 2001). It is coastal and pelagic in its distribution where it occurs from the surf zone to well offshore and from surface depths to 400 meters (Compagno, 1984). Because it apparently avoids areas of lower salinities, it is not commonly found in estuaries (Compagno, 1984; Musick et al., 1993).

The Atlantic and Gulf of Mexico populations of the sand tiger shark (*Odontspis taurus*) were added to the candidate species list in 1997. Sand tiger sharks have a broad inshore distribution. In the western Atlantic, this shark occurs from the Gulf of Maine to Florida, in the northern Gulf of Mexico, in the Bahamas and in Bermuda. Although first reported in Texas in the 1960s, this species does not seem to be uncommon (Hoese and Moore, 1998). A cool temperate species, it is more common north of Cape Hatteras (Hoese and Moore, 1998). They are generally coastal, usually found from the surf zone down to depths around 75 feet. However, they may also be found in shallow bays, around coral reefs and to depths of 600 feet on the continental shelf. They usually live near the bottom, but may also be found throughout the water column (NMFS, 2001).

NMFS designated the night shark (*Carcharhinus signatus*) a candidate species in 1997. Data on this species are minimal because the shark is a deepwater shark. The shark has been reported in waters from Delaware south to Brazil, including the Gulf of Mexico. It has also been reported from West Africa. It was formerly abundant in deep waters off the northern coast of Cuba and the Straits of Florida (NMFS, 2001).

The speckled hind (*Epinephelus drummondhayi*) inhabits warm, moderately deep waters from North Carolina to Cuba, including Bermuda, the Bahamas and the Gulf of Mexico. The preferred habitat is hard bottom reefs in depths ranging from 150 to 300 feet, where the temperatures are from 60 to 85 degrees Fahrenheit (°F). The speckled hind was added to the candidate species list in 1997 (NMFS, 2001).

NMFS designated the saltmarsh topminnow (*Fundulus jenkinsi*) as a candidate species in 1997. This rare species is restricted to coastal streams and adjacent bay shores on the western side of Galveston Bay and from Vermilion Bay to the Florida Panhandle. Usually found in low salinities, it has been taken from the Chandeleur Islands (Hoese and Moore, 1998). This species tends to live in salt marshes and brackish water, although it has been known to survive in freshwater. This species can also be found in shallow tidal meanders of *Spartina* marshes (NMFS, 2001).

The goliath grouper (*Epinephelus itajara*), formerly named the jewfish, was added to the candidate species list in 1991 for the region of North Carolina southward to the Gulf of Mexico, which encompasses the entire range of this species in U.S. waters. Historically, goliath grouper were found in tropical and subtropical waters of the Atlantic Ocean, both coasts of Florida, and from the Gulf of Mexico down to the coasts of Brazil and the Caribbean. They were abundant in very shallow water, often associated with piers and jetties along the Florida Keys and southwest coast of Florida (NMFS, 2001).

The Warsaw grouper (*Epinephelus nitrigus*) was added to the candidate species list in 1997. It is a very large fish found on the deepwater reefs of the southeastern United States. Warsaw grouper range from North Carolina to the Florida Keys and throughout much of the Caribbean and Gulf of Mexico to the northern coast of South America. The species inhabits deepwater reefs on the continental shelf break in waters 350 to 650 feet deep. As for all of the candidate species above, the main threat to them has been mortality associated with fishing (NMFS, 2001).

The TXBCD includes one State-threatened fish, which may potentially occur in the project area. The opossum pipefish (*Microphis brachyurus*) has been reported from the Rio Grande River, and in *Spartina* marshes as well as in *Sargassum* mats in the Gulf of Mexico (Hoese and Moore, 1998). Brooding adults are found in fresh or low salinity waters and the young move into more saline waters (TXBCD, 1999).

3.6.2.4 Mammals

The red wolf (*Canis rufus*) has been considered extinct in the wild since 1980 according to Davis and Schmidly (1994). This species inhabited brushy and forested areas along the coastal prairies throughout the eastern half of Texas (Davis and Schmidly, 1994).

The ocelot (*Leopardus pardalis*) and the jaguarundi (*Herpailurus yagouaroundi*) are listed by the FWS and TPWD as endangered. Both of these cat species' historic range included San Patricio and Nueces counties and both are included on TXBCD's Special Species List as potentially occurring in the counties in which the study area occurs The ocelot is a medium-sized cat which ranges from southern Texas and Arizona to northern Argentina (Campbell, 1995). According to Campbell (1995), the ocelot prefers habitat described as dense thorn scrub with a dense canopy cover. Ocelots have been known to prey on small mammals, birds, reptiles, amphibians and some fish (Davis and Schmidly, 1994). The ocelot currently occurs only in the extreme southern part of the state (Davis and Schmidly, 1994) and is unlikely to occur in the study area, due to the lack of suitable brushy habitat.

The Federally and State-listed endangered jaguarundi occurs in south Texas, eastern and western portions of Mexico, and south into South America (Hall, 1981). In Texas, this cat inhabits very similar habitat as described for the ocelot: very dense thornscrub (Davis and Schmidly, 1994) with a preference for streams (Goodwyn, 1970; Davis and Schmidly, 1994). Jaguarundi distribution in Texas should be considered restricted to the Rio Grande Valley (Tewes and Everett, 1987). Due to the lack of suitable brushy habitat and any known populations in the area, this species is unlikely to occur in the study area.

The West Indian manatee (*Trichechus manatus*) is a Federally and State-listed endangered aquatic mammal which inhabits brackish water bays, large rivers, and salt water (Davis and Schmidly, 1994). They feed upon submergent, emergent, and floating vegetation with the diet varying according to plant availability (O'Shea and Ludlow, 1992). The manatee is more common in the warmer waters off of coastal Mexico, the West Indies, and Caribbean to northern South America (NatureServe, 2000b). In the U.S., populations are primarily found in Florida, but occasional vagrants migrate along the coast into Texas. Although extremely rare in Texas, recent Texas records include specimens from Cameron, Galveston, Matagorda, and Willacy counties (FWS, 1995). Davis and Schmidly (1994) describe a record of a manatee which was found dead in the surf near the Bolivar Peninsula near Galveston, Texas. Albert Oswald of the Texas State Aquarium spotted a manatee in the inlet between the Texas State Aquarium and the Lexington Museum on 23 September 2001. This is the third and probably most reliable sighting of the manatee in Corpus Christi Bay (Beaver, 2001). While the West Indian manatee has been recently sighted in Corpus Christi Bay, such occurrences are rare.

The southern yellow bat (*Lasiurus ega*) is a neotropical bat that is listed as State threatened. In the U.S., this bat has been recorded from southern California, southern Arizona, extreme southwestern New Mexico and south Texas (Schmidly, 1991). In Texas, the southern yellow bat occurs in the extreme south where it utilizes trees as roosting sites. In some areas of south Texas, palm trees appear to be preferred roosting sites (Davis and Schmidly, 1994). This mammal is unlikely to be found in the study area.

The maritime Texas pocket gopher (*Geomys personatus maritimus*), a Federal SOC, is known from Kleberg and Nueces counties (TOES, 1995; TXBCD, 1999). It inhabits areas with deep, sandy soils where it constructs its burrows and tunnels. It is a possible resident of the study area.

3.6.2.5 Reptiles

Five sea turtles are Federally and State endangered within Nueces and San Patricio counties. These sea turtles include the loggerhead sea turtle (*Caretta caretta*), green sea turtle (*Chelonia mydas*), leatherback sea turtle (*Dermochelys coriacea*), Atlantic hawksbill sea turtle (*Eretmochelys imbricata*), and Kemp's Ridley sea turtle (*Lepidochelys kempii*). These sea turtles are known to occur in the Gulf of Mexico, including associated bay and estuarine waters and sometimes nest along the Gulf beaches (Garrett and Barker, 1987). It is a possibility for any of these species to be observed within the study area.

The loggerhead sea turtle is widely distributed within its range. It can be found in waters hundreds of miles offshore as well as inshore areas such as bays, lagoons, salt marshes, ship channels, and mouths of large rivers (FWS, 1995). This species feeds on various marine invertebrates – crustaceans, mollusks, sponges, echinoderms, gastropods and some plants, fish, and jellyfish. They nest on high energy beaches on barrier islands with steeply sloped beaches and gradually sloped offshore approaches. The nesting range in the U.S. is mainly the Atlantic Coast, although nesting on barrier islands along the Texas coast has been recorded (NMFS and FWS, 1991a; Shaver, 2000).

The green sea turtle's favored habitat appears to be lagoons and shoals with an abundance of marine grasses and algae (FWS, 1995). The adults are primarily herbivorous while the juveniles consume more invertebrates. Foods consumed include seagrasses, macroalgae and other marine plants, mollusks, sponges, crustaceans, and jellyfish (Mortimer, 1982). Terrestrial habitat is typically limited to nesting activities on deep, coarse to fine sands with little organic content, along high energy beaches. Major nesting activity occurs in Costa Rica and Surinam with small numbers nesting in

Florida and rarely in Texas, Georgia and North Carolina (NMFS and FWS, 1991b). This species has been recorded in Nueces County (Dixon, 2000).

Leatherback sea turtles are considered to be the most pelagic of the sea turtles, seldom approaching land except for nesting. They are mainly found in coastal water only when nesting and when following concentrations of jellyfish, which is the principal food source (TPWD, 2000; FWS, 1995; Garrett and Barker, 1987). The leatherback nests on sandy, sloping beaches, often near deepwater and rough seas (NMFS and FWS, 1992). The largest nesting beaches are found in the U.S. Virgin Islands, Puerto Rico, and Florida (NMFS, 2000).

The Atlantic hawksbill sea turtle is found in rocky bottom, shallow, coastal water areas, lagoons, estuaries, and mangrove-bordered bays in water generally less than 60 feet deep (FWS, 1995). This species prefers foraging habitat of coral reefs, rocky outcrops, and high energy shoals, which are optimum sites for sponge growth; sponge being one of their principal food sources. Other forage foods include crabs, sea urchins, shellfish, jellyfish, plant material, and fishes. Nesting activities may include deep sand beaches of low energy to high energy beaches. Nesting in the Continental U.S. is limited to the southeast coast of Florida, Florida Keys, Puerto Rico, and U.S. Virgin Islands. Most of the Texas sightings involve posthatchlings and juveniles which are primarily associated with stone jetties and originated from nesting beaches in Mexico (NMFS, 2000).

The Kemp's Ridley sea turtle is known to inhabit shallow coastal and estuarine waters usually over sand or mud bottoms where a food source of crabs can be found (FWS, 1995). Other food items include shrimp, snails, bivalves, sea urchins, jellyfish, sea stars, fish, and occasional marine plants (Campbell, 1995). Nesting activities are essentially restricted to the Gulf of Mexico at Rancho Nuevo, Tamulipas, Mexico. Sporadic nesting has been reported from Mustang Island, Texas southward to Isla Aquada, Campeche, Mexico (NMFS, 2000; Hildebrand 1983, 1986, 1987).

The American alligator (*Alligator mississippiensis*) was first Federally-listed as endangered in 1967 because hunting and poaching had substantially reduced its numbers. It was reclassified as threatened in certain parts of Texas in 1977 because of partial recovery. In 1983, it was further reclassified in Texas as threatened due to similarity of appearance (T/SA) reflecting complete recovery of the species in the state. Thus, in Texas, the alligator is no longer biologically threatened or endangered, but because of the similarity of appearance of its hides and parts to those of protected crocodilians elsewhere, it is necessary to restrict commercial activities involving alligators taken in Texas to safeguard against excessive harvesting, and to ensure the conservation of other crocodilians that are still biologically threatened or endangered. The potential for this species to occur within the study area is low.

The Texas tortoise (*Gopherus berlandieri*) and Texas horned lizard (*Holbrookia lacerata*) are listed as threatened species by TPWD. Texas tortoise is confined to arid south Texas and northeastern Mexico. The Texas tortoise prefers sandy soils in areas of low, sparse vegetation (Garrett and Barker, 1987). If appropriate habitat is present then some potential for their occurrence exists within the study area. The Texas horned lizard was historically found throughout the state in areas with flat, open terrain, scattered vegetation, and sandy or loamy soils. Over the past 20 years, it has almost vanished from the eastern half of the state, but still maintains relatively stable numbers in west Texas. This species has been recorded from counties within the study area (Dixon, 1987) and may occur within the study area.

Three snakes that are listed as threatened by TPWD, but not by the FWS, and may potentially occur in the study area are scarlet snake (*Cemophora coccinea*), timber/canebrake rattlesnake (*Crotalus horridus*), and Texas indigo snake (*Drymarchon corais*) (Dixon, 1987; TXBCD, 1999). In addition, the Gulf salt marsh snake (*Nerodia clarkii*) is considered a SOC by the FWS (2000). The scarlet snake inhabits loose, sandy soil potentially associated with baygall thickets, live oaks scattered across sand dunes, watermelon patches, and dry, sandy land dominated by honey mesquite, huisache and prickly pear (*Opuntia* sp.) (Werler and Dixon, 2000; Tennant, 1984). The timber rattlesnake prefers moist lowland forests and hilly woodlands near rivers, streams, and lakes characterized by hollow logs and decaying tree stumps within the eastern third of Texas (Werler and Dixon, 2000). Potential for occurrence would likely be associated with brushy or woody lowland areas adjacent to the bay or Nueces River. The Texas indigo snake is most common in thorn brush woodland in riparian corridors and in mesquite savannah (Tennant, 1984). The Gulf salt marsh snake inhabits crayfish and fiddler crab burrows in the saltgrass-lined margins of tidal mud flats (Garrett and Barker, 1987). This species is shown to be outside of its range in Nueces County by Dixon (1987), yet the FWS (2000) indicates Nueces County to be within its range. Although there is potential for the scarlet snake to occur within the study area, this rare snake is unlikely to be found. Potential occurrence of the Texas indigo snake is low due to the lack of suitable habitat, except inland or on Padre Island. Habitat for the Gulf salt marsh snake is present in the study area, thus there is potential for its occurrence.

The Texas diamondback terrapin (*Malaclemys terrapin littoralis*) is identified as a SOC by the FWS (2000) in Nueces County. This species occurs from the Texas-Louisiana border south to Nueces County (Dixon, 1987). The Texas diamondback terrapin is the only turtle in the world entirely restricted to estuarine habitat, where it lives in coastal marshes, tidal mudflats, and tidal creeks (Garrett and Barker, 1987). This species has been observed in the Upper Laguna Madre (EH&A, 1993) and may occur in the study area.

3.6.2.6 Insects

One insect species, the maculated manfreda skipper (*Stallingsia maculosus*), is a rare butterfly known from several south Texas counties and northern Mexico. The FWS (2000) identifies this species as a SOC in Nueces and Kleberg counties. The larvae of this species are closely associated with Texas tuberose (*Manfreda maculosus*) which grows on prairies and chaparral covered hills of the Rio Grande Valley and Plains (Tilden and Smith, 1986; Correll and Johnston, 1970). Its presence in the study area is unlikely.

3.7 HAZARDOUS, TOXIC, RADIOACTIVE WASTE

The purpose of the Hazardous, Toxic, Radioactive Waste (HTRW) assessment is to identify indicators of potential hazardous materials or waste issues relating to the study area. A review of a regulatory agency database information search, an aerial photographic review, interviews with regulatory officials, and a site reconnaissance were conducted to determine the location and status of sites regulated by the State of Texas and the EPA and any unreported hazardous material sites. The support data for the assessment can be found in PBS&J Document No. 010095 entitled "Hazardous, Toxic, and Radioactive Waste Assessment, Corpus Christi Ship Channel – Channel Improvements Project, Corpus Christi and Nueces Bays, Nueces and San Patricio Counties, Texas" dated April 2001. A review of oil and gas wells and pipelines located within the study area was also conducted.

The review of the regulatory agency database search indicated a total of 1,611 sites or listings associated with 257 facilities or properties located within the study area. Several of these listings were associated with the same facilities or property (e.g., a facility/property containing multiple petroleum storage tanks and is the site of several reported spills or emergency response actions). On the basis of the results of the regulatory database searches, the following sites are located within the subject area:

- 16 CERCLIS/NFRAP/CORRACT sites;
- 27 RCRA generators sites;
- 5 RCRA treatment, storage, and disposal sites;
- 296 petroleum storage tanks;
- 55 leaking underground storage tank sites;
- 2 State voluntary cleanup sites;
- 528 reported emergency response actions at 60 facilities/properties;
- 323 reported spills at 58 facilities/properties;
- 7 NPDES sites;
- 152 TRI listings associated with one facility; and
- 200 FINDS listings associated with 69 facilities/properties.

No National Priority List, State Superfund or City/County solid waste landfill sites were located within the study area.

Examination of the aerial photographic coverage indicated that the study area includes a variety of land uses which include highly developed residential-urban, heavy industrial, government land, recreational, range-pasture, and saline and brackish-water marsh. Generally, the land immediately adjacent to the southern shore of Corpus Christi and Nueces Bays is highly developed, while the land immediately adjacent to northern shore is moderately developed to undeveloped. Mustang Island is sparsely developed.

The urban areas of the cities of Corpus Christi (including Flour Bluff), Port Aransas, Aransas Pass, Ingleside, and Portland include residential, commercial, governmental, and some industrial development. The Inner Harbor, which is identified as the land-locked segment of the CCSC, is a highly developed industrial area. Similarly, the northern shore of Corpus Christi Bay includes industrial development and a U.S. Department of Defense (DoD) facility.

According to TNRCC regional officials, the industrial activity adjacent to the Inner Harbor of the CCSC and La Quinta Channel has caused measurable impacts to the groundwater adjacent to the waterways. The seepage of contaminated groundwater to the waterway has been nearly contained through the efforts of the TNRCC and the responsible parties. Historically, the groundwater seepage to the Inner Harbor is reported to occur adjacent to Elementis Chrome and involves hydrocarbon from an upgradient petroleum refinery and chrome from the Elementis facility. The release of hydrocarbon contaminated groundwater has been under control since mid-2000, while some contaminated groundwater containing chromium has likely seeped into the surface water in the channel within the last year. Groundwater seepage to La Quinta Channel is reported by the TNRCC to occur adjacent to the DuPont Corpus Christi Plant. A total of five contaminate plumes are documented to exist at the facility. According to a DuPont Baseline Risk Assessment Report (March 7, 1997), which presents results from groundwater modeling and a risk assessment, contaminants are discharging to Corpus Christi Bay. The TNRCC approved a Response Action Plan for one of the areas of concern (Bulk Storage and Rail Loading Area) in January 2000. The constituents of concern are carbon tetrachloride and perchloroethane (PCE).

The results of the oil/gas well review indicate a total of 1,568 permitted well sites located within the study area. These well sites include 1,368 vertical wells and 200 directional wells. The database indicates that the vertical well sites include the following types/status:

- 378 are listed as active producing oil/gas wells;
- 573 as plugged;
- 291 as dry holes;
- 75 as permitted locations;
- 41 as abandoned locations;
- 5 as injection wells; and
- 5 well sites as unknown.

The database indicates that the directional well sites include the following types/status:

- 67 active producing oil/gas wells;
- 56 plugged wells;
- 40 dry holes;
- 20 permitted well sites;
- 10 abandoned locations;
- 3 shut-in wells;
- 1 injection well; and
- 3 well sites were listed as the type/status of unknown.

A total of 473 pipelines/pipeline segments were identified within the study area. Two hundred sixty-six of the pipelines are listed as active, 193 are listed as inactive, and the status of 14 pipelines was unknown. The pipelines are reported to transport the following material:

- 199 transport natural gas;
- 93 crude oil;
- 91 oil and gas;
- 25 gasoline;
- 12 gas and condensate;
- 7 condensate;
- 10 propane/propylene;
- 6 ethane/ethylene;

- 22 miscellaneous gases and products; and
- 8 were listed as idle.

Based on the findings of the HTRW survey, there is moderate potential of encountering contaminated material during construction of the project. According to TNRCC regional officials, the industrial activity adjacent to the Inner Harbor of the CCSC and the turning basin of La Quinta Channel has caused measurable impacts to the groundwater adjacent to the waterways. The seepage of contaminated groundwater to these waterways has resulted in the potential of impacting channel sediments (refer to Section 3.3 for sediment quality). However, all material from the Inner Harbor will be placed in confined upland areas and the only project activity for the La Quinta Channel is extension beyond the turning basin.

The TNRCC reported a contaminate plume containing hydrocarbons and chromium seeping into the Inner Harbor adjacent to the Elementis Chrome facility. According to analytical results of sediment samples collected from the channel in 1983, 1988, 1991, 1994, 1997, and 2000, chromium was found above detection limits, but well below the ERL, at all sampling stations for each year. Hydrocarbons were not detected in the samples until the 2000 sampling event. The TNRCC reports that the release of hydrocarbon-contaminated groundwater to the waterway has been significantly reduced or eliminated since mid-2000.

The TNRCC also reported a contaminate plume containing carbon tetrachloride and perchloroethane seeping into the La Quinta Channel turning basin adjacent to the DuPont Corpus Christi Plant. Previous analytical testing of water and sediment samples included basic and supplemental parameters but did not include these two constituents of concern.

In addition, with the laws and regulations which govern the handling of hazardous material, there is a decreased risk of future releases of hazardous material causing long-term detrimental impacts to the sediments of the study area. However, any activity regarding releases of hazardous material into the waters of the study area and the resulting remediation should be monitored through the regulatory agencies.

3.8 HISTORIC RESOURCES

The Corpus Christi study area is located in the Southern Coastal Corridor (SCC) Archeological Region of the Central and Southern Planning Region of Texas as delineated by the Texas Historical Commission (Mercado-Allinger and Ricklis, 1996). This Archeological Region encompasses the Coastal Bend from the Colorado River in Matagorda County south to the Rio Grande (Bailey, 1987; Ricklis, 1990). The study area is confined to the Corpus Christi and Nueces bays in San Patricio and Nueces counties.

The SCC Archeological Region contains five subareas, each possessing unique geographic and cultural features. The current study area in Corpus Christi Bay is in the Aransas/Guadalupe subarea with a small portion in Nueces County being included in the Baffin/Oso subarea. In these subareas the primary resource zones are the coastal estuaries and terrestrial flood plains with adjacent prairies.

3.8.1 Cultural History Overview

Archaeological evidence supports the continued presence of indigenous groups in the SCC Archeological Region from at least 10,000 B.C. through the time of European contact and colonization (Mercado-Allinger and Ricklis, 1996). The generally accepted cultural history of the area is divided into four periods, the Paleoindian, Archaic, Late Prehistoric, and Historic. Each of these periods is briefly summarized below.

3.8.1.1 Paleoindian Period

The Paleoindian period in the SCC Archeological Region is the earliest recognized cultural period, dating from at least 10,000 B.C. to circa 6,000 B.C. Little is known about this initial adaptation of the region, but researchers have suggested that this period was marked by a very low population density, small band sizes, and extremely large territorial range (Black, 1989). Material indications of the Paleoindian period include projectile point types such as *Clovis*, *Folsom*, *Scottsbluff*, and *Angostura*. Many of the Paleoindian diagnostic materials are surface finds although some have been from subsurface contexts. In Nueces County the presence of early materials along Oso and Petronila creeks demonstrates that assemblages dating to Paleoindian times occur in this region (Shafer and Bond, 1983). A site in Nueces County with a possible Paleoindian component is 41NU246, the Petronila Creek Site. This site is not located within the Corpus Christi study area.

3.8.1.2 Archaic Period

The Archaic period (approximately 6000 B.C. to A.D. 1200) is identified during the early and middle Holocene by intensive human utilization of a wide variety of ecological niches including the coastal zone. The tripartite division of the Archaic is the Early (6000 B.C. to 2500 B.C.), Middle (2500 to 1000), and Late (1000 B.C. to 1000 A.D.) subperiods. The Early Archaic is the least well understood, but represents a period of transition beyond the Paleoindian period. Some characteristics of the earlier period are still present, such as careful chipping of stone tools and occupation of older sites, yet distinctive artifact styles are found. Large triangular points, corner notched points, stemmed points (*Gower*) and large-barbed points (*Bell*) begin to appear. Population density remains low during this time and large territorial ranges are still utilized (Black, 1989). Sites dating to this subperiod occur in the SCC Archeological Region. Sites with identified Early Archaic deposits in Nueces County include 41NU124, the Means Site (Fox and Hester, 1976) and sites at White's Point on Nueces Bay (Ricklis, 1993).

During the Middle Archaic subperiod exploitation of marine resources appears to have accelerated. This may be evidenced by the thicker shell strata evident in shell middens as well as the more abundant fish remains. The presence of central Texas related groups in the study area during the Middle Archaic and later periods is more conclusively indicated. Clear Fork Phase, *Nolan* and *Travis* type dart points, dated to the beginning of the Middle Archaic period (Prewitt, 1981) occur at three sites, 41KL5, 41KL8, and 41KL9 (Campbell, 1964). Single specimens of later Middle Archaic *Lange* points (Prewitt, 1981) were collected from site 41KL3 (Campbell, 1964).

During the Late Archaic the sea level stabilized at its modern position and remains from this period are abundant and varied. Sites dating to the Late Archaic in the SCC Archeological Region are shell middens with thick deposits that yield a greater range and quantity of artifacts than do the shell middens dating to the Early Archaic. All of this suggests more frequent and/or intensive occupations than previously, and perhaps a higher regional population density (Ricklis, 1995). Settlement during this time is also characterized by summer occupations in the interior portions of the study area resulting in open lithic scatters. Numerous cemeteries have been identified in the SCC Archeological Region dating to the Late Archaic and Late Archaic/Late Prehistoric associations.

3.8.1.3 Late Prehistoric Period

The Late Prehistoric Period is represented by the Rockport phase in the SCC Archeological Region. With the advent of the bow and arrow and ceramic vessels, the Rockport focus replaces the Aransas focus. The later phase is characterized by the exploitation of larger game and an intensified exploitation of fish (Campbell, 1964). Settlement and subsistence patterns during the Rockport phase involved, to some significant degree, shifting seasonal emphases, with occupation of shoreline fishing camps during the fall through winter-early spring, and later spring through summer residences at hunting camps commonly located along the upland margins of stream valleys (Ricklis, 1995). Both shell middens and lithic sites of this phase tend to be stratified, indicating seasonally inhabited sites. This is probably a result of food resources along the coast and on the barrier islands being more seasonally specific (Thomas and Weed, 1980a).

Artifacts representative of the Rockport phase include, *Perdiz* projectile points as well as *Fresno*, *Young*, *Cliffton*, *Scallorn*, and *Starr* types and *Rockport* ceramic wares (Campbell, 1956). In terms of resource exploitation and cultural assemblages, the pattern for this phase tentatively established a link between the Rockport phase sites and the Karankawas, a historically known coastal group of Coahuiltecan speaking indigenous people (Thomas and Weed, 1980a). The Rockport phase dates from about A.D. 100 until the extinction of the Karankawas in the mid-nineteenth century (Newcomb, 1993). Most of the prehistoric sites thus far investigated in depth in the area are interpreted as reflecting a littoral adaptation with a secondary dependence on inland prairie resources (Prewitt, 1984). Historically, the Karankawa are reported to have camped on shell middens located near sources of fresh water whenever possible. Artifacts associated with Rockport phase sites include shell containers, jewelry, shell working-tools, asphaltum, burned clay nodules, sandstone shaft straighteners, and decorated ceramics including polychrome (Calhoun, 1964), asphaltum-painted black on gray (Fitzpatrick et al., 1964) and scallop-shell scored (Calhoun, 1964).

Late Prehistoric cemeteries and burials are relatively common along the Texas coast and are often found in clay dunes (Headrick, 1993). One coastal cemetery is documented for the Oso Creek/Oso Bay area in Nueces County. According to Hester (1980) the Texas coast encompasses the largest number of prehistoric cemeteries in the region. One of these cemetery sites 41NU2 (Calle del Oso) is one of the largest known. At one time it may have contained as many as 600 burials. Unfortunately, this site has been largely destroyed by development and adequate studies were never conducted at the site. It is believed that site 41NU2 may have also been in use during the Late Archaic period. Another cemetery located in Nueces County is the Berryman Site (41NU173) (Hall, 1987).

3.8.1.4 Historic Period

The post-contact historic period for the Texas coast and south Texas effectively begins with the explorations of the Gulf of Mexico by Spanish explorers seeking to locate new land and economic resources for the Spanish royal crown in Madrid. The first European explorer known to have visited the area of Corpus Christi and Nueces bays was Alonso Alvarez de Piñeda in 1519. Piñeda explored and mapped the Gulf Coast from Apalachicola to the Yucatan and became the first European to sail through Aransas Pass into a shallow body of water he named Corpus Christi Bay. Following Alonzo Piñeda's initial mapping of the Gulf of Mexico and Corpus Christi Bay in 1519, Cabeza de Vaca traversed the area in the 1520s (Webb, 1952).

Two historic Indian groups inhabited the Texas coastal area at that time: the Coahuiltecan and the Karankawas. These nomadic hunters and gatherers were decimated by European diseases and by encroachment of the Spaniards from the south and the Apaches and Comanches from the north, as well as by the Anglo-Americans from the east. By 1850 neither the Coahuiltecans nor the Karankawas occupied the coastal area (Campbell, 1956).

Coahuiltecans

The Coahuiltecans settled primarily on the mainland and only after contact with the Spaniards did they venture out onto some of the islands (Thomas and Weed, 1980a). Some of the Coahuiltecan bands were the Orejon, west of Corpus Christi Bay; the Malaquite, along the coast from Corpus Christi Bay to Baffin Bay; and the Borrado, in the area from Baffin Bay to the Rio Grande (Scurlock, et al., 1974). Each band occupied a territory that included both inland and coastal areas at either end of their yearly-round. Population was estimated to be about 15,000 individuals with about 220 bands identified in 1690; however, by 1870 only remnants of the population remained (Thomas and Weed, 1980a). The influence of the Coahuiltecans on Padre Island was primarily from their trade with the Karankawa. The Coahuiltecan worked extensively with basketry, which they traded with the Karankawa, and worked to a lesser degree with ceramics.

As mentioned above the Coahultecans were not, nor are they today, one group of people, rather they were a conglomerate of different bands probably joined by the Coahuilteco language. Currently there are groups from the coastal plains of northeastern Mexico and adjacent southern Texas that have organized into the Coahuiltecan Nation (Gardner, 2001). Even though they are not an Indian tribe *per se*, on December 2, 1997 the Coahuiltecan Nation submitted a Letter of Intent to Petition for Federal recognition to the Bureau of Indian Affairs. However, as of now, they are not a Federally recognized Indian tribe (Gardner, 2001).

Karankawas

The Karankawa, unlike the Coahuiltecan, occupied the coastline and barrier islands from Trinity to Aransas bays (Thomas and Weed, 1980a). Five major groups were historically documented and included the Capoques and Hans to the north; the Kohanis around the mouth of the Colorado; the Karenkake, Clamcoets, and Carancaquacas on Matagorda Bay and Matagorda Island; and the Kopanos, along Copano Bay and St. Joseph's Island (Scurlock et al., 1974). According to early European accounts, the Karankawa subsisted primarily on oysters, clams, scallops, other mollusks, turtles, various fish species, porpoises, and several marine plant species (Thomas and Weed, 1980a). Other ethnographic and archaeological evidence supports the contention that historic Karankawas resided during the fall and winter in large shoreline camps of 400-500 people, during the spring and summer they camped along stream courses in bands averaging about 55 individuals (Ricklis, 1992). Karankawa sites were generally located in sheltered bays or on the leeward side of stabilized dunes on the Laguna Madre side of Padre Island (Thomas and Weed, 1980a).

Like the Coahuiltecans, cultural material of the Karankawa was sparse. Huts were constructed of willow branches covered with brush, with hearths in the center of each hut. They did, however, have several varieties of ceramics used for cooking and eating. These were decorated and sometimes coated with asphaltum. The ceramics were globular in shape, reminiscent of Rockport phase types (Thomas and Weed, 1980a).

By the 1700s, the indigenous populations were being affected by Spanish missions and presidios such as the Goliad missions of Espiritu Santo and Rosario, as well as by raiding Lipan Apaches and other central and southwestern groups (Mounger, 1959; Headrick, 1993). Due to the ill treatment the indigenous populations received from the Spanish, especially the Spanish military, prior friendly relations became increasing hostile (Newcomb, 1993). By the early-nineteenth century the increase in Anglo and Mexican ranchers and the establishment of coastal ports and towns left the indigenous populations without access to the coastal resources needed for subsistence. By the early 1840s, most remaining members of the Karankawa tribe had migrated to Mexico. After this time the Karankawa either dispersed or assimilated into other groups. Currently the Karankawa are not a Federally recognized tribe nor is there an extant Karankawa tribe (Gardner, 2001).

European Settlement

Little exploration or settlement took place in the Corpus Christi Bay region during the first two centuries following Piñeda's discovery of the bay in 1519. The Spanish government only regained interest in colonizing this region after the French explorer Réne Robert Cavelier, Sieur de La Salle claimed land in the Northern Gulf of Mexico for France in 1685. La Salle mistakenly entered Matagorda Bay while searching for the entrance to the Mississippi River. His expedition established the settlement of Fort St. Louis there on Garcitas Creek, some 50 miles north of Aransas Bay (Weddle, 1991). This colonization attempt failed, and most of the colonists perished, but the significance of its attempt spurred the Spanish to action. Wanting to protect their interests in Texas and their silver mines in Northern Mexico, Spain sent Alonso de León to reconnoiter the French fort and report back his findings. De León made several attempts and in 1688, he reported to the Spanish government that the threat from La Salle was over and that the fort had been destroyed (Weddle, 1991).

Hostilities between the French and Spanish over what was to become Texas continued into the eighteenth century. In 1720, France sent Jean Béranger to explore and map the Gulf Coast. He visited Aransas Bay and described the local inhabitants and their environment in detail. This expedition and that of La Salle, forced Spain to realize a more aggressive approach had to be taken in regards to Texas. In response to this conclusion, by 1726, Spanish missions or presidios had been established from

East Texas near the French post of Natchitoches on the Red River to Matagorda Bay and the Guadalupe River. This arrangement of presidios and missions provided Spain with a continuous system of communication across Texas and helped curb the immigration of Anglo-American settlers.

Spain's ability to control Texas began to deteriorate when Mexico waged war for independence. Over the next 10 years (1811-1821), resources were pulled away from the Texas frontier and an influx of Anglo-American immigrants came to Texas. This immigration was illegal until 1823, when the newly formed Mexican government passed the Imperial Colonization Law. The law invited individuals of Roman Catholic faith to settle in Mexico including Texas (Freeman, 1990). In addition, Mexico granted large tracts of land to immigration agents, called empresarios, who were given the authority to parcel out the land to settling families. Stephen F. Austin became the first empresario in Texas and was granted permission to search for land to colonize. Austin traveled the entire coastline of Texas, including the region of Corpus Christi Bay before he settled on the land between the Lavaca and Brazos rivers. Further development came in 1824 when the Mexican Congress incorporated all of Texas into a new state, Coahuila y Tejas, with its capital at Saltillo. At that time, states within the Mexican interior were given the power to set up land grants for colonization. As a result, Coahuila y Tejas granted more than 2 dozen empresario contracts.

As the numbers of Anglo-American's increased due to immigration, the tension between the Mexican government and the new settlers increased. Prior to 1821, the majority of American settlers in Texas were not actively seeking independence. Most settlers sought more influence over local affairs and greater control over their economy. Mexico, hoping to halt further American incursions into the region, enacted a law on April 6, 1830, supporting further military occupation of Texas, and increased colonization by Mexicans and Europeans. Mexico also insisted on increased trade between Texas and Mexico. The American settlers resented this action and in response, organized the Conventions of 1832 and 1833 to voice their complaints about the Mexican Government and to draft a constitution for Texas. As a result of the growing unrest by the American settlers, the Mexican Government sent General Juan N. Almonte to Texas on a tour of inspection in 1834. Almonte's recommendations were delivered to the Government but were never carried out (Guthrie, 1988). At this same time, the Mexican government placed the schooner *Santa Pia* in Copano Bay, hoping to help control spreading Anglo influence in Texas. None of these actions improved conditions and in 1835 armed rebellion broke out. As the war concluded with an independent Texas, settlement and economic growth of the area resumed.

Henry Kinney and his partner William P. Aubrey established Corpus Christi as a trading post in 1839. With more settlers coming to the region, overland trade developed between their post and Mexico and other inland posts (Pearson and James, 1997). As a maritime port however, Corpus Christi was slow to develop. With the shallowness of the bay and the numerous obstacles hampering navigation, only shallow draft vessels could service the town. Even with the development of overland trade, it was not until General Zachary Taylor stationed 4,000 troops at the post in 1845 during the Mexican American War that Corpus Christi began to flourish (Guthrie, 1988). With the conclusion of the war, the town was deserted almost overnight when Taylor's troops left. This soon changed as the California Gold Rush brought gold-seekers to Corpus Christi to purchase supplies and transportation west (Pearson and Simmons, 1995).

During the Civil War the area became an important center for Confederate commerce. According to Tyler (1996) not less than forty-five small vessels carried trade between Corpus Christi and Indianola. Small boats sailing inside the barrier islands transported goods from the Brazos River to the Rio Grande, while inland cotton was moved along the Cotton Road through Banquete to Matamoros and on to the mills in England. In an effort to halt the trade, Union forces seized control of Mustang Island in the fall of 1863, and twice Federal gunboats bombarded Corpus Christi and disrupted water transportation. The overland trade, however, continued without interruption until the end of the war.

After the Civil War, ranching developments characterized the area's economy. The expanding cattle industry came to dominate maritime commerce in the bays. With the growth of the packing industry, stockyards and packeries sprang up around Corpus Christi and other small settlements along the coast. These developments stimulated the growth of the area and increased the need for shipping to transport cattle out of the region and supplies back to the local populations. The use of Aransas Pass increased significantly, corresponding to the growth in these stockyards and packeries.

In the years 1871-1875, 171 ships made a total of 1452 crossings through Aransas Pass (Kuehne, 1973). During this period, the Morgan Line steamer *Mary* made 120 appearances, more than any other ship (Hoyt, 1990). By the late 1870s, when the cattle industry again started transporting their herds overland, cotton began to replace the tonnage lost from the cattle industry. By 1882, 364 bales were transported and it was predicted that in the near future, thousands of bales would be shipped yearly (USACE, 1882).

CATTLE EXPORTS FROM CORPUS CHRISTI BAY

Year	No. of Head Exported
1873	23,000
1874	26,000
1875	21,600
1876	18,300
1877	15,700
1878	One load
1879	None

Source: Hoyt, 1990.

History of Waterway Improvements in Corpus Christi Bay

Aransas Pass has remained the main entrance into Corpus Christi Bay since early historic times. Its dynamic nature, harsh environment and lack of deepwater channels has been a hindrance to traffic in and out of the bay throughout its development. The first navigation improvement in the bay system was a lighthouse that was erected on Harbor Island in Aransas Pass in 1856. This improvement quickly became immaterial as the unstable and shifting nature of the pass soon placed the lighthouse too far north to be effective. It was because of this migration that one of the primary local navigation goals became stabilizing Aransas Pass (Pearson and Simmons, 1995).

Realizing the need to have a secure entrance into Corpus Christi Bay, a 600-foot-long wooden dike on St. Joseph's Island in 1868 was constructed. This project was an attempt to halt the migration and shoaling of the pass. The dike reportedly opened a 12-foot channel for several months. It was destroyed soon after, possibly by wood boring worms (mainly *Teredo navalis* [shipworm]) and wave action, and the pass shoaled back to 7.5 feet (Hoyt, 1990).

The shoaling of Aransas Pass became a serious problem for Corpus Christi Bay commerce by the late 1870s. Steamships could no longer enter the bay and after 1878, the majority of commercial products were sent via lighter to Indianola for long distance shipment (USACE, 1880 reported in Hoyt, 1990). It was obvious that the citizens around Corpus Christi Bay and their economic survival depended on a means to have a permanent entrance into the bay, and Aransas Pass was the only option.

In 1874, the Corpus Christi Navigation Company and Messrs. Morris and Cummings dredged the first deep-water channel into Corpus Christi Bay. This channel, known as the Morris and Cummings Cut, ran along the inshore side of Harbor Island and connected with Aransas Pass through the Lydia Ann Channel that lay between Harbor Island and St. Joseph's Island. The channel was approximately 8 feet deep, 100 feet wide and 6 miles long (Alperin, 1977; James and Pearson, 1991). It was later abandoned with the development of the Corpus Christi Channel (USACE, 1910:552).

While Galveston was initially chosen as the best location along the Texas coast for a deepwater port, several towns in the Corpus Christi Bay area were vying for government approval to be designated the main U.S. port in south Texas. The local inhabitants realized that without a continuous, direct deep-water route to its port facilities, in addition to a stable entrance into the bay, Corpus Christi Bay would not be able to compete. In response to this need, the Turtle Cove Channel Project was adopted in 1907 with the intention of dredging a channel 10 feet deep and 100 feet wide into Corpus Christi Bay. By 1910, the cut had been expanded to a depth of 12 feet. The channel, also known as the Corpus Christi Channel, extended 21 miles to Corpus Christi in 1926, of which only 12 miles between Port Aransas and McGloins Bluff required dredging.

With the completion of this channel, Corpus Christi had fulfilled its need for a deep-water route to its harbor, and thus could lead the economic development of the area. The Port of Corpus Christi was officially opened September 14, 1926, and chosen as the principle port in south Texas. At that time, a 25- by 200-foot channel extended across Corpus Christi Bay to Corpus Christi. The Corpus Christi Ship Channel was again closed for improvement in 1932 with the realization that an increase in vessel sizes led to an increase in vessel groundings. With the coming of larger ships with deeper drafts, the depth of the channel had to be increased to accommodate their size. A proposal to enlarge the channel to 37 feet deep and 400 feet wide was soon adopted (James and Pearson, 1991; Schmidt and Hoyt, 1995).

Another attempt at improving the navigation into Corpus Christi Bay is historically under documented. Packery Channel extended northward from its Gulf outlet, along the west edge of Mustang Island, passing to the east of the Crane Islands before entering the Bay. Historic documentation is made more difficult because Packery Channel, currently one of three passes in the area, was originally referenced and documented on early maps as Corpus Christi Pass (Board of Engineers 1846; U.S. Coast Survey 1869).

During the nineteenth century, there was no channel outlet into the Laguna Madre, and much of the area between north Mustang Island and Flour Bluff is depicted on 1887 Coast Chart No. 210 as "...flats with less than 6 inches of water." Early maps and navigation charts list a maximum depth at both the Gulf and Corpus Christi Bay outlets of Packery Channel as no more than 2 to 3 feet. C.W. Howell, in an 1879 USACE annual report on a survey of the pass noted that "A man of ordinary stature can wade it now at several points" (1879:930). A notation on one of the USACE maps by Assistant Engineer H.C. Collins (Collins et al. 1878) states that water at the Gulf entrance did not exceed 2 feet in depth and was breaking across the bar. Collins' description of the survey states that their schooner could not enter the pass, and that a "yawl-boat" drawing only 1.5 feet was necessary to sail as close to shore as possible to take soundings.

At the time of Howell's survey and report Packery Channel was apparently little used, and he proposed constructing a dam to further restrict its flow (1879:930). The proposed dam was to be of stone construction approximately 1,900 feet in length, with the crest of the dam being no higher than the plane of mean low tide. Howell proposed that the dam would enable the pass to continue to act as a safety valve for major storm surges while at the same time increasing the tidal flows at the more important Aransas Pass. Howell also thought that the dam would improve the channel connecting Corpus Christi Bay and Laguna Madre to the south, noting that the latter bay was important because the beef packers along that portion of the coast required its salt production.

Although the USACE had concluded that the maintenance of Packery Channel was not a viable option, promoter and land developer Colonel E.H. Ropes was not dissuaded. In 1890 Ropes commissioned the steam powered "dipper dredge" *Josephine* to establish a cut through Padre Island at Packery Channel. While Ropes succeeded in cutting through the island the cut quickly filled. His dredge was unable to extricate itself and had to be abandoned (Alexander et al. 1950).

The role of Packery Channel in navigation to Corpus Christi Bay was seriously reduced by its tendency to shoal and by the economic interests in the last half of the nineteenth century, which favored the development of Aransas Pass for a shipping outlet. There are several reports of beef products being shipped outbound from Packery Channel to overseas destinations (Alexander et al. 1950:168) although some references suggest that the shallow pass required the use of lighter vessels to make the seaward connection. In one instance shallow-draft vessels were reported to be carrying packery products north through Corpus Christi Bay rather than seaward through Packery Channel.

Other improvements in the bay area included a channel through Harbor Island 25 feet deep and 250 feet wide to connect the town of Aransas to Aransas Pass in 1922 (USACE, 1922). Later, in the mid-1900s, the USACE was requested to dredge a channel through Ingleside Cove along the western side of McGloin's Bluff. This channel, known as the La Quinta Channel, was necessary for the development of the Reynolds Metal Company located northeast of McGloins Bluff. Bauxite ore would be brought from Jamaica to be processed at the plant. The Reynolds Metal Company requested that the

USACE dredge a 32-foot channel to its aluminum plant wharf at La Quinta in order for vessels to load and unload cargoes. Work began in 1954 on the 6-mile-long, 150-foot-wide La Quinta Channel. It was completed at 36 feet deep and 200 feet wide in 1958 (Alperin, 1977).

Potential Shipwrecks in the Project Vicinity

There have been a number of ships wrecked in Corpus Christi Bay and Aransas Pass during the historic period. Vessel losses, documented in numerous historic sources, have been summarized in several archaeological reports, among them Hoyt (1990), James and Pearson (1991), Schmidt and Hoyt (1995), Pearson and Wells (1995), Pearson and Simmons (1995), and Pearson and James (1997). Seventy-six shipwrecks are listed in those combined publications. Most of those wrecks are listed in the THC's shipwreck database. The THC gleaned information about those wrecks from a number of sources. James and Pearson (1991) added wrecks to the THC's list from government sources, including the U.S. Life-Saving Service, the U.S. Army Corps of Engineers and the U.S. Coast Guard. Other wrecks, especially more recent ones, are known from sources such as the Automated Wreck and Obstruction Information System (AWOIS) maintained by the National Atmospheric and Oceanic Administration. The AWOIS database contains information about wrecks and obstructions that appear on modern navigation charts. A combined list of shipwrecks from Pearson and Simmons (1995) and Pearson and James (1997) is reproduced below as Table 3.8-1.

The majority of wrecks are known to have occurred in the vicinity of Aransas Pass (the bay entrance, not the town), owing to the concentration of vessel traffic there combined with the hazards of shifting sandbars prior to construction of the jetties. At least 48 vessels wrecked in this vicinity. Another 28 wrecks are known from within Corpus Christi Bay, including Nueces Bay and adjacent portions of Laguna Madre. Vessel names are known for only 46 of the total 76 shipwrecks. These shipwrecks range in age from 1830 to 1981. At least 39 wrecks occurred prior to 1952. Vessels wrecked earlier than 1952 are at least 50 years old, thus meet the suggested age criterion for NRHP eligibility. Some vessels which wrecked within the past 50 years are, no doubt, older than 50 years, thus vessels should not be automatically disregarded based upon the year in which they were wrecked.

The number of shipwrecks that have been archaeologically documented in the vicinity of impact areas is significantly smaller than the total number of wrecks listed in the historic record. Only four shipwrecks have been confirmed in the vicinity of project impacts. This number includes the S.S. *Mary* (41NU252) (Hoyt, 1990; Pearson and Simmons, 1995) located on the southern channel margin between the jetties at Aransas Pass, an unidentified wreck (41NU264) located just south of the channel near the seaward end of the southern jetty (formerly identified as the *Utina* in both Pearson and Simmons, 1995 and Schmidt and Hoyt, 1995), a wreck believed to be the *Utina* (designated as Anomaly M39 until a trinomial site number is assigned) which lies against the submerged seaward end of the south jetty, and an unidentified wreck (designated as Anomaly M39 until a trinomial site number is assigned) located slightly south of the Corpus Christi Ship Channel opposite McGloin's Bluff. The latter wreck, discovered by PBS&J during the summer of 2001, may be the remains of the steamboat *Dayton* whose boiler exploded within a quarter mile of McGloin's Bluff in 1845 (Enright, et al., in preparation). Three other vessels, which may have a higher than average chance of occurring near project impact areas, include the small Confederate boats *Elma, A. Bee* and *Hanna.* These vessels reportedly were scuttled in Corpus

TABLE 3.8-1

LIST OF VESSELS REPORTED LOST IN THE PROJECT STUDY AREA

Name of Vessel	THC Number	Vessel Type	Year Lost	Location
Vessels Lost in the Vicinity of Aransas Pass				
Unknown	113	Unknown	1830	Aransas Pass Vicinity
Cardena	115	Sail	1834	Aransas Pass Vicinity
Unknown	1678	Schooner	1834	Aransas Pass Vicinity
Wildcat	114	Unknown	1834	Aransas Pass Vicinity
Colonel Yell	192	Sidewheeler	1847	Aransas Pass Vicinity
Umpire	512	Sailing/ Steam	1852	Aransas Pass Vicinity
Unknown	1056	Unknown	1853	Aransas Pass Vicinity
Mary Agnes	655	Schooner	1862	Aransas Pass Vicinity
William Bagley	1045	Sidewheeler	1863	Aransas Pass Vicinity
Louisa	659	Schooner	1865	Aransas Pass Vicinity
L'éclair	1272	Schooner	1866	Aransas Pass Vicinity
Philadelphia	423	Sailing/ Steam	1868	Aransas Pass Vicinity
Mattie	653	Sailing	1873	Aransas Pass Vicinity
Mary	51	Sidewheeler	1876	Aransas Pass Vicinity
St. Mary	1004	Sailing/ Steam	1876	Aransas Pass Vicinity
Ramyrez	1049	Sail	1882	Aransas Pass Vicinity
Tex Mex	1412	Schooner	1882	Aransas Pass Vicinity
Two Marys	1411	Schooner	1882	Aransas Pass Vicinity
O. Jennings Gill	1386	Schooner	1887	Aransas Pass Vicinity
Henrietta	5	Schooner	1888	Aransas Pass Vicinity
Mystery	623	Sail	1899	Aransas Pass Vicinity
Mary Lorena	None	Schooner	1900	Aransas Pass Vicinity
Ellen	None	Schooner	1902	Aransas Pass Vicinity
Mary E. Lynch	None	Schooner	1902	Aransas Pass Vicinity
Silas	None	Schooner	1902	Aransas Pass Vicinity
Lake Austin	None	Schooner	1904	Aransas Pass Vicinity
Pilot Boy	None	Steamer	1916	Aransas Pass Vicinity
Utina	513	Steamer	1920	Aransas Pass Vicinity
Baddacock	None	Steam Tug	1920	Aransas Pass Vicinity
Unknown	1047	Unknown	1935	Aransas Pass Vicinity
Unknown	1048	Unknown	1935	Aransas Pass Vicinity
Coral Sands	197	Oil Steamer	1955	Aransas Pass Vicinity
Jiffie	None	Unknown	1955	Aransas Pass Vicinity
Princess Pat	None	Unknown	1958	Aransas Pass Vicinity
Cabezon	None	Unknown	1959	Aransas Pass Vicinity
Chuck A Dee II	175	Unknown	1963	Aransas Pass Vicinity
Liberia C	None	Unknown	1964	Aransas Pass Vicinity
Desco	214	Unknown	1966	Aransas Pass Vicinity
Unknown	1534	Unknown	1970	Aransas Pass Vicinity
Unknown	1535	Unknown	1970	Aransas Pass Vicinity
Unknown	1536	Unknown	1970	Aransas Pass Vicinity
Unknown	1537	Unknown	1970	Aransas Pass Vicinity
Jimbo	1031	Cabin Cruiser	1971	Aransas Pass Vicinity
De Rail	None	Cabin Cruiser	1972	Aransas Pass Vicinity
Unknown	1028	Unknown	1974	Aransas Pass Vicinity
Unknown	1019	Unknown	Unknown	Aransas Pass Vicinity
Jane and Julie	None	Fishing Vessel	1981	Aransas Pass Vicinity
Eagles Cliff	None	Cargo Ship	1981	Aransas Pass Vicinity

TABLE 3.8-1 (Concluded)

Name of Vessel	THC Number	Vessel Type	Year Lost	Location
Vessels Lost in the Corpus Christi Bay				
Dayton	208	Sidewheel Steamer	1845	McGloin's Bluff
Swallow	155	Unknown	1845	Nueces Bay
A. Bee	1797	Unknown	1862	Corpus Christi
Unknown	1787	Schooner	1862	Corpus Christi
Elma	1802	Schooner	1862	Corpus Christi
Hanna	637	Schooner	1862	Corpus Christi
Catha Minerva	1388	Schooner	1874	Corpus Christi
Captiva II	165	Lugger	1949	Nueces Bay
40 Fathom No. 12	256	Unknown	1955	Corpus Christi
Captain Steve	163	Unknown	1968	Laguna Madre
Unknown	1288	Unknown	1970	Corpus Christi
Unknown	1289	Unknown	1970	Corpus Christi
Unknown	1529	Unknown	1970	Corpus Christi
Unknown	1533	Unknown	1970	Laguna Madre
Unknown	1538	Unknown	1976	Corpus Christi
Unknown	1539	Unknown	1976	Corpus Christi
Unknown	1130	Unknown	1976	Laguna Madre
Unknown	1086	Unknown	1977	Corpus Christi
Unknown	1087	Unknown	1977	Corpus Christi
Unknown	1088	Unknown	1977	Corpus Christi
Unknown	1089	Unknown	1977	Corpus Christi
Unknown	1090	Unknown	1977	Laguna Madre
Unknown	1091	Unknown	1977	Corpus Christi
Unknown	1092	Unknown	1977	Corpus Christi
Unknown	1180	Unknown	1977	Corpus Christi
Unknown	1181	Unknown	1977	Corpus Christi
Unknown	1234	Unknown	1977	Corpus Christi
Unknown	1085	Unknown	1977	Laguna Madre

Source: Pearson and Simmons, 1995; Pearson and James, 1997.

Christi Bay to prevent their capture by Union forces. Their location is reported by Pearson and James (1997: 18) as either near the town of Corpus Christi or near the mouth of the Nueces River.

3.8.2 Previous Investigations

Some of the earliest archaeological investigations in this region were conducted in the 1920s. Syntheses of this work have been prepared by Suhm et al. (1954), Campbell (1958) and Briggs (1971). E.B. Sayles and two avocational archaeologists, George C. Martin and Wendell H. Potter, carried out some of this early work. They conducted an archaeological survey of much of the coastal zone north of Corpus Christi between 1927 and 1929 (Martin and Potter, n.d.; Sayles, 1953). In some instances, limited excavation was performed, but most of the materials were recovered from beaches and eroded bluffs. During the 1930s and 1940s, major archaeological excavations were conducted using Works Progress Administration assistance at the Johnson, Kent-Crane, and Live Oak Point sites on Live Oak Peninsula. These three shell midden sites were the first controlled excavations in the area. The Johnson and Kent-Crane sites were primarily associated with the Late Archaic subperiod.

Since the acquisition of the land by the National Park Service, two major archaeological investigations have been conducted within Padre Island National Seashore, as well as a number of more limited surveys related to proposed oil exploration and extraction activities. The first professional investigations on Padre Island were conducted by T.N. Campbell in 1963. Dr. Campbell relied on a number of avocational archaeologists during his reconnaissance survey of the then-proposed Padre Island National Seashore (Campbell, 1964). His survey areas were located between Corpus Christi Bay and a point about 15 miles north of Mansfield Pass. A total of 15 prehistoric and proto-historic sites were recorded, 12 of which were found within the proposed National Seashore boundaries. Three distinct clusters of sites were documented but were confined to the northern end of the island. The significance of this distribution, however, is uncertain because of erratic ground surface visibility and other problems in site identification.

From 1957 to 1963, Corbin (1963) conducted a number of surface surveys on the northern shore of Corpus Christi Bay that further defined the range of variability in Rockport ceramics. All of the sites recorded by Corbin (1963) were shell middens, except for one, the McGloin Bluff Site (41SP11). The McGloin Bluff Site is described in the site form as a large, open habitation site which yielded ceramics, lithic debitage and tools, and shell artifacts. The shell midden sites were all located along a narrow strip of land adjacent to the shoreline and were described as small, thin, and diffuse components probably due to short term occupation by small groups (Ricklis, 1999).

In 1968, Story excavated a midden at Ingleside Cove, north of Corpus Christi Bay in San Patricio County, that had been exposed by Hurricane Carla. This site exhibited several stratified Archaic and Late Prehistoric occupations with a subsistence base oriented heavily toward marine procurement. The Ingleside Cove Site provided an enormous amount of information regarding coastal adaptation and marine exploitation.

Limited archaeological investigations completed in the SCC Archeological Region include two cultural resource surveys located near the mouth of Baffin Bay. Both surveys were conducted by New

World Research (NWR) in 1980 (Thomas and Weed, 1980a, 1980b). Those surveys, combined, covered 5.5 miles of proposed pipeline easement. The survey corridor was examined at 66-foot intervals. The ground surface was generally visible, but grass was removed in an attempt to improve the visibility in heavily vegetated areas (Thomas and Weed, 1980a). In both surveys, systematic and intuitively placed auger holes were also excavated in an attempt to locate buried cultural materials. No evidence of either prehistoric or historic occupations was observed. In the following year, NWR also completed two surveys of proposed seismic lines opposite Port Mansfield (NWR, 1981a, 1981b).

The Center for Archeological Research (CAR) conducted surveys at three proposed well pad drilling sites (Gibson and Hester, 1982; Valdez 1982; Warren, 1985). Two of the drilling sites are within the Padre Island National Seashore near Yarborough Pass (Valdez, 1982; Warren, 1985) and the third is located in the vicinity of South Bird Island (Gibson and Hester, 1982). Investigations at all three of the drilling sites consisted of a surface examination only. No subsurface excavations were conducted. No cultural resources were observed at any of the well pad locations. Two alternative well pad locations within the National Seashore also were surveyed in 1984 by Prewitt & Associates, Inc. (Fields, 1984). The surface examination encountered areas of both poor and good visibility but found no evidence of either prehistoric or historic occupations. Two shallow trowel tests were dug at each pad location in order to document subsurface sediments.

Several major archaeological investigations have been conducted in the project vicinity. In 1977, the CAR conducted a survey of the Tule Lake Tract (Highley et al., 1977) for the USACE. Only one site, 41NU157, was located. That site was a large, heavily disturbed rangia midden with Rockport ceramics. In 1980, the Texas Department of Water Resources conducted a survey of the proposed Allison Wastewater Treatment Plant. Two large prehistoric sites, 41NU185 and 41NU186, were identified. Site 41NU185, a multi-component prehistoric midden, was subsequently tested by Texas A&M University (Carlson et al., 1982). In 1984, the USACE conducted a survey of two large proposed dredge disposal areas (Good, 1984). The survey resulted in the identification of one archaeological site, 41NU211, a large prehistoric occupation site.

In 1985 and 1986, Ricklis conducted excavations at the McKinzie Site (41NU221), a small multi-component occupation site in the Baffin/Oso subarea (Ricklis, 1986). Site 41NU221 is located on the edge of the uplands overlooking the floodplain of the Nueces River (Mercado-Allinger and Ricklis, 1996). The archaeological work conducted at the site identified two discrete prehistoric components, one Archaic and the other Late Prehistoric. Based on lithics and diagnostic ceramics the Late Prehistoric component has been assigned to the Rockport complex (Ricklis, 1988). The work at site 41NU221 yielded data that was incorporated into studies of seasonality and subsistence strategies.

Texas Parks and Wildlife has also completed an archaeological survey and history of Mustang Island in eastern Nueces County (Howard et al., 1997). The survey recorded two previously unknown sites, 41NU284 and 41NU285 and relocated previously recorded site 41NU224. All three sites contain prehistoric components, and two of the sites, 41NU224 and 41NU284, also contain late-nineteenth-century and early-twentieth-century components.

Cultural resource management surveys and testing programs have proliferated in the Baffin/Oso Subarea since the 1970s (Mercado-Allinger and Ricklis, 1996). This work has provided models of Late Prehistoric settlement and subsistence patterns, as well as native responses to Spanish colonization (Patterson and Ford, 1974; Carlson, 1983; Warren, 1987). Additionally, these investigations have also contributed to the enhancement of the Archaic chronology of the region (Ricklis and Cox, 1991; Ricklis, 1993, 1995). Three previous archaeological studies have been conducted in the vicinity of a new upland beneficial use area, BU Site E, proposed for use under the preferred alternative. Those studies include Corbin's (1963) investigations, a survey by McDonald and Dibble (1973) of a 2,300-acre tract for the Port of Corpus Christi Authority, and a recent survey and excavation conducted by Ricklis (1999). Ricklis' survey is particularly applicable to BU Site E. Ricklis' pedestrian survey of the La Quinta Terminal expansion area investigated 10 sites (41SP32-35, 41SP105-108, 41SP198 and 41SP199) all of which were recommended as ineligible for the NRHP. The THC concurred with that assessment. The Ricklis survey covered the entire area of BU Site E.

Several underwater archaeological investigations have been conducted in the Aransas Pass and Corpus Christi Bay areas, beginning in the late 1980s. Those studies incorporated historical research, remote-sensing surveys, diver evaluations, and data recovery. In 1989, Espey, Huston and Associates, Inc. (EH&A), now PBS&J, conducted a remote-sensing survey over an area within the Aransas Pass Channel to locate the remains of a sidewheel steamer *SS Mary* that sank in 1876 (Hoyt, 1990). Subsequent diving was conducted on the wreck to assess its condition and its possible eligibility for the National Register of Historic Places (NRHP). That work was performed as part of the Section 106 compliance process for the USACE, Galveston District (Hoyt, 1990). EH&A determined that the *Mary* was in poor condition. Nevertheless, the vessel was recommended as eligible for the NRHP based upon several factors, including its association with the Morgan Line, its long service as a typical coastal steamer of the period, and its construction by the innovative H&H Corporation (Hoyt, 1999). The THC concurred with their recommendation. The *Mary* is also eligible for designation as a SAL under the criteria specified in The Antiquities Code of Texas, Section 191.091.

In 1991 Coastal Environments Inc. (CEI) surveyed Aransas Pass and located seven magnetic anomalies (James and Pearson, 1991). Then in 1993, CEI conducted diver evaluations of those seven targets (Pearson and Simmons, 1995). The latter study included additional assessment of the *SS Mary*. During their survey and subsequent diver evaluations, CEI located the fragmentary remains of a vessel that was tentatively identified as the *Utina*, a ship built for the U.S. Emergency Fleet in World War I and wrecked on the south jetty at Port Aransas in 1920.

EH&A undertook further investigation of the same wreck in 1994 (Schmidt and Hoyt, 1995). Their investigations consisted of diving on the site in order to map and delineate the wreck's extent and prominent structures. That study suggested that the site was not archaeologically significant nor eligible for the NRHP because of its fragmentary condition and due to the fact that better preserved examples of the *Utina* vessel type exist elsewhere. Schmidt and Hoyt agreed with CEI's tentative identification of the site as the *Utina*, although they noted some inconsistency between the site and the physical description of the *Utina.* For example, there was no evidence of the heavy iron hull strapping known from historic documents to have been an integral part of the *Utina's* heavy construction.

A more likely candidate for the *Utina* was discovered inadvertently by PBS&J during the summer of 2000. A second wreck was discovered at the end of the south jetty while conducting a close-order magnetometer survey of the wreck CEI and EH&A had tentatively identified as the *Utina*. PBS&J designated that site, investigated by divers during the 1990s, as Anomaly M2. The latter wreck, first located by archaeologists in 2000, has been designated Anomaly M39. Dimensions of the side-scan sonar target associated with M39 closely match the size of the *Utina*. Furthermore, the *Utina* is known from historic documents, including photography, to have stranded on the Gulf end of the south jetty (Schmidt and Hoyt, 1995), precisely where M39 is located. Anomaly M2, on the other hand, is located in deep water between the jetties on the southern margin of the ship channel.

A strong case can now be made that the vessel at Anomaly M2, investigated by CEI and EH&A during the 1990s, is not the *Utina*. Schmidt and Hoyt (1995) had concluded that the M2 wreck was not archaeologically significant based largely on the fact that several better preserved Emergency Fleet vessels, constructed similarly to the *Utina,* exist in the Sabine River. Given this new information, however, the M2 wreck must once again be considered potentially eligible for the NRHP until such time as its identity can be firmly established.

CEI also conducted a remote-sensing survey of a 45-mile-long segment of the GIWW extending from the Ship Channel at the northern end of Corpus Christi Bay to Point Penascal, Texas (Pearson and Wells, 1995). A total of twenty features were recorded during this study. One of the targets exhibited characteristics similar to historic shipwrecks. A diver assessment of that target was conducted, given that the wreck of the *Dayton*, a sidewheel steamer that sank in 1845, had been reported in the vicinity. In 1996, CEI returned to conduct diving operations on the site to further investigate the remains. The examination revealed the target to be modern debris rather than the remains of an historic vessel (Pearson and James, 1997).

Under the direction of PBS&J, additional marine remote-sensing surveys were completed in June and December of 2000 and in June 2001 to determine whether any unrecorded shipwrecks possibly lie within the study area (Enright et al., in prep.). Those surveys were conducted specifically to investigate proposed impact areas under study in this FEIS. The surveys covered all impact areas that had not already been addressed either by previous studies or through consultation with the State Historic Preservation Office (SHPO). Areas adjacent the CCSC, surveyed in June 2000, included the proposed Outer Bar Channel Extension (an area measuring 800 feet x 1.9 miles and centered on the proposed channel), the existing Outer Bar Channel (a 200-foot-wide x 2.8-mile-long area on each side of the channel beginning 50 feet inside the existing top of cut), the Inner Basin (just inside Aransas Pass jetties) to La Quinta Junction (200 feet x 10.8 miles on each side of channel), La Quinta Junction to Light Beacon 82 (400 feet x 9.7 miles on each side of channel), and Light Beacon 82 to Inner Harbor (200 feet x 1 mile on each side of channel). Areas adjacent the La Quinta Channel, surveyed in June 2000, include areas measuring 200 feet wide on each side of the existing channel (5.3 miles long) and a block to encompass the proposed La Quinta Channel Extension and Turning Basin (5,000 x 7,400 feet). Proposed BU sites surveyed in June 2001 include sites CQ (4,975 x 5,175 feet, 591 acres), I (4,825 x 6,875 feet, 762 acres), P (650 x 2,550 feet, 28 acres), R (4,500 x 6,000 feet, 620 acres), and S (4,900 x 5,375 feet, 605 acres). Marine impact areas which were not surveyed include landlocked portions of the CCSC Inner Harbor Reach, offshore BU sites MN and ZZ, BU Pelican, BU Site L, the western 20 percent of BU Site

GH, and all existing open-water PAs (both bay and offshore). Anticipated impacts to all areas were discussed with the SHPO. Low probability areas and previously disturbed areas, the latter including all existing PAs, BU Pelican and BU Site L, were excluded from survey. The inner harbor reach, the offshore BU's and the western 20 percent of BU Site GH were considered low probability areas. In the case of the Inner Harbor Reach this was because of it's recent construction date (from 1934 to 1958).

Thirty-seven magnetic anomalies were recommended for avoidance or further investigation based upon PBS&J's initial survey completed in June 2000 (see interim letter report, Remote-Sensing Survey of Corpus Christi and La Quinta Channels, DACW64-97-D-0004, Delivery Order No. 0013, PBS&J Project No. 440507.00, Texas Antiquities Permit No. 2407). Those anomalies shared characteristics with anomalies recorded over documented shipwrecks. Anomalies M01-M37 include twenty-three along the Corpus Christi Ship Channel, thirteen along the existing La Quinta Channel and turning basin, and one in the proposed extension of the La Quinta Channel turning basin and placement area.

A close-order remote-sensing survey was conducted in December 2000 over the 37 anomalies identified by the initial survey. The purpose of the close-order survey was to increase the resolution of the data over the recommended anomalies in an effort to better discriminate between significant and insignificant anomalies. As a result of the close-order survey, 28 of the original 37 anomalies were removed from further consideration. Ten anomalies (M1, M2, M3, M7, M9, M14, M17, M21, M25 and M38), including one newly discovered during the close-order survey (M38), were recommended for either avoidance of diver assessment. Two additional anomalies, M12 and M13, were recommended for further investigation provisional upon the findings at M38. If M38 was determined to be potentially associated with the wreck of the *Dayton*, then M12 and M13 were thought likely to contain scattered elements from the explosion of the *Dayton's* boilers (see interim letter report, Close-Order Remote-Sensing Survey of 37 Anomalies along Corpus Christi and La Quinta Ship Channels, DACW64-97-D-0004, Delivery Order No. 0013, Modification 01, PBS&J Project No. 440507.00, Texas Antiquities Permit No. 2407).

Consultation with the SHPO reduced the number of anomalies requiring further investigation to nine. Anomaly M2, the wreck formerly identified as the *Utina*, was excluded from further investigation due to the previous diver investigations of the site. Diver assessment of the nine remaining anomalies took place during June and July of 2001. A remote-sensing survey of 5 BU sites (CQ, P, I, R and S) took place simultaneously. As a result of the BU survey, diver assessment of two additional anomalies (I1 and I3) was appended to the diving on the other nine anomalies. Based on the diver assessments, ten of the eleven anomalies investigated were determined to be unassociated with historic shipwrecks. Anomaly M38, on the other hand, was determined to be associated with a shipwreck. Furthermore, the location, construction style and width of the wreck were all consistent with what is known of the *Dayton* (see interim letter report, Remote-Sensing Survey of Beneficial Use Areas and Diver Assessment of Eleven Anomalies, Corpus Christi and La Quinta Ship Channels, DACW64-97-D-0004, Delivery Order No. 0018 and Modification 01 to the same, PBS&J Project No. 440879.00, Texas Antiquities Permit No. 2407).

Additional consultation with the SHPO following discovery of the shipwreck at M38 resulted in concurrence with PBS&J's recommendation for further investigation of anomalies M12 and M13, both located adjacent M38. Diver assessment of M12 and M13 was conducted in October 2001. None of the objects causing those two anomalies appear to be associated with a shipwreck (see interim letter report, Diver Assessment of Two Anomalies for Historic Properties Investigations, Corpus Christi Ship Channel Improvements and La Quinta Channel Improvements and Extension, DACW64-97-D-0004, Delivery Order No. 0020, PBS&J Project No. 440966.00, Texas Antiquities Permit No. 2407). Anomaly M38 is considered potentially eligible for the NRHP and should be avoided by all future bottom disturbing activities.

3.8.3 Records Review

Records were reviewed at the Texas Archeological Research Laboratory (TARL) and at the THC to identify known cultural resource sites and to determine the location and type of sites previously identified in the study area vicinity. The listings on the National Register of Historic Places (NRHP) were reviewed for sites listed on, or determined eligible for, inclusion on the NRHP. The list of State Archeological Landmarks (SAL) prepared by the Department of Antiquities Protection at the THC was consulted for sites determined significant by the State. The Historical Marker Program of the THC was also consulted.

Based on the site maps at TARL, the review revealed 143 previously recorded terrestrial sites within 500 feet of the coastline, in the Corpus Christi Study Area. The THC records identified two of those 143 sites as having been determined eligible for listing to the NRHP. Those two sites, 41NU185 and 41NU219 are both prehistoric occupations. Ten SAL designated terrestrial sites (41NU7, 41NU15, 41NU40, 41NU41, 41NU86, 41NU87, 41NU88, 41NU89, 41NU185, and 41NU286) were also identified during the THC file review. The SAL sites are all prehistoric shell middens or campsites.

None of the NRHP eligible properties or SALs are located within the project impact areas. Site 41NU185 is located approximately 2.5 miles west of PA 7 (Site Tule Lake) and 41NU219 is located about 15 miles to the southeast of the impact locations. Site 41NU7 is at the northern end of Padre Island approximately 1.5 miles northeast of the eastern end of the causeway across the Laguna Madre. The South Guth Park Site, 41NU15, is located on the Oso Creek NE quadrangle map on the eastern bank of Oso Bay. This location is approximately 12 miles from the impact locations. The six King Ranch Prehistoric Sites (41NU40, 41NU41, 41NU86, 41NU87, 41NU88, 41NU89) that are designated SALs are located on the south bank of Oso Creek about 10 miles southeast of the impact locations. Site 41NU286 is located on the Estes topographic 7.5-minute quadrangle. The site is on Hog Island north of the Port Aransas Causeway.

Records for 81 historical markers were found for Nueces County and records for twenty-seven markers were found for San Patricio County. Some of these markers are 1936 Centennial Markers and some of the sites marked are Registered Texas Historical Landmarks.

PBS&J researched the THC shipwreck files recent AWOIS listings, and previous archaeological publications to determine whether any known shipwrecks are located within the current study area. Three shipwrecks have been confirmed in the immediate vicinity of project impacts. This includes the wreck of the S.S. *Mary* (41NU252) (Hoyt, 1990; Pearson and Simmons, 1995) located on the southern channel margin between the jetties at Aransas Pass, an unidentified wreck (41NU264) located just south of the channel near the seaward end of the southern jetty (formerly identified as the *Utina* in Pearson and Simmons, 1995, and Schmidt and Hoyt, 1995), and an unidentified wreck (site number unassigned at present) located slightly south of the Corpus Christi Ship Channel opposite McGloin's Bluff. The latter wreck, discovered by PBS&J during the summer of 2001, may be the remains of the *Dayton* whose boiler exploded within a quarter mile of McGloin's Bluff in 1845 (Enright, et al., in preparation). The S.S. *Mary* has been determined eligible for the NRHP. Site 41NU264 and the vessel discovered recently near McGloin's Bluff are believed to be potentially eligible for the NRHP, although a formal determination has not been made for either site.

3.9 AIR QUALITY

The Clean Air Act, which was last amended in 1990, requires the EPA to set National Ambient Air Quality Standards (NAAQS) for pollutants considered harmful to public health and the environment. The Clean Air Act established two types of national air quality standards:

- Primary standards set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly.
- Secondary standards set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings.

The EPA Office of Air Quality Planning and Standards has set NAAQSs for six principal pollutants that are called "criteria" pollutants. They are carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), lead (Pb), particulate matter with particle diameters of 10 micrometers or less (PM_{10}), particulate matter with particle diameters of 2.5 micrometers or less ($PM_{2.5}$), and sulfur dioxide (SO_2). In its General Air Quality Rules, the State of Texas provides for enforcement of the Federal NAAQSs. In addition, the TNRCC has set standards for net ground-level concentrations for particulate matter and sulfur compounds. Resulting air concentrations from sources on a property that emit these air contaminants should not exceed the applicable property-line standards. Air quality is generally considered acceptable if pollutant levels are less than or equal to established standards on a continuous basis. These pollutants are summarized in Table 3.9-1.

The Clean Air Act also requires EPA to assign a designation of each area of the U.S. regarding compliance with the NAAQS. EPA categorizes the level of compliance or noncompliance as follows:

1. Attainment – area currently meets the NAAQS
2. Maintenance – area currently meets the NAAQS, but has previously been out of compliance
3. Nonattainment – area currently does not meet the NAAQS

Nueces County is considered to be "near nonattainment" for ozone under Federal air quality standards and, therefore, is monitored closely by State and Federal environmental agencies. Once

TABLE 3.9-1

NATIONAL AMBIENT AIR QUALITY STANDARDS AND TNRCC PROPERTY-LINE NET GROUND-LEVEL CONCENTRATION STANDARDS

Air Constituent	Averaging Time	NAAQS Primary	NAAQS Secondary	TNRCC Regulation Standard
Sulfur Dioxide (SO_2)	30-min.	---	---	0.4 ppm (1,021 $\mu g/m^3$) 0.28 ppm (for Galveston or Harris County) 0.32 ppm (for Jefferson or Orange County)
	3-hr.	---	0.50 ppm	
	24-hr.	0.14 ppm		
	Annual Arithmetic Mean	0.03 ppm		
Particulate Matter (PM)	1-hr.	---	---	400 $\mu g/m^3$
	3-hr.	---	---	200 $\mu g/m^3$
Inhalable Particulate Matter (PM_{10})	24-hr.	150 $\mu g/m^3$	150 $\mu g/m^3$	---
	Annual Arithmetic Mean	50 $\mu g/m^3$	50 $\mu g/m^3$	---
Fine Particulate Matter ($PM_{2.5}$)	24-hr.	65 $\mu g/m^3$	65 $\mu g/m^3$	---
	Annual Arithmetic Mean	15 $\mu g/m^3$	15 $\mu g/m^3$	---
Nitrogen Dioxide (NO_2)	Annual Arithmetic Mean	0.053 ppm	0.053 ppm	---
Carbon Monoxide (CO)	1-hr.	35 ppm	---	
			---	---
	8-hr.	9 ppm		
Lead (Elemental) (Pb)	3-mo. (Calendar Quarter)	1.5 $\mu g/m^3$	1.5 $\mu g/m^3$	---
Ozone (O_3)	1-hr.	0.12 ppm	0.12 ppm	---
	8-hr.	0.08 ppm	0.08 ppm	

Source: EPA, 2002a.

µg/m3 – micrograms per cubic meter.

ppm – parts per million.

a metropolitan area has violated ozone levels over a 3-year period, the EPA can require stringent measures to bring that area back into compliance with the NAAQS.

The TNRCC is responsible for monitoring air and water quality within the State and for reporting that information to the public. The staff examines and interprets the causes, nature, and behavior of air pollution in Texas. The TNRCC operates several monitors located in the Corpus Christi area. TNRCC'S Corpus Christi Regional Office maintains these monitors. Four of the eight active monitoring stations measure the concentrations of the criteria pollutants in the air. All are used to measure meteorological parameters such as air temperature, wind velocity, and other meteorological parameters. The ozone monitors operate continuously 24 hours a day, 7 days a week, and are checked by technicians who perform equipment maintenance and conduct quality assurance checks.

Monitored values for the criteria pollutants in Nueces County are shown in Table 3.9-2. No data are available for CO, NO_2 or Pb. The monitoring data show that in 1995, the area exceeded the ozone and sulfur dioxide NAAQS standards (0.12 parts per million (ppm) and 0.14 ppm, respectively) for the 1-hour value. Since then, monitored values have been below the NAAQS.

When measured by the EPA's newer 8-hour standard, instituted in 1997, Corpus Christi has shown exceedances of the standard. Although challenged in federal court, the U.S. Supreme Court recently upheld the standard. Therefore, this 8-hour standard will apply to the Corpus Christi area in lieu of the 1-hour standard.

The air quality issues associated with port activities include non-road mobile air emission sources associated with waterborne traffic, including ships, barges, tugs, dredges, and various other types of marine and commercial vessels. Other activities include the loading and unloading of bulk cargo vessels and tankers. In addition, the port is supported by inland railway and highway transportation systems with associated emissions from combustion of fuel in railcars and vehicular traffic. Although the surrounding area is typically rural, air quality is hampered with dust from agricultural plowing, other automobile emissions, and manufacturing and industrial activities. (TNRCC, 1998).

In 1996, Nueces and San Patricio counties, acting through the Corpus Christi Air Quality Committee, finalized a 5-year plan for identifying actions that have been implemented by residents and businesses on a voluntary basis to control and reduce air pollution including ambient ozone. The plan was formalized in a Flexible Attainment Region memorandum of agreement approved by the EPA and TNRCC. Since then, residents and businesses of Nueces and San Patricio counties have carried out the provisions of the plan embodied in that agreement, successfully reducing and controlling ambient ozone. According to the TNRCC (2001b), key controls include:

- Controls of dockside emissions by industry
- Use of cleaner gasoline
- Training aimed at small and large businesses

As part of the TNRCC State Implementation Plan, regional strategies aimed at the eastern portion of the State, including Corpus Christi, will require the use of cleaner diesel fuel in vehicles such as tractors and bulldozers, and cleaner low-sulfur gasoline. As a result, Nueces and San Patricio

TABLE 3.9-2

MONITORED VALUES COMPARED WITH PRIMARY NAAQS
CORPUS CHRISTI, NUECES COUNTY

	Monitoring Year							
Value/Constituent	1995	1996	1997	1998	1999	2000	2001	NAAQS
2nd 24-hour value for PM_{10} ($\mu g/m^3$)	56	45	74	67	88	71	48	150
Annual mean value for PM_{10} ($\mu g/m^3$)	31.1	25.1	30.5	34.9	35.2	35.7	27.6	50
2nd max. 1-hour value for O_3 (ppm)	0.128	0.103	0.094	0.102	0.103	0.099	0.090	0.12
4th highest 8-hour value for O_3 (ppm)	no data	no data	0.077	0.082	0.085	0.083	0.077	0.08
2nd max. 24-hour value for SO_2 (ppm)	0.144	0.015	0.020	0.029	0.019	0.017	0.017	0.14
Annual mean value for SO_2 (ppm)	0.002	0.002	0.003	0.003	0.002	0.003	0.002	0.03
2nd max. 1-hour value for CO (ppm)	no data	no data	no data	no data	no data	no data	no data	35
2nd max. 8-hour value for CO (ppm)	no data	no data	no data	no data	no data	no data	no data	9
Annual mean value for NO_2 (ppm)	no data	no data	no data	no data	no data	no data	no data	0.053
Quarterly mean value for Pb ($\mu g/m^3$)	no data	no data	no data	no data	no data	no data	no data	1.5

Source: EPA, 2002a.

µg/m3 – micrograms per cubic meter.

ppm – parts per million.

counties, which compose the Corpus Christi urban air shed, are currently in attainment of the NAAQS for ozone adopted by the EPA pursuant to the Clean Air Act.

3.10 NOISE

As directed by Congress in The Noise Control Act of 1972 as amended by the Quiet Communities Act of 1978, the EPA has developed appropriate noise-level guidelines. The EPA generally recognizes rural areas to have an average day-night noise level (L_{dn}) of less than 50 decibels A-weighting (dBA) (EPA, 1978) and urban areas between 55 and 60 dBA. Average outdoor noise levels in excess of 70 dBA or more for 24 hours per day over a 40-year period can result in hearing loss (EPA, 1974). Several factors affect response to noise levels including background level, noise character, level fluctuation, time of year, time of day, history of exposure, community attitudes and individual emotional factors. Typically, people are more tolerant of a given noise level if the background level is closer to the level of the noise source. People are more tolerant of noises during daytime than at night. Residents are more tolerant of a facility or activity if it is considered to benefit the economic or social well being of the community or them individually. Noise levels also affect outdoor activities greater than indoor activities. The immediate activities within the study area affecting noise levels could include waterborne transportation (i.e., barges, commercial fishing vessels, sport and recreational boats, etc.) and dredging. Other noise sources on land include nearby airports and transportation corridors. The noise levels within the study area would increase in proximity to urban communities due to vehicular traffic and major construction activities.

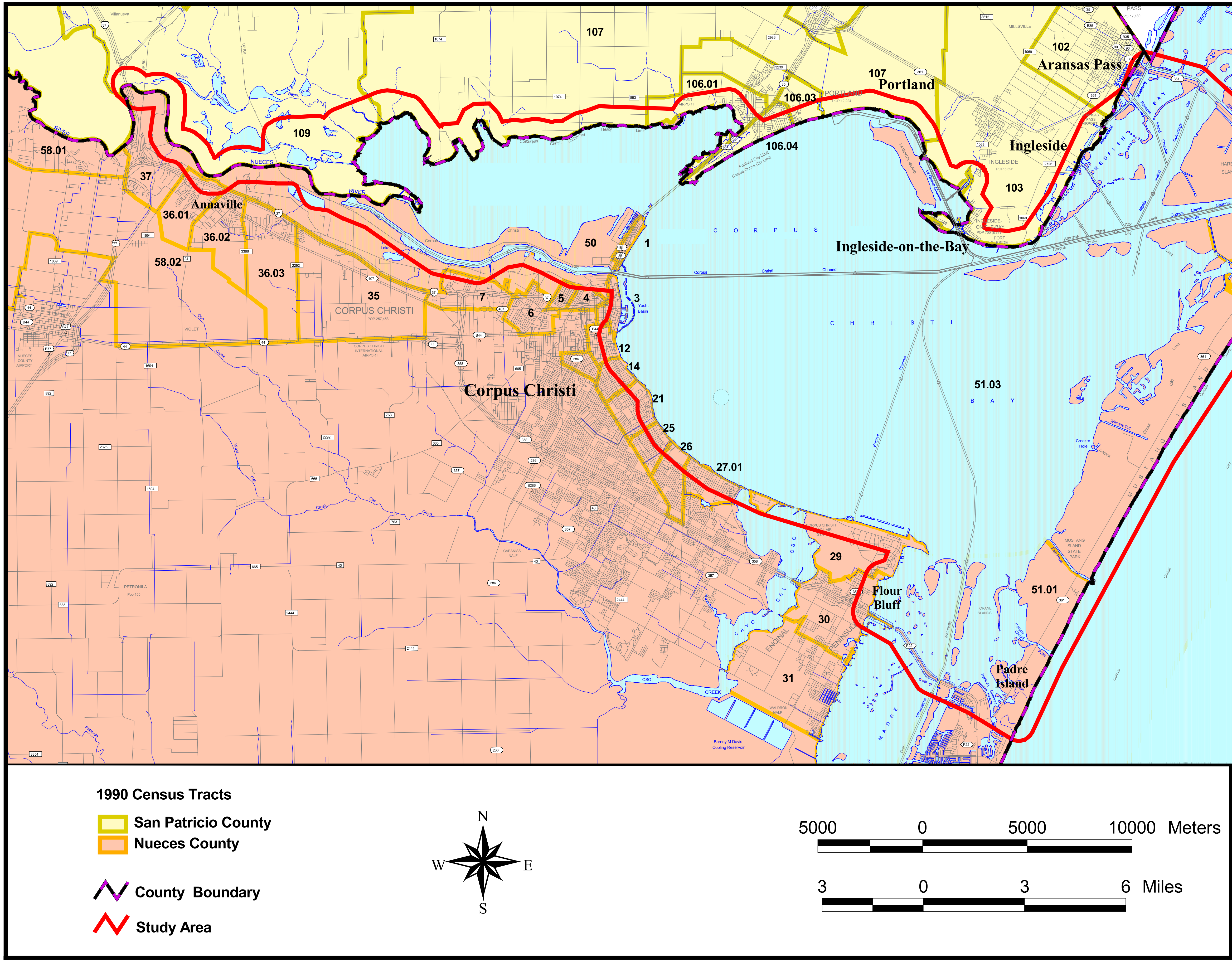
3.11 SOCIOECONOMIC RESOURCES

This section presents a summary of economic and demographic characteristics of the study area and surrounding areas within Nueces and San Patricio counties. The scope of this review includes both county level research and census tract level research (see Figure 3-3). Population, employment, the area economy, a historical perspective of economic development, land use, and Environmental Justice (EJ) are key areas of discussion. Also, a visual survey of the vicinity surrounding the study area was conducted on August 16 and 17, 2001, as a source of information for the land use section.

3.11.1 Population

The proposed project involves improvements to the existing CCSC and extension of the La Quinta Channel. The study area includes Nueces County on the south and San Patricio County on the north, as well as a number of port towns. Vessels enter the CCSC east of Port Aransas, immediately passing north of the City of Port Aransas and then traversing the east end of Corpus Christi Bay toward Ingleside and Aransas Pass. The channel extends west into the Inner Harbor where it parallels the Corpus Christi shoreline. The La Quinta Channel extends to the north bordering Ingleside-On-The-Bay toward Portland.

The proposed project is located in Nueces and San Patricio counties. The 2000 population of Nueces County was 313,645 persons. The City of Corpus Christi, population 277,454, is located within Nueces County on the south side of Corpus Christi Bay. Nueces County maintained steady growth, increasing by 8.5 percent between 1980 and 1990 and by 7.7 percent between 1990 and 2000



206 Wild Basin Rd., Ste. 300
Austin, Texas 78746-3343
Phone: (512) 329-8342 Fax: (512) 327-2453

Figure 3-3
Corpus Christi Ship Channel Census Tracts

Prepared for: USACE

Job No.: 440524	Scale: 1" = 3 Miles
Prepared by: G. Rackley	Date: Feb 2002

File: N:\440524\av\census.apr (census_B_size layout)

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(Table 3.11-1). Aransas Pass (pop. 8,138), Port Aransas (pop. 3,370), Ingleside (pop. 9,388), Ingleside-On-The-Bay (pop. 659), and Portland (pop. 14,827) border the northern part of the study area within San Patricio County. The 2000 census places San Patricio County's population at 67,138 persons, an increase of 14.3 percent since 1990. The county maintained a steady population between 1980 and 1990 increasing by only 1.3 percent (from 58,013 to 58,749) over that decade. Neither county grew as fast as the State during the 1980s or the 1990s.

As shown in Table 3.11-2, population projections provided by the Texas State Data Center (TSDC) indicate that growth in both counties is expected to continue; however, neither county is expected to surpass state growth rates through 2030. Nueces County is projected to grow at 0.5 percent per year, while San Patricio County is projected to grow at 1.2 percent per year. Growth rates in both counties are expected to remain positive but decline steadily after 2000. Year 2000 projections have proven to be substantially higher than current 2000 counts for Nueces County and lower than 2000 counts for San Patricio County. The resulting 2010 to 2030 projections may prove to be similarly skewed.

Generally speaking, the populations of Nueces and San Patricio counties are more ethnically diverse than that of the State of Texas (Table 3.11-3). Largely, this is attributable to a higher percentage of Hispanic people living in the two counties. In 2000, both Nueces and San Patricio counties had percentages of White persons (37.7 and 45.8 percent, respectively) that are substantially less than that of the State of Texas (at 52.4 percent). The percentage of African-Americans for both Nueces and San Patricio counties (4.1 and 2.6 percent, respectively) was substantially less than that of the State (at 11.3 percent). The percentage of Hispanics for these two counties (55.8 percent and 49.4 percent, respectively) was substantially higher than for the State (at 32 percent). The percentage of persons of all other races for the two counties (2.4 and 2.1 percent, respectively) was slightly less than for the State (at 4.2 percent).

3.11.1.1 Population and Community Cohesion

This section provides an assessment of various population demographics. Provided below is USBOC information collected for the following categories: family households, household tenure, length of residency, average per capita income, average median household incomes, and poverty levels.

The USBOC classification of "family households" (homes that are occupied by a family) is the dominant form of household composition in both Nueces and San Patricio County census tracts (USBOC, 1990) (Table 3.11-4). Within the Nueces County census tracts located in the study area, households are categorized as follows: family households represent 86.4 percent of all households; non-family households were 11.8 percent of all households, and group quarter households represent 1.8 percent of all households. Within the San Patricio County census tracts located in the study area, the breakdown of household types are as follows: family households represent 92.3 percent of all households; non-family households were 7.2 percent of all households, and group quarter households were 0.5 percent of all households. Unusually high percentages of non-family and/or group quarters households were found in the following census tracts: Nueces County study area census tracts 3, 4, 12, 14, 21, 25, 26, 29, 30, 50, 51.01, 51.02, and 51.03, and San Patricio County study area census tracts 102, and 106.01.

TABLE 3.11-1

POPULATION TRENDS 1980-2000

	Population			Percent Change		
Place	1980	1990	2000	1980-90	1990-2000	Average Annual 1980-2000
San Patricio County	58,013	58,749	67,138	1.3%	14.3%	0.7%
Nueces County	268,215	291,145	313,645	8.5%	7.7%	0.8%
State of Texas *(in 1,000s)*	14,229	16,987	20,852	19.4%	22.8%	1.9%

Source: USBOC, 1980, 1990; TSDC, 2000.

TABLE 3.11-2

POPULATION PROJECTIONS 2000-2030

	Population					Percent Change				
Place	1990	2000	2010	2020	2030	1900-2000	2000-10	2010-20	2020-30	Average Annual 1990-2030
San Patricio County	58,749	68,958	78,443	87,716	95,581	17.4%	13.8%	11.8%	9.0%	1.2%
Nueces County	291,145	318,690	339,100	351,885	355,000	9.5%	6.4%	3.8%	0.9%	0.5%
State of Texas *(in 1,000s)*	16,987	20,345	24,129	28,685	33,912	19.8%	18.6%	18.9%	18.2%	1.7%

Source: USBOC, 1990; TSDC, 2000.

TABLE 3.11-3

DETAILED 1990 POPULATION CHARACTERISTICS BY STATE AND COUNTY

	Population	Number White	Percent White	Number African American	Percent African American	Hispanic Origin	Percent Hispanic	Number Other	Percent Other	Number Below Poverty	Percent Below Poverty
Texas	16,986,510	10,291,680	60.6%	1,976,360	11.6%	4,339,905	25.5%	378,565	2.2%	3,074,558	18.10%
Nueces County	58,749	28,005	47.7%	745	1.3%	29,586	50.4%	413	0.7%	14,686	25.0%
San Patricio County	291,145	124,643	42.8%	12,206	4.2%	151,000	51.9%	3,296	1.1%	59,528	20.4%

Source: USBOC, 1990.

TABLE 3.11-4

HOUSEHOLD COMPOSITION BY STUDY AREA CENSUS TRACTS, 1990

Nueces County Census Tracts	Number of Households	Family Households	% Family Households	Non-Family Households	% Non-Family Households	Living in Group Quarters	% in Group Quarters
3	1,618	419	25.9%	424	26.2%	775	47.9%
4	2,503	2,094	83.7%	337	13.5%	72	2.9%
5	2,433	2,186	89.8%	247	10.2%	0	0.0%
6	8,012	7,286	90.9%	641	8.0%	85	1.1%
7	3,902	3,421	87.7%	428	11.0%	53	1.4%
12	4,342	3,223	74.2%	838	19.3%	281	6.5%
14	4,726	3,636	76.9%	1,030	21.8%	60	1.3%
21	7,180	5,709	79.5%	1,396	19.4%	75	1.0%
25	4,374	3,743	85.6%	590	13.5%	41	0.9%
26	7,520	6,207	82.5%	1,313	17.5%	0	0.0%
27.01	4,994	4,430	88.7%	564	11.3%	0	0.0%
29	1,827	1,426	78.1%	0	0.0%	401	21.9%
30	8,121	6,967	85.8%	1,154	14.2%	0	0.0%
31	8,688	8,056	92.7%	632	7.3%	0	0.0%
35	2,371	2,123	89.5%	248	10.5%	0	0.0%
36.01	5,779	5,389	93.3%	390	6.7%	0	0.0%
36.02	6,359	5,908	92.9%	451	7.1%	0	0.0%
36.03	2,356	2,231	94.7%	125	5.3%	0	0.0%
37	3,136	2,983	95.1%	153	4.9%	0	0.0%
50	1,344	1,174	87.4%	170	12.6%	0	0.0%
51.01	2,741	2,371	86.5%	370	13.5%	0	0.0%
51.02	2,191	1,730	79.0%	461	21.0%	0	0.0%
51.03	84	68	81.0%	16	19.0%	0	0.0%
58.01	3,939	3,739	94.9%	200	5.1%	0	0.0%
58.02	4,251	3,994	94.0%	221	5.2%	36	0.8%
Total/Average	104,791	90,513	86.4%	12,399	11.8%	1,879	1.8%

San Patricio County Census Tracts	Number of Households	Family Households	% Family Households	Non-Family Households	% Non-Family Households	Living in Group Quarters	% in Group Quarters
102	7187	6300	87.7%	740	10.3%	147	2.0%
103	6656	6195	93.1%	461	6.9%	0	0.0%
106.01	5382	4932	91.6%	450	8.4%	0	0.0%
106.03	1045	1036	99.1%	9	0.9%	0	0.0%
106.04	3107	2883	92.8%	224	7.2%	0	0.0%
107	1894	1794	94.7%	100	5.3%	0	0.0%
109	4430	4264	96.3%	166	3.7%	0	0.0%
Total/Average	29,701	27,404	92.3%	2,150	7.2%	147	0.5%
Total/Average Both Counties	134,492	117,917	87.7%	14,549	10.8%	2,026	1.5%

Source: USBOC, 1990.

"Household tenure" is a category that distinguishes between owner-occupied housing units and renter-occupied housing units. The 1990 census data within the study area shows that owner-occupied housing units are more abundant than renter occupied housing units in both Nueces and San Patricio counties (Table 3.11-5). Within the Nueces County census tracts, occupied housing units can be categorized as follows: owner-occupied units represent 61 percent, and renter-occupied units represent 39 percent. Within the San Patricio County census tracts, occupied housing units can be categorized as follows: owner-occupied units represent 66.6 percent, and renter-occupied units represent 33.4 percent. Unusually high percentages of renter-occupied housing units were found in the following census tracts: Nueces County study area census tracts 3, 4, 5, 12, 21, 26, 29, 30, 36.01, 51.01, 51.02, and 51.03, and San Patricio County study area census tracts 102, 103, and 106.01.

The "Length of Residency" category shows the average number of years that housing units are occupied. The 1990 census data within the study area shows that a majority of residents moved into their homes between 1980 and 1990 (Table 3.11-6). Within the Nueces County census tracts, the percentage of homes occupied was 28.4 percent between 1989 and 1990, 26.1 percent between 1985 and 1988, 13.1 percent between 1980 and 1984, 15.7 percent between 1970 and 1979, 9 percent between 1960 and 1969, and 7.7 percent of the homes have been occupied since 1959 or earlier. Within the San Patricio County census tracts, the percentage of homes occupied was: 23.9 percent between 1989 and 1990, 24.6 percent between 1985 and 1988, 15 percent between 1980 and 1984, 20.8 percent between 1970 and 1979, 9.2 percent between 1960 and 1969, and 6.5 percent of the homes have been occupied since 1959 or earlier.

Table 3.11-7 shows the age characteristics for the study area census tracts, and provides a comparison with the overall age characteristics in Nueces and San Patricio counties and the State. Relative to the State, the study area population had higher proportions of the population within the following age cohorts: 5 to 9 (8.6 percent), 10 to 14 (8.3 percent), 15 to 19 (7.8 percent), 35 to 44 (15.6 percent), 45 to 54 (10.1 percent), 55 to 59 (4.3 percent), 60 to 64 (4.1 percent), 65 to 74 (6.5 percent), and 75 to 84 (3.5 percent). The study area population had lower proportions than the State for the following age cohorts: 0 to 5 (7.9 percent), 20 to 24 (6.2 percent), 25 to 34 (16.3 percent), and 85 and over (0.9 percent).

An examination of per capita incomes for census tracts within the study area in Nueces County shows that the average per capita income in 1989 was $14,536. There were significant variations among the census tracts in the study area (Table 3.11-8). Unusually low per capita incomes were recorded for the following Nueces County study area census tracts: 4, 5, 6, 7, 12, 29, 30, 35, and 36.03. For study area census tracts in San Patricio County, the average per capita income in 1989 was $13,138. There were also significant variations among these census tracts. Unusually low per capita incomes were recorded for the following San Patricio County study area census tracts: 102, 103, and 109.

Average median household incomes (average of all median household income values reported by the USBOC for all study area census tracts) were also examined in the study area. For study area census tracts in Nueces County, the average median household income in 1989 was $28,013 although there were significant variations among the census tracts (see Table 3.11-8). Comparatively low median household incomes were recorded for the following Nueces County study area census tracts: 3, 4, 5, 6, 7, 12, 30, 35, and 51.02. For study area census tracts in San Patricio County, the average median

TABLE 3.11-5

STUDY AREA TENURE BY STUDY AREA CENSUS TRACTS, 1990

Nueces County Census Tracts	# Occupied Household Units	Owner Occupied Units	% Owner Occupied Units	Renter Occupied Units	% Renter Occupied Units
3	546	31	5.7%	515	94.3%
4	830	127	15.3%	703	84.7%
5	842	389	46.2%	453	53.8%
6	2,501	1,673	66.9%	828	33.1%
7	3,902	3,421	87.7%	428	11.0%
12	1,598	414	25.9%	1,184	74.1%
14	2,039	1,258	61.7%	781	38.3%
21	3,144	1,587	50.5%	1,557	49.5%
25	1,818	1,270	69.9%	548	30.1%
26	3,142	1,784	56.8%	1,358	43.2%
27.01	1,981	1,430	72.2%	551	27.8%
29	385	22	5.7%	363	94.3%
30	3,018	1,336	44.3%	1,682	55.7%
31	2,895	2,021	69.8%	874	30.2%
35	710	505	71.1%	205	28.9%
36.01	1,827	1,104	60.4%	723	39.6%
36.02	2,179	1,368	62.8%	811	37.2%
36.03	825	644	78.1%	181	21.9%
37	986	682	69.2%	304	30.8%
50	488	313	64.1%	175	35.9%
51.01	1,245	643	51.6%	602	48.4%
51.02	963	571	59.3%	392	40.7%
51.03	45	22	48.9%	23	51.1%
58.01	1,320	964	73.0%	356	27.0%
58.02	1,255	1,074	85.6%	181	14.4%
Total/Average	40,484	24,653	61.0%	15,778	39.0%

San Patricio County Census Tracts	# Occupied Household Units	Owner Occupied Units	% Owner Occupied Units	Renter Occupied Units	% Renter Occupied Units
102	2,504	1,483	59.2%	1,021	40.8%
103	2,239	1,415	63.2%	824	36.8%
106.01	1,880	1,022	54.4%	858	45.6%
106.03	293	254	86.7%	39	13.3%
106.04	1,101	897	81.5%	204	18.5%
107	580	442	76.2%	138	23.8%
109	1,300	1,081	83.2%	219	16.8%
Total/Average	9,897	6,594	66.6%	3,303	33.4%
Total/Average Both Counties	50,381	31,247	62.0%	19,081	38.0%

Source: USBOC, 1990.

TABLE 3.11-6
STUDY AREA LENGTH OF RESIDENCY, 1990
Year Householder Moved Into Residence

Nueces County Census Tracts	# Occupied Housing Units	1989 to 1990	%	1985 to 1988	%	1980 to 1984	%	1970 to 1979	%	1960 to 1969	%	1959 or Earlier	%
3	546	228	41.8%	209	38.3%	43	7.9%	39	7.1%	19	3.5%	8	1.5%
4	830	248	29.9%	222	26.7%	137	16.5%	76	9.2%	70	8.4%	77	9.3%
5	842	244	29.0%	186	22.1%	71	8.4%	134	15.9%	125	14.8%	82	9.7%
6	2,501	596	23.8%	353	14.1%	240	9.6%	440	17.6%	438	17.5%	434	17.4%
7	1,338	365	27.3%	272	20.3%	122	9.1%	286	21.4%	109	8.1%	184	13.8%
12	1,598	608	38.0%	331	20.7%	171	10.7%	303	19.0%	82	5.1%	103	6.4%
14	2,039	534	26.2%	528	25.9%	192	9.4%	228	11.2%	230	11.3%	327	16.0%
21	3,144	778	24.7%	640	20.4%	451	14.3%	574	18.3%	251	8.0%	450	14.3%
25	1,818	350	19.3%	388	21.3%	198	10.9%	339	18.6%	282	15.5%	261	14.4%
26	3,142	842	26.8%	713	22.7%	342	10.9%	573	18.2%	460	14.6%	212	6.7%
27.01	1,981	427	21.6%	431	21.8%	242	12.2%	473	23.9%	264	13.3%	144	7.3%
29	385	218	56.6%	167	43.4%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
30	3,018	1,196	39.6%	1,025	34.0%	444	14.7%	220	7.3%	92	3.0%	41	1.4%
31	2,895	667	23.0%	1,000	34.5%	531	18.3%	497	17.2%	132	4.6%	68	2.3%
35	710	222	31.3%	88	12.4%	112	15.8%	126	17.7%	98	13.8%	64	9.0%
36.01	1,827	572	31.3%	734	40.2%	318	17.4%	104	5.7%	53	2.9%	46	2.5%
36.02	2,179	658	30.2%	548	25.1%	300	13.8%	405	18.6%	200	9.2%	68	3.1%
36.03	825	117	14.2%	180	21.8%	79	9.6%	199	24.1%	161	19.5%	89	10.8%
37	986	182	18.5%	249	25.3%	158	16.0%	227	23.0%	105	10.6%	65	6.6%
50	488	149	30.5%	171	35.0%	110	22.5%	31	6.4%	14	2.9%	13	2.7%
51.01	1,245	733	58.9%	349	28.0%	100	8.0%	52	4.2%	11	0.9%	0	0.0%
51.02	963	299	31.0%	292	30.3%	129	13.4%	177	18.4%	39	4.0%	27	2.8%
51.03	45	12	26.7%	19	42.2%	14	31.1%	0	0.0%	0	0.0%	0	0.0%
58.01	1,320	401	30.4%	444	33.6%	186	14.1%	230	17.4%	50	3.8%	9	0.7%
58.02	1,255	112	8.9%	372	29.6%	260	20.7%	235	18.7%	125	10.0%	151	12.0%
Total/Average	37,920	10,758	28.4%	9,911	26.1%	4,950	13.1%	5,968	15.7%	3,410	9.0%	2,923	7.7%

San Patricio County Census Tracts	# Occupied Housing Units	1989 to 1990	%	1985 to 1988	%	1980 to 1984	%	1970 to 1979	%	1960 to 1969	%	1959 or Earlier	%
102	2,504	676	27.0%	686	27.4%	332	13.3%	540	21.6%	153	6.1%	117	4.7%
103	2,239	530	23.7%	527	23.5%	324	14.5%	469	20.9%	234	10.5%	155	6.9%
106.01	1,880	623	33.1%	435	23.1%	193	10.3%	333	17.7%	230	12.2%	66	3.5%
106.03	293	54	18.4%	104	35.5%	87	29.7%	48	16.4%	0	0.0%	0	0.0%
106.04	1,101	262	23.8%	208	18.9%	65	5.9%	323	29.3%	136	12.4%	107	9.7%
107	580	86	14.8%	166	28.6%	130	22.4%	117	20.2%	35	6.0%	46	7.9%
109	1,300	132	10.2%	311	23.9%	355	27.3%	224	17.2%	127	9.8%	151	11.6%
Total/Average	9,897	2,363	23.9%	2,437	24.6%	1,486	15.0%	2,054	20.8%	915	9.2%	642	6.5%
Total/Average Both Counties	47,817	13,121	27.4%	12,348	25.8%	6,436	13.5%	8,022	16.8%	4,325	9.0%	3,565	7.5%

Source: USBOC 1990.

Table 3.11-7
Age Characteristics of Study Area Census Tracts, 1990

Place	Years of Age																										Total
	under 5		5 to 9		10 to 14		15 to 19		20 to 24		25 to 34		35 to 44		45 to 54		55 to 59		60 to 64		65 to 74		75 to 84		85 and over		
Nueces County Census Tracts	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	Persons
3	37	2.3%	32	2.0%	25	1.5%	110	6.8%	177	10.9%	402	24.8%	246	15.2%	119	7.3%	39	2.4%	43	2.7%	118	7.3%	166	10.2%	107	6.6%	1,621
4	354	14.4%	329	13.4%	249	10.1%	210	8.5%	183	7.4%	318	12.9%	218	8.8%	170	6.9%	72	2.9%	69	2.8%	164	6.7%	101	4.1%	27	1.1%	2,464
5	182	7.5%	219	9.0%	200	8.2%	222	9.1%	160	6.6%	351	14.4%	318	13.1%	196	8.1%	107	4.4%	135	5.5%	216	8.9%	100	4.1%	27	1.1%	2,433
6	602	7.5%	750	9.4%	801	10.0%	758	9.5%	514	6.4%	1,125	14.0%	1112	13.9%	745	9.3%	291	3.6%	343	4.3%	561	7.0%	343	4.3%	67	0.8%	8,012
7	381	9.8%	351	9.0%	303	7.8%	277	7.1%	278	7.1%	655	16.8%	527	13.5%	334	8.6%	170	4.4%	160	4.1%	297	7.6%	129	3.3%	42	1.1%	3,904
12	421	9.7%	317	7.3%	283	6.5%	283	6.5%	352	8.1%	780	18.0%	533	12.3%	296	6.8%	151	3.5%	178	4.1%	320	7.4%	266	6.1%	147	3.4%	4,327
14	366	7.7%	295	6.2%	246	5.2%	247	5.2%	264	5.6%	897	19.0%	831	17.6%	402	8.5%	204	4.3%	180	3.8%	362	7.7%	339	7.2%	93	2.0%	4,726
21	538	7.5%	529	7.4%	476	6.6%	450	6.3%	385	5.4%	1186	16.5%	1078	15.0%	608	8.5%	261	3.6%	297	4.1%	672	9.4%	554	7.7%	146	2.0%	7,180
25	275	6.3%	291	6.7%	279	6.4%	229	5.2%	221	5.1%	599	13.7%	698	16.0%	466	10.7%	209	4.8%	257	5.9%	507	11.6%	286	6.5%	57	1.3%	4,374
26	450	6.0%	491	6.5%	477	6.3%	478	6.4%	454	6.0%	1211	16.1%	1093	14.5%	760	10.1%	392	5.2%	491	6.5%	779	10.4%	363	4.8%	81	1.1%	7,520
27.01	308	6.1%	356	7.0%	336	6.6%	315	6.2%	251	4.9%	694	13.6%	802	15.8%	581	11.4%	278	5.5%	353	6.9%	591	11.6%	183	3.6%	39	0.8%	5,087
29	330	17.7%	183	9.8%	108	5.8%	87	4.7%	337	18.1%	586	31.4%	185	9.9%	38	2.0%	7	0.4%	1	0.1%	2	0.1%	0	0.0%	1	0.1%	1,865
30	705	8.7%	751	9.3%	729	9.0%	649	8.0%	602	7.4%	1524	18.9%	1317	16.3%	748	9.3%	280	3.5%	244	3.0%	362	4.5%	147	1.8%	25	0.3%	8,083
31	642	7.4%	794	9.1%	855	9.8%	792	9.1%	384	4.4%	1338	15.4%	1567	18.0%	1081	12.4%	392	4.5%	313	3.6%	394	4.5%	120	1.4%	16	0.2%	8,688
35	179	7.6%	207	8.8%	248	10.6%	255	10.9%	130	5.6%	357	15.3%	422	18.0%	220	9.4%	79	3.4%	78	3.3%	106	4.5%	53	2.3%	6	0.3%	2,340
36.01	611	10.6%	701	12.1%	597	10.3%	448	7.8%	331	5.7%	1252	21.7%	1021	17.7%	405	7.0%	134	2.3%	83	1.4%	128	2.2%	59	1.0%	9	0.2%	5,779
36.02	488	7.7%	585	9.2%	588	9.2%	564	8.9%	403	6.3%	1080	17.0%	1083	17.0%	697	11.0%	260	4.1%	209	3.3%	252	4.0%	122	1.9%	28	0.4%	6,359
36.03	145	6.1%	184	7.7%	239	10.0%	194	8.1%	137	5.7%	316	13.2%	319	13.4%	258	10.8%	136	5.7%	146	6.1%	206	8.6%	89	3.7%	19	0.8%	2,388
37	303	9.6%	270	8.6%	292	9.3%	285	9.1%	222	7.1%	510	16.2%	504	16.0%	322	10.2%	138	4.4%	95	3.0%	130	4.1%	58	1.8%	14	0.4%	3,143
50	99	7.9%	133	10.6%	132	10.5%	113	9.0%	73	5.8%	181	14.5%	200	16.0%	125	10.0%	56	4.5%	41	3.3%	62	5.0%	34	2.7%	3	0.2%	1,252
51.01	140	4.9%	124	4.4%	128	4.5%	157	5.5%	201	7.1%	509	18.0%	548	19.3%	399	14.1%	195	6.9%	166	5.9%	212	7.5%	44	1.6%	12	0.4%	2,835
51.02	114	5.2%	156	7.1%	131	5.9%	129	5.8%	99	4.5%	308	13.9%	422	19.1%	289	13.1%	145	6.6%	116	5.2%	200	9.0%	86	3.9%	17	0.8%	2,212
51.03	4	3.8%	7	6.6%	2	1.9%	4	3.8%	4	3.8%	10	9.4%	16	15.1%	19	17.9%	8	7.5%	5	4.7%	20	18.9%	4	3.8%	3	2.8%	106
58.01	280	7.0%	369	9.2%	383	9.5%	365	9.1%	145	3.6%	611	15.2%	797	19.8%	529	13.2%	185	4.6%	133	3.3%	153	3.8%	52	1.3%	14	0.3%	4,016
58.02	296	7.1%	450	10.8%	434	10.5%	360	8.7%	207	5.0%	650	15.7%	587	14.1%	431	10.4%	224	5.4%	166	4.0%	217	5.2%	107	2.6%	22	0.5%	4,151
Total/Average	8,250	7.9%	8,874	8.5%	8,541	8.1%	7,981	7.6%	6,514	6.2%	17,450	16.6%	16,444	15.7%	10,238	9.8%	4,413	4.2%	4,302	4.1%	7,031	6.7%	3,805	3.6%	1,022	1.0%	104,865
San Patricio County Census Tracts																											
102	591	8.2%	689	9.5%	621	8.6%	545	7.5%	438	6.1%	1,019	14.1%	975	13.5%	676	9.3%	338	4.7%	343	4.7%	555	7.7%	347	4.8%	97	1.3%	7,234
103	550	8.2%	625	9.3%	577	8.6%	583	8.7%	406	6.1%	1,035	15.5%	992	14.8%	797	11.9%	272	4.1%	261	3.9%	361	5.4%	198	3.0%	34	0.5%	6,691
106.01	501	9.3%	495	9.2%	459	8.5%	434	8.0%	377	7.0%	1,008	18.6%	859	15.9%	548	10.1%	218	4.0%	178	3.3%	212	3.9%	99	1.8%	17	0.3%	5,405
106.03	66	6.2%	123	11.6%	96	9.1%	112	10.6%	38	3.6%	114	10.8%	240	22.6%	176	16.6%	38	3.6%	27	2.5%	27	2.5%	2	0.2%	1	0.1%	1,060
106.04	176	5.7%	229	7.4%	261	8.4%	273	8.8%	165	5.3%	348	11.3%	505	16.3%	467	15.1%	219	7.1%	171	5.5%	185	6.0%	80	2.6%	13	0.4%	3,092
107	142	8.1%	159	9.1%	166	9.5%	165	9.4%	87	5.0%	281	16.1%	253	14.5%	189	10.8%	70	4.0%	73	4.2%	116	6.6%	42	2.4%	7	0.4%	1,750
109	299	7.0%	418	9.8%	414	9.7%	386	9.1%	262	6.2%	578	13.6%	644	15.1%	457	10.7%	202	4.7%	214	5.0%	251	5.9%	100	2.4%	28	0.7%	4,253
Total/Average	2,325	7.9%	2,738	9.3%	2,594	8.8%	2,498	8.5%	1,773	6.0%	4,383	14.9%	4,468	15.2%	3,310	11.2%	1,357	4.6%	1,267	4.3%	1,707	5.8%	868	2.9%	197	0.7%	29,485
Study Area Average Both Counties	10,575	7.9%	11,612	8.6%	11,135	8.3%	10,479	7.8%	8,287	6.2%	21,833	16.3%	20,912	15.6%	13,548	10.1%	5,770	4.3%	5,569	4.1%	8,738	6.5%	4,673	3.5%	1,219	0.9%	134,350
Nueces County	24,043	8.3%	25,838	8.9%	24,759	8.5%	23,331	8.0%	19,960	6.9%	50,538	17.4%	43,049	14.8%	27,025	9.3%	11,696	4.0%	11,484	3.9%	17,879	6.1%	9,079	3.1%	2,464	0.8%	291,145
San Patricio County	4,827	8.2%	5,639	9.6%	5,382	9.2%	5,097	8.7%	3,790	6.5%	8,614	14.7%	8,332	14.2%	5,924	10.1%	2,568	4.4%	2,479	4.2%	3,615	6.2%	1,946	3.3%	536	0.9%	58,749
Texas (in 1,000s)	1,390	8.2%	1,396	8.2%	1,294	7.6%	1,312	7.7%	1,334	7.9%	3,086	18.2%	2,539	14.9%	1,629	9.6%	662	3.9%	628	3.7%	998	5.9%	552	3.2%	167	1.0%	16,987

Source: USBOC, 1990.

TABLE 3.11-8
INCOME BY STUDY AREA CENSUS TRACTS, 1990

Nueces County Census Tracts	Number of Persons	Per Capita Income	Median Household Income	# Below Poverty	% Below Poverty
3	1,618	$20,276	$12,576	313	19.3%
4	2,503	$4,351	$4,999	1,710	68.3%
5	2,433	$5,727	$11,734	1,041	42.8%
6	8,012	$7,634	$17,791	2,552	31.9%
7	3,902	$8,276	$21,907	906	23.2%
12	4,342	$7,889	$13,341	1,714	39.5%
14	4,726	$20,973	$28,382	564	11.9%
21	7,180	$16,739	$26,293	1,046	14.6%
25	4,374	$23,736	$37,246	406	9.3%
26	7,520	$15,216	$26,182	1,316	17.5%
27.01	5,087	$28,576	$37,136	493	9.7%
29	1,827	$9,005	$26,010	88	4.8%
30	8,121	$9,799	$22,125	1,561	19.2%
31	8,688	$12,388	$32,351	1,110	12.8%
35	2,371	$8,655	$23,169	400	16.9%
36.01	5,779	$13,084	$37,804	503	8.7%
36.02	6,359	$12,051	$32,423	559	8.8%
36.03	2,356	$10,444	$30,000	414	17.6%
37	3,136	$11,408	$32,151	405	12.9%
50	1,344	$11,902	$27,316	343	25.5%
51.01	2,750	$24,196	$47,348	149	5.4%
51.02	2,207	$14,688	$23,224	349	15.8%
51.03	84	$38,300	$51,869	6	7.1%
58.01	3,954	$16,671	$45,966	210	5.3%
58.02	4,251	$11,425	$30,970	602	14.2%
Total/Average	104,924	$14,536	$28,013	18,760	17.9%

San Patricio County Census Tracts	Number of Persons	Per Capita Income	Median Household Income	# Below Poverty	% Below Poverty
102	7,187	$8,938	$16,318	2,596	36.1%
103	6,656	$10,096	$24,634	1,009	15.2%
106.01	5,382	$11,216	$27,094	669	12.4%
106.03	1,045	$23,232	$63,907	11	1.1%
106.04	3,107	$16,509	$40,625	73	2.3%
107	1,894	$12,100	$37,115	380	20.1%
109	4,430	$9,872	$26,119	785	17.7%
Total/Average	29,701	$13,138	$33,687	5,523	18.6%
Total/Average Both Counties	134,625	$14,230	$29,254	24,283	18.0%

Source: USBOC, 1990.

household income in 1989 was $33,687. There were fairly moderate variations among these census tracts. Comparatively low median household incomes were recorded for the following San Patricio County study area census tracts: 102, 103, 106.01, and 109.

Poverty levels were examined in the study area. For study area census tracts in Nueces County, the average percentage of the population living below the poverty line ($15,000) in 1989 was 17.9 percent. There were significant variations among the census tracts (see Table 3.11-8). Relatively high percentages of persons living below the poverty line were recorded for the following Nueces County study area census tracts: 4, 5, 6, 12, and 37. For study area census tracts in San Patricio County, the average percentage of the population living below the poverty line in 1989 was 18.6 percent, and there were fairly moderate variations among these census tracts. A high percentage of persons living below the poverty line was recorded for San Patricio County study area census tract 102.

3.11.2 Employment

According to the Texas Workforce Commission, most of the jobs in Nueces County fall within the Service sector (32 percent) and Trade sector (26 percent). In San Patricio County, manufacturing is the dominant economic sector employing 3,472 persons, or 24 percent of the labor force; the trade and service sectors employ 19 and 16 percent of the workforce, respectively. In Nueces County, the total civilian labor force increased 8.6 percent between 1990 and 2000 from 136,056 to 147,857. The unemployment rate remained constant at approximately 6.6 percent during this period. In San Patricio County, the civilian labor force increased by 21 percent from 24,981 in 1990 to 30,208 in September of 1998. During the same period, the unemployment rate remained relatively constant, decreasing from 6.9 percent in 1990 to 6.7 percent in September 2000 (Texas Workforce Commission, 2001).

Table 3.11-9 provides a list of the top 20 major employers within the Corpus Christi area. The top employers are concentrated in the government (including public school and military employees), healthcare, telecommunications, petroleum refining, and petrochemical manufacturing industries, and other oil industry/port-related enterprises. The employers listed in Table 3.11-9 that are associated with the operations of the Port of Corpus Christi appear with an asterisk following the company name. Within the top 20 employers, seven have operations directly related to the Port of Corpus Christi, providing just over 10,900 jobs within the Corpus Christi area. The Corpus Christi Chamber of Commerce estimates that port-related companies employed approximately 50,000 people in the Corpus Christi area in 2001 (Corpus Christi Chamber of Commerce, 2001).

3.11.3 Economics

3.11.3.1 Historical Perspective

Corpus Christi began as a small supply post for the Mexican war in the early 1800s. Throughout its history, it has been dependent upon a channel to accommodate its burgeoning ship trade. After the Civil War, the Corpus Christi Bay became a shipping point for moving notable Texas crops (e.g., cattle and cotton) to eastern markets. By 1874, an 8-foot channel, known as the Corpus Christi Channel, was dredged through the bay that allowed steamships to dock at Corpus Christi markets (Heines and Williams, 2001; San Patricio County, 2001).

TABLE 3.11-9

STUDY AREA MAJOR EMPLOYERS, 2002

Top 20 Study Area Employers	Number of Employees
Naval Air Station Corpus Christi	8,800
Corpus Christi ISD	5,355
Christus Spohn Health System	4,500
Naval Station Ingleside*	3,400
Corpus Christi Army Depot	3,000
City of Corpus Christi	3,000
Columbia Healthcare Corp.	2,882
Bay, Inc.*	2,200
HEB Grocery Co.	2,200
Koch Refining Company*	1,253
First Data Corp	1,200
Walmart, Inc.	1,200
APAC Teleservices	1,200
Driscoll Children's Hospital	1,100
Celanese*	1,050
Sherwin Alumina*	1,000
Gulf Marine Fabricators*	1,000
Kiewit Offshore Service, Ltd.*	1,000
Whataburger, Inc.	967
Sam Kane Beef Processors	840

Sources: Corpus Christi Chamber of Commerce, 2002; Portland Chamber of Commerce, 2002; Ingleside Chamber of Commerce, 2002; Corpus Christi Regional Economic Development Corporation, 2002.

* Employer associated with the operations of the Port of Corpus Christi.

In 1911, the first causeway was built across Nueces Bay linking Corpus Christi with the North Bay area. The following year, a major natural gas field was discovered in San Patricio County on the north side of Nueces Bay. Eventually, Corpus Christi became a major center for oil refining and petrochemical industries (San Patricio County, 2001).

In 1907, the channel (under the auspices of the Turtle Cove Channel Project) was deepened to 10 feet and widened to 100 feet. By 1910, the channel was deepened again to a depth of 12 feet. The channel was extended 21 miles to Corpus Christi in 1926 of which only 12 miles between Port Aransas and McGloins Bluff required dredging. On September 14, 1926, the Port of Corpus Christi's 25- by 200-foot channel was opened as the principal port in south Texas (Heines and Williams, 2001).

The channel was dredged to 37 feet wide by 400 feet deep in 1932 (James and Pearson, 1991; Schmidt and Hoyt, 1995). The deep-water port supported the simultaneously occurring oil boom. Between 1935 and 1937, Nueces County increased its number of oil fields from two to 894 (Heines and Williams, 2001).

Throughout the second half of the twentieth century, the bay area's infrastructure and channel related commerce thrived. In 1938, the U.S. Navy opened a training base in the city, and in 1945 the Intracoastal Canal opened a 12-foot-deep canal from Galveston to Corpus Christi, allowing free trade to move quickly between the two cities. In 1947, the University of Corpus Christi (Now Texas A&M University–Corpus Christi) opened at the former U.S. Navy facility on the city's southern end (Heines and Williams, 2001). In 1950, the 4-mile-long Padre Island Causeway (later renamed the John F. Kennedy Causeway) connected the city with Padre and Mustang Islands, and in 1959 the Harbor Bridge over the CCSC was completed (Heines and Williams, 2001). Also in the late 1950s, at the request of Reynolds Metal Company, the USACE dredged a channel through Ingleside Cove along the western side of McGloin's Bluff known as the La Quinta Channel. The 36-foot-deep and 200-foot-wide channel facilitated the development of Reynolds Metal Company (Alperin, 1977). In 1960, the Corpus Christi International Airport was built. In 1962, President Kennedy authorized the purchase of 80.5 miles of Padre Island for a national seashore, with the construction of Interstate Highway 37 (IH 37) connecting Corpus Christi to San Antonio beginning soon after (Heines and Williams, 2001). In 1972, Mustang Island State Park was purchased and added into the park system. By the mid-1980s, the Port of Corpus Christi was ranked the sixth largest port in the nation in terms of tonnage (Heines and Williams, 2001).

Tourism has become a major industry in the area. In 1997, tourism in Corpus Christi and the surrounding area generated over $700 million in local spending, an increase of $204 million compared with 1996 spending estimates. Oil and gas are still important within both Nueces and San Patricio County economies, but its role is declining. The services industry has been the fastest growing job industry in the area in the 1990s. Five out of six jobs in the area are in the service sector. Between 1970 and 1997, the local economy created 35,450 new service jobs, and the mining industry and oil and gas lost 1,500 jobs (San Patricio County, 2001).

The Coastal Bend's petrochemical industry pumps more than $1 billion into the area's economy and provides an estimated 30,000 jobs. Four major operations are located along the north shore of Corpus Christi Bay: DuPont, Occidental Chemical Corporation, Reynolds Metals Company, and Aker-Gulf Marine which is the second largest off-shore platform builder in the country (San Patricio County, 2001).

3.11.3.2 Current Regional Economics

The economy of the Corpus Christi Bay area is broadly based in manufacturing, agriculture and fishing. The port of Corpus Christi handles large volumes of commodities including crude petroleum and petroleum products, aluminum ores, and agricultural products (USACE, 2000). The port ranks fifth in the nation in total cargo tonnage and fourth in foreign trade volume (Port of Corpus Christi, 1999). Industrial development in the area consists of plants devoted to processing agricultural products, petrochemicals, and chemical derivatives; manufacturing fishing and offshore service vessels, drilling rigs, offshore producing platforms, and offshore service equipment; and reducing ores to produce aluminum, zinc, and chrome products.

The CCSC was the first waterway in Texas to be completed to a 45-foot depth. The channel ranks fifth in the nation in tonnage shipped on deep-draft vessels. This amount of deep-draft tonnage transport through the channel has been increasing steadily since 1965. In Texas, only the Houston Ship Channel handles more traffic (Figure 3-4).

Government also contributes greatly to the area economy. The military is the single largest employer in the Corpus Christi area with the Army Depot and Naval Air Station located on the south side of Corpus Christi Bay, employing 11,800 persons. This 4,400-acre facility has eight runways and provides a $226 million civilian and $107 million military economic contribution to the area. Also within the study area, Naval Station Ingleside is located on the north side of Corpus Christi Bay. Selected as Gulf homeport in 1985, Naval Station Ingleside is currently home to twenty-five minesweepers and three reserve frigates (U.S. Navy, 2000; Corpus Christi Regional Economic Development Corporation, 2002).

3.11.3.3 Tourism and Recreation

Tourism is a major contributor to the Corpus Christi area economy. According to the Corpus Christi Chamber of Commerce, tourism revenues were estimated at $603 million (in constant dollars) in 1994 and increased by 11 percent to $670 million in 2000. Corpus Christi is the second most frequented visitor destination in Texas, with approximately 4 million visitors annually (Corpus Christi Chamber of Commerce, 2000). A majority of the tourism (approximately 70 percent) is drawn from the intrastate travel market, primarily from the largest metropolitan areas of Texas (Hammer, Siler, George Associates, 1997). Much of the tourism in the Corpus Christi area occurs due to the extensive opportunities for outdoor recreation, and the natural beauty of the Corpus Christi Bay, Mustang Island, North Padre Island, and the Gulf of Mexico. Also, the Corpus Christi area is a popular destination for conventions. Man-made tourism destinations within the area include the Texas State Aquarium, the Greyhound Racetrack, and the USS *Lexington* Museum by the Bay (Corpus Christi Chamber of Commerce, 2000).

The natural resources of the Corpus Christi Bay and the Gulf of Mexico provide extensive recreational opportunities in the Corpus Christi area. Outdoor recreation in the area includes fishing, bird-watching, waterfowl hunting, windsurfing, camping, boating, jet skiing, swimming, horseback riding, shelling and beach combing (among others). There are several marinas located within the Corpus Christi Bay area, Port Aransas, and Aransas Pass that support recreational as well as commercial fishing. The Padre Island National Seashore is a popular destination, providing approximately 60 miles of protected beaches along North Padre Island just south of the Corpus Christi city limits. Mustang Island State Park contains 3,703 acres and is located within the southern portion of Mustang Island. This park provides RV spaces, rest rooms and campsites and provides another popular point for beach access. Also, located within the vicinity of the study area is the Corpus Christi Bay Loop of the Great Texas Coastal Birding Trail, that is managed by the TPWD. Fourteen separate trails used for bird-watching make up the Corpus Christi Bay Loop (TPWD, 1999).

3.11.3.4 Commercial Fisheries

Commercial fishing within the Corpus Christi Bay system is a relatively moderate contributor to the Corpus Christi area economy compared to other industry sectors. Table 3.11-10

Figure 3-4
Corpus Christi Ship Channel Transport

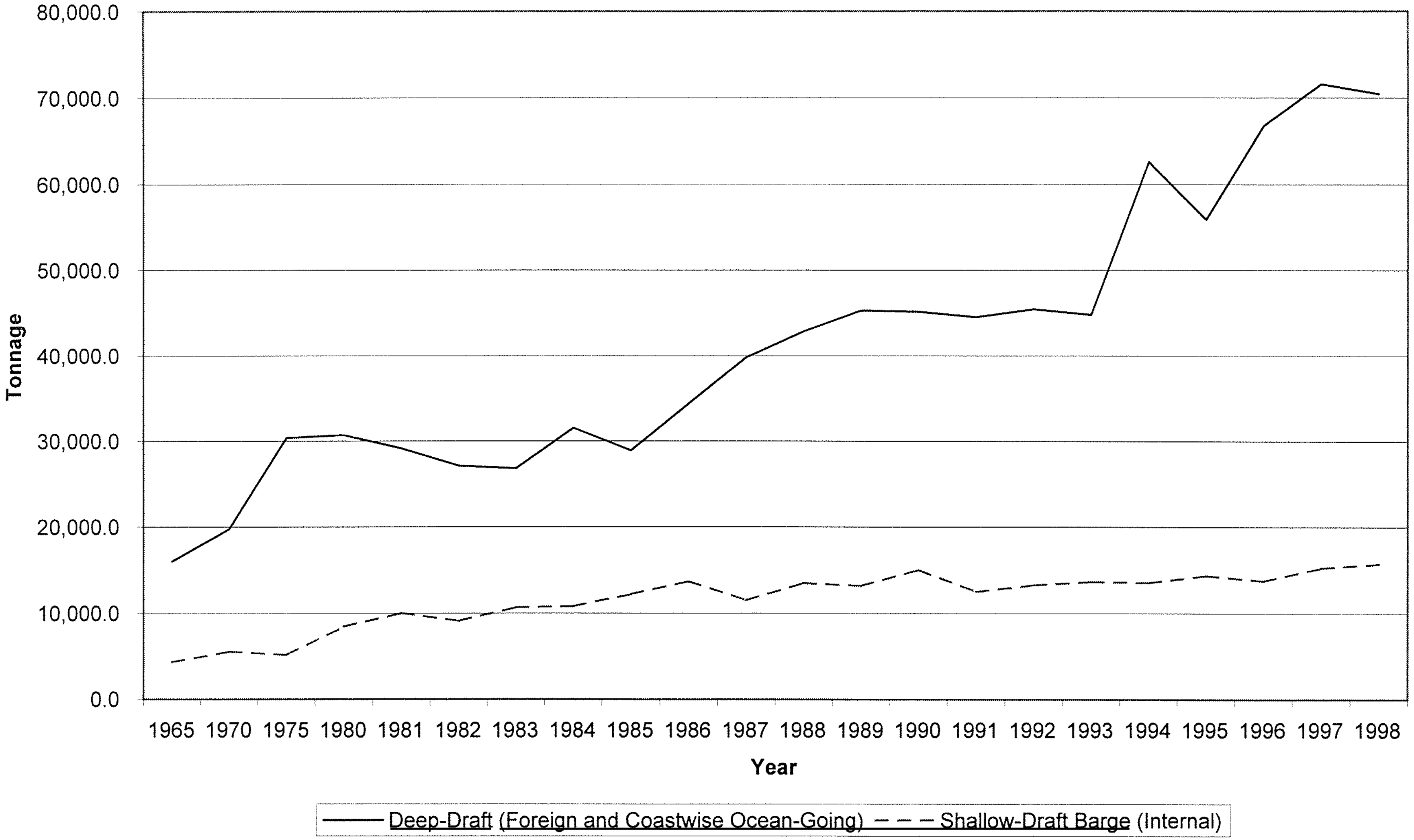

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Table 3.11-10
Trends in Commercial Fishery Landings
Corpus Christi Bay Compared With All Texas Bay Systems, 1999

	Corpus Christi Bay System						All Texas Bay Systems	
	weight (lbs) of fish landed	% of total weight of all Corpus Christi Bay finfish and shellfish	% of total weight from all Texas bay system landings	wholesale value of fish landed	% of total wholesale value from all Corpus Christi Bay finfish and shellfish	% of total wholesale value from all Texas bay system landings	weight (lb x 1,000) from all Texas bay system landings	wholesale value ($ x 1,000) from all Texas bay system landings
Black drum	134,920	18.8%	4.8%	$136,549	14.8%	5.1%	2,798.5	$2,689.8
Flounder	1,841	0.3%	0.6%	$4,039	0.4%	0.7%	284.2	$597.1
Sheeps-head	2,893	0.4%	2.5%	$1,546	0.2%	3.2%	117.4	$47.7
Mullet	1,488	0.2%	2.5%	$3,112	0.3%	4.6%	60.2	$68.0
other finfish	18,719	2.6%	10.8%	$88,569	9.6%	16.1%	173.7	$551.7
Total finfish	159,861	22.2%	4.7%	$233,815	25.3%	5.9%	3,434.0	$3,954.2
Brown and Pink shrimp	512,867	71.4%	9.1%	$568,355	61.5%	11.7%	5,637.7	$4,857.8
White shrimp	33,755	4.7%	0.7%	$113,347	12.3%	1.4%	4,837.0	$8,095.6
Other shrimp	137	0.0%	0.2%	$137	0.0%	0.7%	59.8	$18.8
Total shrimp	546,759	76.1%	5.2%	$681,839	73.7%	5.3%	10,534.6	$12,972.2
Blue crab	8,039	1.1%	0.1%	$3,707	0.4%	0.1%	6,471.9	$4,294.7
Eastern oyster	0	0.0%	0.0%	$0	0.0%	0.0%	5,183.3	$11,216.4
other shellfish	3,994	0.6%	4.6%	$5,190	0.6%	3.4%	86.5	$151.3
Total shellfish	558,792	77.8%	2.5%	$690,737	74.7%	2.4%	22,276.4	$28,634.5
Total finfish and shellfish	**718,653**	**100.0%**	**2.8%**	**$924,552**	**100.0%**	**2.8%**	**25,710.4**	**$32,588.8**

Source: TPWD, 2001.

compares the commercial fishery landings of the Corpus Christi Bay with all Texas bay systems in 1999. The total wholesale value for all finfish and shellfish landings in the Corpus Christi Bay system in 1999 was $924,552, or 2.8 percent of the wholesale value of all such landings for all Texas bay systems in that same year (at $32.6 million). For the Corpus Christi Bay system, shrimp had the greatest wholesale value, by far, worth $681,839 in 1999, or 73.7 percent of wholesale value for all finfish and shellfish. Black drum and "other finfish" also represented substantial shares of the overall wholesale value of finfish and shellfish from landings in the Corpus Christi Bay system, at $136,549 (or 14.8 percent) and $88,569 (9.6 percent) in 1999. The total weight of all finfish and shellfish landings in the Corpus Christi Bay system in 1999 was 718,653 pounds, or 2.8 percent of the weight of all such landings for all Texas bay systems in 1999 (at 25.7 million pounds). Shrimp and black drum landings represented the greatest share of the weight of all finfish and shellfish landings in 1999, at 546,759 pounds (or 76.1 percent) and 134,920 pounds (18.8 percent), respectively. It is noteworthy, however, that 1999 was not a particularly good year for commercial fishing in the Corpus Christi Bay system. During the 1990s, 1992 had the greatest total value for all finfish and shellfish landings, at $6.0 million, or 549 percent greater than the 1999 value (TPWD, 2001).

3.11.3.5 Tax Base

In Texas, the state sales tax is 6.25 percent, with local sales/use tax not to exceed 8.25 percent. Within the general vicinity of the study area, local sales/use taxes are as follows (Texas Comptroller of Public Accounts, 2001a):

- The City of Corpus Christi sales/use tax is 8.125 percent and includes 1.25 percent Corpus Christi City Tax, 0.125 percent Corpus Christi Crime Control District, and 0.5 percent Corpus Christi MTA Tax.
- The City of Port Aransas sales/use tax is 8.25 percent and includes 1.5 percent Port Aransas City Tax and 0.5 percent Corpus Christi MTA Tax.
- The City of Ingleside sales/use tax is 8.25 percent and includes 2 percent Ingleside City Tax.
- The City of Portland sales/use tax is 7.75 percent and includes 1.5 percent Portland City Tax.
- The City of Aransas Pass sales/use tax is 7.75 percent and includes 1 percent Aransas Pass City Tax, and 0.5 percent Aransas Pass Municipal Development District Tax.

In Texas, property is appraised and property tax is collected by local (county) tax offices or appraisal districts, and these funds are used to fund many local needs including public schools, city streets, county roads, and police and fire protection (Texas Comptroller of Public Accounts, 2001b). Property taxes within Nueces County are collected by the Nueces County Tax Office; in San Patricio County, they are collected by the San Patricio County Appraisal District. Table 3.11-11 provides a summary of property tax jurisdictions and tax rates for jurisdictions that affect large portions of the population living in the vicinity of the study area.

TABLE 3.11-11

PROPERTY TAX JURISDICTIONS, NUECES AND SAN PATRICIO COUNTIES – 2000

Tax Jurisdictions	Tax Rate per $100 of Appraised Valuation
Nueces County	
Nueces County	0.352742
Port of Corpus Christi	0.023718
City of Port Arthur	0.470000
Corpus Christi Independent School District	1.570000
Port Aransas Independent School District	1.449057
Hospital	0.228028
Farm-to-Market Road	0.002738
San Patricio County	
San Patricio County/Drainage District	0.628500
San Patricio County Navigation District	0.036800
City of Ingleside	0.810000
Ingleside Independent School District	1.389180
City of Aransas Pass	0.831850
Aransas Pass Independent School District	1.487000
City of Ingleside-by-the-Bay	0.184620
City of Portland	0.570000
Gregory-Portland Independent School District	1.639100
Ingleside Industrial	0.810000

Sources: Nueces County Tax Office, 2001;
San Patricio County Appraisal District, 2001.

3.11.4 Land Use

Nueces and San Patricio counties lie in the Coastal Bend region of Texas. Land use within the two-county area consists of agricultural land, range-pasture land, industrial land, urban-residential and urban-commercial land, recreational land and facilities, military installations, and marshlands. Water use includes mineral production, commercial and sport fishing, recreation, and transportation.

In San Patricio County, agriculture has historically been, and continues to be, an important part of the economy despite the highly variable rainfall. Approximately 83 percent of the land is used for agriculture, of which about 36 percent is used for range and pastureland, and the remaining 64 percent is cultivated. Only about 9 percent is considered urban. In Nueces County, about 61 percent of the land is used for agriculture, 79 percent of which is under cultivation. Similarly, about 10 percent is considered urban (NRCS, 1992).

The study area for the proposed project encompasses Corpus Christi Bay, including the southern section of Redfish Bay and the northern section of the Laguna Madre, Nueces Bay, the lower Nueces River (12 miles), Tule Lake Channel, Viola Channel, La Quinta Channel and the watershed surrounding these water bodies up to roughly one-half mile inland from all shorelines (see Figure 1-1). The coastline of this area extends across Nueces and San Patricio counties and is adjacent to the cities of Corpus Christi, Portland, Ingleside-On-The-Bay, and Port Aransas.

Along the southern shore of Corpus Christi Bay, is the City of Corpus Christi. With a population of over a quarter million persons, Corpus Christi is the seventh largest city in Texas. Corpus Christi is also South Texas's regional center for banking, retailing, healthcare, and business. The Corpus Christi central business district (CBD) is located southeast of the ship channel entrance to the Inner Harbor (or the Port of Corpus Christi). The Corpus Christi CBD is the most densely urbanized of any area within the vicinity of the study area. Included in this area are skyscrapers, hotels, office buildings, apartment buildings, parks, civic buildings, and other businesses. Also, included in this area is the Convention and Visitors Bureau, the Art Center of Corpus Christi, the Memorial Medical Center, and the Corpus Christi Municipal Marina. Along the shoreline of the Corpus Christi Bay is Shoreline Boulevard and the Seawall, which serves as a gathering place for visitors, joggers, strollers, bikers, and others (Heines and Williams, 2001).

To the southeast of the Corpus Christi CBD along Ocean Drive (which parallels the Corpus Christi Bay Shoreline), land uses consist primarily of large single-family homes, apartments, condos, and a few businesses. Further to the east along Ocean Drive is the campus of Texas A&M University–Corpus Christi, which is built on a thin isthmus between Corpus Christi Bay and Cayo del Oso Bay. Located at the eastern end of Ocean Drive is the Corpus Christi Naval Air Station, a 4,400-acre facility.

The community of Flour Bluff extends south of the Corpus Christi Naval Air Station. This area is dominated by single-family homes with some schools, businesses, and vacant land. Boat docks, small private marinas, and gulf marshes border the western shore of the Laguna Madre within Flour Bluff.

The JFK Causeway crosses the Laguna Madre and connects Flour Bluff and Corpus Christi with North Padre Island. This causeway crosses a few small islands where a variety of restaurants, boat ramps, bait shops, and other fishing related businesses are located.

North Padre Island is located on the east side of JFK Causeway. The portion of this barrier island that is located within the vicinity of the study area contains a variety of land uses, including single-family homes, condominiums, apartments, hotels, restaurants, and other businesses. Businesses in this area cater to beachgoers, and fishermen who frequent this area. The Padre Isles residential community includes waterways and canals adjacent to large single-family homes. Packery Channel is a waterway that cuts through this portion of North Padre Island, but does not connect with the Gulf of Mexico. Nueces County manages the beaches along the Gulf of Mexico shoreline of North Padre Island.

Mustang Island is located north of North Padre Island and along State Highway 361 (SH 361). The southern end of Mustang Island is very sparsely developed, with only a few condos and single-family residences. Also located along the southern portion of Mustang Island is Mustang Island State Park. This state park includes beach access, campgrounds, and RV hookups. Traveling further north along Mustang Island toward the City of Port Aransas, the island becomes progressively more developed. Land uses consist of single-family homes, condos, apartments, hotels, and businesses that are located along SH 361. Also located in this area are the Island Moorings Marina and the Port Aransas Airport, a small landing strip. At the northern end of Mustang Island is the City of Port Aransas, a small coastal community that attracts surfers, beachcombers, anglers, artists, and tourists. Land uses in this area include single-family homes, condos, hotels, restaurants, civic buildings, and shops. The University of Texas – Marine Science Institute is located on the northeastern side of Port Aransas adjacent to the CCSC. The Port Aransas Municipal Marina, which provides docks for fishing and recreational boats, is also adjacent to the CCSC. The channel entrance to the CCSC is located on the north side of Port Aransas where ferries shuttle cars across the channel to Harbor Island to the north allowing cars to access Aransas Pass.

Harbor Island has a variety of land uses including petroleum tanks, industrial uses, fishing docks, bait shops, and a terminal site for the Texas Treasures Casino Cruises. SH 361 connects Harbor Island with the City of Aransas Pass. Aransas Pass is a small coastal community developed with single-family homes, condos, businesses, civic buildings, waterways and canals, and the Conn Brown Harbor.

Along the western shore of the Redfish Bay, south of Aransas Pass, land uses are mostly industrial, including the Gulf Coast Fabricators, a builder of offshore oil drilling platforms. Also within this area are two small private harbors with associated apartments, RV parks, and a wastewater treatment plant.

The City of Ingleside consists of residential, commercial, civic, industrial, and parkland uses. The Naval Station at Ingleside is located on the south side of town and is the headquarters for the Navy's mine warfare fleet and equipment. On the west side of Ingleside's CBD along the Corpus Christi Bay shoreline are a few major manufacturing plants, such as Reynolds Aluminum, DuPont, and OxyChem. Southeast of Ingleside are the south yards of the Gulf Marine Fabricators. South of Ingleside is the small community of Ingleside-On-The-Bay. Land use in Ingleside-On-The-Bay is mostly residential, concentrated near the Bahia Mar Marina. The CCSC passes just to the south of Ingleside-On-The-Bay.

The City of Portland is located west of Ingleside and north of Corpus Christi Bay and the Nueces Bay Causeway. Land uses in this area include residential, commercial, civic, and park land uses that are centered mostly along SH 35. The Hunt Airport is located on the southwest side of Portland. West of Portland, on the north side of Nueces Bay, land uses are mostly agricultural or vacant with some single-family homes and ranchettes.

Along the Nueces River, to the west of its confluence with the Nueces Bay, land uses are mostly residential and vacant. The area is characterized by a moderate degree of urban encroachment upon the 100-year floodplain (riparian zone). The Nueces River State Park provides an area for picnics and field sports along the river on the west side of IH 37.

The Port of Corpus Christi manages port commerce along the Inner Harbor of the CCSC which is south of Nueces Bay and northwest of the City of Corpus Christi CBD. The Port includes dock-side storage areas, open storage and fabrication sites, cargo terminals, refrigerated warehouse space, direct transportation support from three major rail carriers, and several State and Federal highways. The Port of Corpus Christi has renovated its Cargo Docks 1 and 2 into a multi-purpose cruise terminal/meeting and banquet facility (Port of Corpus Christi, 2001). Also located along the Inner Harbor are numerous heavy industry land uses. Along this industrial corridor, there are several refinery plants including the Koch Services, Citgo, and Valero plants. Included in this industrial zone is the Equistar Pipeline Operations, Valley Solvents and Chemicals, the Interstate Grain Port Terminal, ADM Growmark (grain elevators), and the Centex Cement Company. Also, in and around the Inner Harbor there are numerous small and large companies associated with equipment and supplies for vessels, shipping and receiving of dry bulk materials, construction materials and other goods, pipeline manufacturing, and a wide variety of other goods and services related to waterborne commerce (USACE, 2002).

North of the Inner Harbor along the Nueces Bay Causeway is a narrow strip of land known as Corpus Christi Beach that divides Corpus Christi Bay from Nueces Bay. In this area, there are a variety of land uses, including apartments, condos, restaurants, souvenir shops, and industrial uses. The USS *Lexington* (aircraft carrier) is permanently docked here and houses a historical naval museum.

3.11.4.1 Transportation

Surface transportation in the vicinity of Corpus Christi Bay is provided by a network of primary, secondary, and local roads.

IH 37 connects Corpus Christi and San Antonio by a distance of 140 miles. In Corpus Christi, IH 37 connects the Annaville, Calallen, Five Points, and Tuloso-Midway neighborhoods on the city's northwest side with the rest of the city. U.S. Highway 77 (US 77) connects Kingsville and Corpus Christi and is the most direct route to and from the Rio Grande Valley on the Mexican border. US 181 runs north from IH 37 near the Corpus Christi bayfront. It crosses the Harbor Bridge, Corpus Christi Beach and the Nueces Bay Causeway towards Portland. After passing through Portland, it veers northwest through several small towns of San Patricio County. SH 35 runs from US 181 north of Portland to Aransas Pass and Rockport. SH 361 runs east from SH 35 to Ingleside, Aransas Pass, Harbor Island, and the north ferry landing to Port Aransas. It then heads south down Mustang Island to Park Road 22 at the southern edge of Corpus Christi. Park Road 22 begins at the southeastern end of SH 358, known locally as South Padre Island Drive, and continues to the entrance of Padre Island National Seashore. SH 358 runs from west of the Crosstown Expressway (SH 286) to the Corpus Christi Naval Air Station on the city's southeast side. The Crosstown Expressway (SH 286) connects IH 37 with South Padre Island Drive (SH 358). Shoreline Boulevard/Ocean Drive runs along the Corpus Christi bayfront from north of IH 37 to the Corpus Christi Naval Air Station (Heines and Williams, 2001).

The Corpus Christi International Airport supports five airlines and a mix of jets and turbo-prop commercial planes providing air service to other major Texas city airports. The airport is located south of SH 44 on the west side of town. Construction has already begun on a 40- to 50-year master plan to upgrade the airport's facilities, an eventual cost of $70 to $80 million. The upgrade will eventually mean an additional 30 gates, more cargo planes, a new 10,000-foot runway, and 1,400 acres added to the airport (Heines and Williams, 2001).

Rail transportation is integral to the operations of the Port of Corpus Christi, and numerous industrial sites that are located within the Inner Harbor and surrounding the Corpus Christi Bay. The Port of Corpus Christi owns and manages 26 miles of rail lines within the Inner Harbor area known as the Corpus Christi Terminal Railroad, Inc. (CCTR). All of the Port of Corpus Christi docks that are located within the Inner Harbor are served by the CCTR. The Union Pacific Railroad (UPRR) provides direct rail access to all of the industrial sites located south of the CCSC in the Inner Harbor area. Two other railroads, the Burlington Northern Santa Fe Railway (BNSF) and the Texas-Mexican Railway, also provide service to the Inner Harbor area. In addition, the UPRR provides rail access to industrial sites located along the northern shoreline of the Corpus Christi Bay (Babin, 2002; Port of Corpus Christi, 2002).

3.11.4.2 Community Services

Fire protection within the vicinity of the study area is handled by a combination of municipal and volunteer fire departments (VFD). Fire departments serving the project study area include the City of Corpus Christi Fire Department, the City of Port Aransas VFD, the Ingleside VFD, and the Ingleside-On-The-Bay VFD.

Fire protection within the city limits of Corpus Christi is handled by the Corpus Christi Fire Department, which serves approximately 300,000 residents. This fire department has 15 stations and has a service area that covers approximately 139 square miles of land, 169 square miles of water, and 12 linear miles of beach along the Gulf of Mexico. The fire stations are located throughout the City and along North Padre Island to Calallen (City of Corpus Christi, 2001a).

The City of Port Aransas VFD provides fire protection and other emergency services to 10,000 people within a 10-square-mile area surrounding the city limits of Port Aransas. This VFD includes 22 volunteer fire fighters and has one fire station and seven fire trucks (Hatzenbuehler, 2002).

The Ingleside VFD provides service to 9,388 people within an 11-square-mile area surrounding the city limits of Ingleside. This VFD includes 49 volunteer fire fighters and has one fire station and nine fire trucks (Marroquin, 2002).

The Ingleside-On-The-Bay VFD provides service to 1,500 people within a 25-square-mile service area (Texas Emergency Services, 2001). This VFD includes approximately five volunteer fire fighters and has one fire station and one fire truck (Hosea, 2002).

The Insurance Services Office, Inc. (ISO) is the entity that evaluates the performance of fire departments throughout the U.S. The ISO rankings are determined through the examination of four primary factors: the city's alerting system (e.g., 911 service and fire alarm systems), the fire department, and the existing water system. In Texas, the *Fire Suppression Rating Schedule* has been modified to include the following fire prevention activities: fire prevention code information, fire investigation, public fire safety education, construction code enforcement, attendance at Texas A&M's Fireman Training School, the number of certified volunteer firefighters available, and membership in the State Fire Marshall's Association or Texas Commission on Fire Protection. On the *Fire Suppression Rating Schedule* scale of 1 to 10, (1 being best) the ISO gives the City of Corpus Christi Fire Department a rating of 4, the Port Aransas Fire Department a rating of 6, the Ingleside Volunteer Fire Department a rating of 5, and the Ingleside-on-the-Bay Volunteer Fire Department a rating of 5 (Bradley, 2002).

Law enforcement within the vicinity of the study area is served by both state and local services. The Texas Highway Patrol, a service of the Texas Department of Public Safety's Traffic Law Enforcement Division, maintains a district office in Corpus Christi. The Nueces County Sheriff's office and the Texas Highway Patrol serve the highways in unincorporated areas of Nueces County. In San Patricio County, the Texas Highway Patrol and the San Patricio County Sheriff's office serve highways in unincorporated areas of that county. Within the incorporated areas of the two counties, the cities of Corpus Christi, Port Aransas, Ingleside, Aransas Pass, and Portland all provide police protection.

In Nueces County, the 911 EMS Service is provided by Metrocom, which is located at the Corpus Christi Police Department. Metrocom dispatches EMS service through the Nueces County Sheriff's Department in unincorporated areas of the county and through the Corpus Christi Police Department for areas within the Corpus Christi city limits (Villarreal, 2001). In San Patricio County, 911 EMS service is covered by the Tri-County EMS for both incorporated and unincorporated areas of the county. The 911 service is dispatched through city police departments and the San Patricio County Sheriff's Department. Tri-County EMS has three stations that are located in Ingleside, Odem, and Portland. The City of Corpus Christi is covered for 911 Emergency Service for emergency medical, police and fire protection (Michaels, 2001).

Within Nueces and San Patricio counties, a variety of entities provide electric utility, natural gas, water, wastewater, and solid waste disposal services. These services are summarized in Table 3.11-12.

TABLE 3.11-12

PUBLIC SERVICES AND UTILITIES FOR VICINITY OF STUDY AREA, 2002

	Electric Utility Service	Natural Gas Service	Water	Waste Water	Solid Waste Disposal Service
City of Corpus Christi	Central Power and Light Co	City of Corpus Christi	City of Corpus Christi	City of Corpus Christi	City of Corpus Christi
City of Port Aransas	Central Power and Light Co	Reliant Energy (Entex, Inc.)	City of Aransas Pass	City of Aransas Pass	City of Aransas Pass
Unincorporated Nueces County	Nueces Electric Co-op	City of Corpus Christi	City of Corpus Christi	City of Corpus Christi	Nueces County (C.C. Disposal)
City of Aransas Pass	Central Power and Light Co	Reliant Energy (Entex, Inc.)	City of Aransas Pass	City of Aransas Pass	City of Aransas Pass
City of Ingleside	Central Power and Light Co.	Reliant Energy (Entex, Inc.)	City of Ingleside	City of Ingleside	BFI
City of Ingleside-by-the-Bay	Central Power and Light Co.	Reliant Energy (Entex, Inc.)	City of Ingleside	Septic System	BFI
City of Portland	Central Power and Light Co.	Reliant Energy (Entex, Inc.)	City of Portland	City of Portland	City of Portland
Unincorporated San Patricio County	Central Power and Light Co., and REA	Reliant Energy (Entex, Inc.)	Municipal Utility Districts, and private wells.	Municipal Utility Districts, and septic systems	Various private contractors.

3.11.4.3 Aesthetics

The term aesthetics deals with the subjective perception of natural beauty in a landscape by attempting to define and measure an area's scenic qualities. Consideration of the visual environment includes a determination of aesthetic values (where the major potential effect of a project on the resource is considered visual) and recreational values (where the location of a proposed project could potentially affect the scenic enjoyment of the area). Aesthetic values considered in this study, which combine to give an area its aesthetic identity, include:

- topographical variation (hills, valleys, etc.)
- prominence of water in the landscape (rivers, lakes, etc.)
- vegetation variety (woodlands, meadows, etc.)
- diversity of scenic elements
- degree of human development or alteration
- overall uniqueness of the scenic environment compared to the larger region

The study area consists of a variety of terrain characterized by varying levels of aesthetic quality. The topography of the area is mostly flat to gently rolling, with very few outstanding elevational changes. However, the study area consists mostly of open-water areas, including Corpus Christi Bay, Nueces Bay, the southern section of Redfish Bay, the northern section of the Laguna Madre, and the Lower Nueces River. Landscapes with water as a major element are generally considered visually pleasing, and this is the case for recreational land adjacent to these water features. However, the study area has also seen widespread urban development which can detract or add, depending on the type and scale, to the overall aesthetic quality. The study area includes a variety of land uses, including downtown business areas, shoreline residential development (single-family homes, condominiums, apartments), commercial development, public and private marinas, parkland, relatively undisturbed natural areas, fishing and tourism related businesses, hotels, military installations, civic uses, transportation systems (highways and railways), port facilities, and heavy industry areas. Generally, these areas are considered to be visually pleasing, with the exception of industrial and port facilities located along the Inner Harbor (CCSC) and other industrial facilities located along the north shore of Corpus Christi Bay and the western shore of Redfish Bay. However, generally speaking, the area is distinguished in aesthetic quality from other adjacent areas within the region that lack the vast water bodies of the study area and many of the outdoor recreational amenities. The landscape exhibits a generally moderate to high level of impact from human activities. No designated scenic views or scenic roadways were identified from the literature review or from field reconnaissance of the study area. However, areas along North Padre Island and Mustang Island have been identified by both TPWD and TxDOT as the Great Texas Coastal Birding Trail (TPWD, 2001).

3.11.4.4 Future Development and Development Restrictions

Urban development within the City of Corpus Christi is expected to continue to grow at a moderate pace in the near future, with most growth occurring within the south, southwestern, and northwestern portions of the city (Payne, 2001). The City of Corpus Christi has an ongoing Comprehensive Planning program that provides the public and private sectors with guidelines for future development within the city limits and the extra-territorial jurisdiction (ETJ). The Comprehensive Planning program includes the adoption of policy statements, Area Development Plans (ADP), the Capital Improvement Program (CIP), Master Service Plans, and Specific Area Plans (City of Corpus Christi, 2001b).

The following is a list of land use guidelines/restrictions and proposed land development projects potentially affecting development within the vicinity of the study area:

- Dune Protection and Beach Access Plan and Dune Protection and Beach Access Regulations – Mustang Island
- JFK Causeway Recreation Area Master Plan Study – includes the causeway and other publicly owned land, such as portions of SH 53 and SH 361, Packery Channel, and the Gulf Beach
- The Village Master Plan – partnership between the GLO and the City of Corpus Christi for design standards and guidelines for State owned lands on the island side of the JFK Causeway
- Corpus Christi International Airport Master Plan – additional 10,000-foot runway proposed
- Packery Channel Project – includes a public marina, a public park and promenade, an RV park, and related commercial (tourism and boating related) development

The City of Port Aransas is currently in the process of updating its comprehensive plan. Future development is likely to occur in southern Port Aransas along SH 361. In the long-term, more tourism-related development is likely to occur along the south side of the city, especially if the Packery Channel development occurs (Hallbrook, 2001).

The City of Portland adopted a Comprehensive Plan in 1998, which will serve as a guide for future development. Future residential growth is expected to occur to the east of downtown Portland, and along the Corpus Christi Bay shoreline. Future industrial development is expected to occur on the north side of Portland, along SH 181 (Boren, 2001).

The Port of Corpus Christi owns numerous large tracts of land along the Inner Harbor, along the northern shoreline of Corpus Christi Bay, on Harbor Island, and along the western shoreline of Redfish Bay. These parcels of land are available for industrial development. Also, the Port of Corpus Christi is proposing a container terminal to be located along the northern shoreline of Corpus Christi Bay, adjacent to La Quinta Channel, on a 1,100-acre tract known as the La Quinta Tract (La Rue, 2001).

3.11.5 Environmental Justice

In compliance with Executive Order (EO) 12898 – Federal Action to Address Environmental Justice (EJ) in Minority Populations and Low-Income Populations, an analysis has been performed to determine whether the proposed project would have a disproportionate adverse impact on minority or low-income population groups within the study area. The EO requires that minority and low-income populations do not receive disproportionately high adverse human health or environmental impacts and requires that representatives of minority or low-income populations, who could be affected by the project, be involved in the community participation and public involvement process.

The data used in this study to determine the potential for disproportionate impacts to low-income and/or minority populations within the project study area and within the region and the State are presented in tables 3.11-3 and 3.11-13. The information is based on 1990 U.S. Bureau of the Census (USBOC) state, county, and census tract level data for ethnicity and income.

In terms of ethnicity, the population living within the project study area census tracts is characterized by some differences, on average, from that of the State, Nueces County, and San Patricio County. The percentage of African-Americans within the study area (3.8 percent), on average, is higher than Nueces County (1.3 percent), lower than San Patricio County (4.2 percent), and substantially lower than the State (11.6 percent). The percentage of Hispanics within the study area (31.9 percent), on average, is substantially lower than San Patricio County (51.9 percent) and Nueces County (50.4 percent), but higher than the State (25.5 percent). Also, the percentage of other races within the study area (1.4 percent), on average, is slightly higher than both San Patricio County (1.1 percent) and Nueces County (0.7 percent), and lower than the State (2.2 percent). However, there are several individual census tracts within the study area where percentages of ethnic minorities are substantially higher than Nueces County, San Patricio County, or the State. These include the following census tracts in Nueces County: 3, 4, 5, 6, 12, and 29. These also include census tract 109 in San Patricio County.

On average, the percentage of people living below the poverty line within the study area census tracts (17.1 percent) is lower than that of San Patricio County (20.4 percent), Nueces County (25 percent), and the State (18.1 percent). However, there are several individual census tracts within the study area where percentages of people living below the poverty line are substantially higher than Nueces County, San Patricio County, or the State. These include the following census tracts in Nueces County: 4, 5, 6, and 12. These also include census tract 102 in San Patricio County.

TABLE 3.11-13

DETAILED 1990 POPULATION CHARACTERISTICS BY PROJECT AREA CENSUS TRACTS

Census Tract	Population	Number White	% White	Number African American	% African American	Hispanic Origin	% Hispanic	Number Other	% Other	Number Below Poverty	% Below Poverty
Nueces County											
3	1,618	751	46.4%	233	14.4%	623	38.5%	11	0.7%	313	19.3%
4	2,503	72	2.9%	1,260	50.3%	1,171	46.8%	0	0.0%	1,710	68.3%
5	2,433	118	4.8%	1,237	50.8%	1,070	44.0%	8	0.3%	1,041	42.8%
6	8,012	1,626	20.3%	691	8.6%	5,503	68.7%	192	2.4%	2,552	31.9%
7	3,902	1,800	46.1%	31	0.8%	2,029	52.0%	42	1.1%	906	23.2%
12	4,342	1,168	26.9%	217	5.0%	2,835	65.3%	122	2.8%	1,714	39.5%
14	4,726	3,197	67.6%	8	0.2%	1,463	31.0%	58	1.2%	564	11.9%
21	7,180	4,391	61.2%	113	1.6%	2,624	36.5%	52	0.7%	1,046	14.6%
25	4,374	3,499	80.0%	32	0.7%	804	18.4%	39	0.9%	406	9.3%
26	7,520	4,987	66.3%	114	1.5%	2,316	30.8%	103	1.4%	1,316	17.5%
27.01	5,087	3,974	78.1%	90	1.8%	953	18.7%	70	1.4%	493	9.7%
29	1,827	1,232	67.4%	230	12.6%	276	15.1%	89	4.9%	88	4.8%
30	8,121	5,802	71.4%	260	3.2%	1,804	22.2%	255	3.1%	1,561	19.2%
31	8,688	6,786	78.1%	191	2.2%	1,428	16.4%	283	3.3%	1,110	12.8%
35	2,371	1,148	48.4%	0	0.0%	1,223	51.6%	0	0.0%	400	16.9%
36.01	5,779	128	2.2%	128	2.2%	1,455	25.2%	30	0.5%	503	8.7%
36.02	6,359	4,583	72.1%	0	0.0%	1,751	27.5%	25	0.4%	559	8.8%
36.03	2,356	1,555	66.0%	15	0.6%	772	32.8%	14	0.6%	414	17.6%
37	3,136	1,928	61.5%	0	0.0%	1,196	38.1%	12	0.4%	405	12.9%
50	1,344	633	47.1%	17	1.3%	678	50.4%	16	1.2%	343	25.5%
51.01	2,750	2,505	91.1%	32	1.2%	166	6.0%	47	1.7%	149	5.4%
51.02	2,207	2,090	94.7%	0	0.0%	84	3.8%	33	1.5%	349	15.8%

TABLE 3.11-13 (Concluded)

Census Tract	Population	Number White	% White	Number African American	% African American	Hispanic Origin	% Hispanic	Number Other	% Other	Number Below Poverty	% Below Poverty
51.03	84	84	100.0%	0	0.0%	0	0.0%	0	0.0%	6	7.1%
58.01	3,954	3,239	81.9%	48	1.2%	616	15.6%	51	1.3%	210	5.3%
58.02	4,251	2,080	48.9%	7	0.2%	2,153	50.6%	11	0.3%	602	14.2%
Total/Avg.	104,924	59,376	56.6%	4,954	4.7%	34,993	33.4%	1,563	1.5%	18,760	17.9%
San Patricio County											
102	7,187	4,371	60.8%	252	3.5%	2,538	35.3%	26	0.4%	2,596	36.1%
103	6,656	4,822	72.4%	43	0.6%	1,758	26.4%	33	0.5%	1,009	15.2%
106.01	5,382	3,536	65.7%	0	0.0%	1,747	32.5%	99	1.8%	669	12.4%
106.03	1,045	925	88.5%	0	0.0%	116	11.1%	4	0.4%	11	1.1%
106.04	3,107	2,605	83.8%	26	0.8%	458	14.7%	18	0.6%	73	2.3%
107	1,894	1,357	71.6%	0	0.0%	537	28.4%	0	0.0%	380	20.1%
109	4,430	1,937	43.7%	0	0.0%	2,486	56.1%	7	0.2%	785	17.7%
Total/Avg.	186,025	111,490	59.9%	5,973	3.2%	57,959	31.2%	2,527	1.4%	30,894	16.6%
Total/Avg Both Counties	290,949	170,866	58.7%	10,927	3.8%	92,952	31.9%	4,090	1.4%	49,654	17.1%

Source: USBOC, 1990.

4.0 ENVIRONMENTAL CONSEQUENCES

4.1 WATER QUALITY

4.1.1 Water Exchange and Inflows

Under the No-Action alternative, water exchange and inflows would continue as they are described in Section 3.2.1.

The preferred alternative would have minimal impacts on water exchange and inflows. A study was conducted by the Texas Water Development Board (TWDB) which demonstrated changes in tidal amplitude of 0.06 feet (<0.72 inch) or less (Matsumoto et al., 2001) as projected for 106 sites around the project area. Based on the recommendations of the Hydrodynamic and Salinity Modeling Workgroup, the Cumulative Impact Workgroup, and the RACT, the study included the opening of Packery Channel and modifications to the JFK Causeway.

4.1.2 Salinity

Under the No-Action alternative, salinity would continue to be as is described in Section 3.2.2.

Like changes in tidal amplitude, the changes in salinity with the preferred alternative would also be minimal relative to existing conditions (Matsumoto et al., 2001), especially for an estuarine system. During normal to dry periods, the change in monthly average salinity would be as follows:

- Nueces Bay – from an increase of 0.11 ppt to a decrease of 0.33 ppt
- Corpus Christi Bay – from an increase of 0.38 ppt to a decrease of 0.41 ppt
- Upper Laguna Madre – from an increase of 0.04 ppt to a decrease of 0.28 ppt

During wet periods, the change in monthly average salinity would be as follows:

- Nueces Bay – from an increase of 0.09 ppt to a decrease of 3.22 ppt
- Corpus Christi Bay – from an increase of 0.12 ppt to a decrease of 4.25 ppt
- Upper Laguna Madre – from no increases to a decrease of up to 4.12 ppt.

As an examination of Matsumoto et al. (2001) will demonstrate, the larger decreases noted for the wet periods only occurred for a few months after an extremely wet period when salinities in Nueces Bay were reduced to around 1 ppt and were limited to portions of the bay.

4.1.3 Water and Elutriate Chemistry

Under the No-Action alternative, there would be no construction dredging; therefore, there would be no new work material for placement. While no turbidity or possibility for the release of undesired chemicals would occur, because there would be no placement, no chance for the decrease in long-term turbidity would result from the development of seagrass beds and wetlands in the BU sites where none exist now. The use of the new work material from the preferred alternative for BU sites would allow the creation of approximately 935 acres of unvegetated and vegetated shallow water habitat, including seagrass beds, with a long-term concomitant decrease in turbidity.

Under the No-Action alternative, the effects of maintenance material disposal on water quality would be as it is presently, as described in Section 3.2.3. There should be very little change with the preferred alternative. While there will be more maintenance material, the source of the maintenance material will not change and the method of placement will not change. There is the possibility of contamination of the maintenance material by a spill or other event, as there is now, but deepening and widening the channel and adding barge lanes should increase safety and decrease the probability of a spill. Additionally, the USACE routinely tests the elutriates prepared from maintenance material according to ITM and Green Book protocols before dredging to ensure that there are no causes for concern. As noted in Section 3.2.3, Tier I and Tier II evaluations indicated that past testing of maintenance material elutriates with chemical analyses and water column bioassays has indicated no cause for concern.

The No-Action alternative may or may not affect DO concentrations in the water column at PAs (Brown and Clark, 1968; Pearce, 1972; Hopkins, 1972; May, 1973; Windom, 1972; Wakeman, 1974). May (1973) found that although the water column DO did not change, there was a temporary decrease in DO at the water/sediment interface in the areas of mud flow. He also found little apparent difference in the immediate oxygen demand between recently deposited sediments from dredged material placement and other sediments. May (1973), Jones and Lee (1978), Peddicord (1979), and Lee (1976) agree that high total oxygen demand, as measured in the laboratory, does not necessarily lead to oxygen depletion upon placement since only a small part of the oxygen demand is exerted at placement. This would apply to both the No-Action and preferred alternatives.

The most obvious impact of the No-Action alternative to the estuarine water column is turbidity associated with maintenance dredging and placement, which has been shown to reduce primary production in laboratory studies (Sherk, 1971). Field studies, however, have shown essentially no biological impacts from turbidity (Odum and Wilson, 1962; May, 1973). May (1973) found that on a still day, the turbidity plume from an open-bay PA was detectable from an aircraft only a little more than 1 mile down current. On days when winds caused natural turbidity in an estuarine system, the plume was not detectable more than a few hundred yards down current from active disposal in an open-bay PA. Use of deflectors to direct the material toward the bottom and the use of deeper water for the open bay sites should reduce turbidity and any associated impacts. However, significant detrimental environmental effects have not been noted in past construction and maintenance operations and are not expected with the preferred alternative.

4.1.4 Brown Tide

Under the No-Action alternative, brown tide conditions would continue as described in Section 3.2.4. No changes in brown tide conditions are expected from the preferred alternative.

4.1.5 Ballast Water

The most likely existing foreign and domestic sources of ballast water that may potentially be discharged into Corpus Christi are from liquid and bulk vessels from foreign and domestic last ports of call coming to Corpus Christi to load cargo. The largest potential foreign sources are from within Mexico (15.4 percent), the West Indies/Caribbean group (1.8 percent), the Northern South America/Caribbean group (1.6 percent) and the Central America group (1.1 percent). The largest potential domestic sources of ballast water are from the states of Texas (37 percent), Florida (21.1 percent), and Louisiana (5.7 percent). About 20 percent of the Texas calls originated from the lightering zones in the open Gulf of Mexico. Compared with 1998 discharge estimates (13.51 mcy), potential ballast water discharge volume from foreign and domestic sources in year 2026 (15.67 mcy) increase for the No-Action alternative by 16 percent (Carangelo, 2001).

There are no significant existing container ship calls at Corpus Christi and that condition would likely continue under the No-Action alternative.

Under the preferred alternative, an estimated 3.8 percent decrease in all liquid and bulk vessel calls is anticipated with the CCSCCIP. Because of the efficiencies to be realized with the deepened channel, vessel trips in the Inner Harbor will decrease 3.8 percent between 2006–2056 with and without the preferred alternative (see economic appendix for details). Focusing on the liquid and bulk ships that come into port in ballast to take on cargo and compared with 1998 estimates, potential ballast water discharge volume for liquid and bulk ships in year 2026 (15.20 mcy) would increase 12.5 percent for the preferred alternative which is a 3 percent decrease from the No-Action alternative.

Container vessels represent a new shipping modality for Corpus Christi with identified trading regions including Europe, Central America, the Caribbean, and Latin America and the domestic Gulf of Mexico ports of call might also be contacted en route to Corpus Christi. The majority of these regions or ports currently, and are expected to in the future, trade directly or indirectly with Corpus Christi via the liquid and bulk vessel calls. No significant change in the existing mix of the ports or world regions that may potentially be sources of ballast water that could potentially be discharged into Corpus Christi is attributed to the preferred alternative. An estimated 1.57 mcy of ballast water could potentially be discharged annually from future container ship use of the proposed La Quinta Trade Gateway.

The combined estimate for year 2026 bulk and tanker vessels and future container vessels indicates 16.74 mcy of ballast water may potentially be discharged annually into Corpus Christi (Carangelo, 2001). Although this represents a potential 6.8 percent increase over the No-Action alternative, some container ships may require ballast discharge, but many do not (Hebert Engineering, 1999). Therefore, the preferred alternative is unlikely to present any significant increase or decrease in ballast water introductions compared with the No-Action alternative.

4.2 SEDIMENT QUALITY

4.2.1 Surficial Sediments

The quality of surficial sediments from the project area is discussed in Section 3.3.1. These are the surficial sediments that will be dredged during project construction. The discussion in Section 3.3.1 indicates no cause for concern with the construction material, except from the Inner Harbor, which will be placed in a UCPA. The CW and the RACT have determined that the construction material from the other reaches of the CCSC are of sufficient quality to be used for beneficial uses, except for the fine material from the upper bay which will continue to go into open-bay, unconfined placement.

4.2.2 Maintenance Material

The existing maintenance material was described in Section 3.3.2. The quantity and quality of this material would not be expected to change with the No-Action alternative. Additionally, it would not be expected to change with the preferred alternative. While slightly more maintenance material is estimated with the preferred alternative, the source of the maintenance material will not change and the method of placement will not change. As noted above, project actions should increase safety and decrease the probability of a spill. The USACE also routinely tests the maintenance material according to ITM and Green Book protocols before dredging to ensure that there are no causes for concern. As noted in Section 3.3.2, past testing of maintenance material with chemical analyses, whole mud bioassays, and bioaccumulation studies has indicated no cause for concern.

4.3 COMMUNITY TYPES

4.3.1 Submerged Aquatic Vegetation/Seagrasses

SAV is an important component in the Corpus Christi Bay estuary complex. As noted below, project impacts can be both negative (e.g., removal of seagrass beds) and positive (e.g., creation of SAV habitat).

The No-Action alternative would not directly impact SAV since there will be no dredging of new work material; however, it would not provide any net benefits to SAV since it would not provide a new 50-year DMM/BU Plan, with projects for SAV habitat creation and protection. Dredged maintenance material from the existing channels would continue to be placed in existing PAs, which includes confined, partially confined, and open-bay placement areas and would have minimal positive or negative impacts on SAV.

Continued industrial expansion coupled with increased ship traffic expected under the No-Action alternative increases the probability for collisions and hazardous materials spills, which could negatively impact SAV communities.

In general, SAV in this area can occur in shallow areas in water depths less than –4 feet MLT. The Mitigation and RACT workgroups determined that the –4-foot MLT bathymetric contour would be used to determine the worst-case scenario of impact to unvegetated bottom, that is potential SAV habitat, and seagrass vegetated habitat within the footprint of the proposed channel. The results of the survey indicate that bay bottom with water depths less than –4 feet MLT comprise approximately 45 acres that would be impacted by the preferred alternative.

Of the 45 acres, only 5 acres of patchy SAV, dominated by shoalgrass and lesser amount of manateegrass, would be directly impacted by the project. In lieu of actual surveys of the coverage of seagrass, the potential impacts to SAV, based on aereal coverage of seagrasses, field verification and water depth, are conservative and worst case. The impacts to SAV are associated with a spit on the north end of PA 13 and are due to the dredging of the La Quinta Channel extension. The construction of BU Site GH west of PA 13 could also impact up to 4 acres of SAV habitat; however, this impact will be avoided by the plan to separate Site GH from PA 13 by several hundred feet. Net positive impacts to SAV at Site GH would result from the creation of approximately 200 acres of shallow-water habitat suitable for colonization by SAV. The planting of 15 acres of seagrass within Site GH will be conducted as mitigation for the direct loss to the 5 acres of SAV during project construction.

The construction of other BU sites would have no direct negative impacts to existing SAV beds other than possibly SAV beds in Red Fish Cove which could experience some short-term, minimal effects from turbidity associated with channel dredging and the placement of dredged material for BU Site I. However, Site I would create approximately 163 acres of suitable SAV habitat and create approximately 15 acres of marsh habitat. Site P, primarily a wavebreak structure, should protect approximately 45 acres of existing SAV.

Altogether, the BU sites would result in the creation of approximately 935 acres of new habitat suitable for colonization by SAV, creation of approximately 26 acres of marsh, and the protection of approximately 45 acres of existing seagrass habitat. Other SAV beds in the area are either distant enough or protected from dredging activities by islands or levees and would not be impacted by dredging or placement activities.

The changes in salinity (seasonally and locally decreased by up to 4 ppt in wet periods and less than 1 percent during normal-to-dry periods) and tidal range (increased 0.04–0.06 feet) predicted in the TWDB simulation (Matsumoto et al., 2001) could cause some slight adjustment in the distribution of SAV. Although impossible to quantify, this change could cause a slight increase in the areal extent of SAV. However, the predicted changes in salinity and tidal range are very small and well within the tolerances and natural ranges of the common SAV species (Stutzenbaker, 1999). In fact, these values are much smaller than the effects of seasonal tides, so it is unlikely that they will cause an appreciable change in SAV distribution.

Potential indirect impacts could be caused by reduced photosynthetically active radiation conditions associated with increased total suspended solids; however, these would be short-term and localized, so impacts should be minimal. These impacts could be further minimized if dredging in close proximity to existing beds is scheduled to avoid seasonally high growth periods.

4.3.2 Coastal Wetlands

4.3.2.1 Salt Marshes/Estuarine Shrublands/Sand Flats/Mud Flats/Algal Mats

A shoreline erosion study (PIE, 2001a) that investigated the potential impacts on shoreline erosion from the preferred alternative was conducted for the PCCA at the request of the RACT. The potential impacts of the No-Action and the preferred alternatives were investigated for several factors that could potentially affect shoreline erosion.

The expected industrial expansion coupled with increased ship traffic for the No-Action alternative would raise the potential for collisions and hazardous materials spills, which could negatively impact coastal wetland communities. This potential would be reduced with the preferred alternative.

None of these habitats occurs within the footprint of the preferred alternative. However, dredging activities associated with the deepening and widening of the channel, maintenance dredging, and operation of the improved ship channel could have impacts on these habitats in the project area. A Section 404(b)(1) Evaluation is located in Appendix A which evaluates wetland impacts according to the Clean Water Act.

PIE (2001a) considered the differences in impacts on shoreline erosion between existing conditions and the preferred alternative for several factors including tidally induced current velocity, sea level rise, pressure field effects (draw-down), wind waves, vessel wakes, and channel morphology. PIE (2001a) concluded that, currently, the main factors contributing to shoreline erosion in this area were wind-generated waves and sea level rise.

Neither the existing or proposed conditions had consistently positive or negative impacts on shoreline erosion. However, the study concluded that overall, the CCSCCIP would slightly increase shoreline erosion, although compared with existing erosion, the effect would probably not be detectable (PIE, 2001a). The study found that, at the proposed La Quinta Channel extension, although there would be changes to the dynamics of the shoreline (due only to changes in the channel morphology), there may not be any net resultant shoreline erosion since the rates of accretion tend to offset the shoreline retreat. The greatest impacts would occur on the shorelines facing the channels, which support little, if any, vegetation. The impacts are discussed in detail in PIE (2001a).

The proposed BU sites would protect some areas of existing shoreline vegetation from erosion as well as result in creating 26 acres of marsh and protecting approximately 45 acres of seagrass habitat. None of the BU sites should negatively impact salt marshes or estuarine shrublands, tidal flats, or algal mats, but most would create and/or protect these habitats, primarily salt marshes and flats.

4.3.3 Open Water/Reef Habitat

These habitats and impacts on them are described in Section 3.4.3 and discussed in Sections 4.1 and 4.4.1.2. Impacts to water quality are expected to be minimal. No significant impacts are expected for recreational and commercial fisheries. Temporary and local impacts may occur during construction and maintenance dredging.

4.3.4 Coastal Shore Areas/Beaches/Sand Dunes

The current channel enters the Gulf of Mexico, separating San Jose Island to the north from Mustang Island to the south. The channel extends into the Gulf, protected on both northern and southern sides by rock jetties. The presence of the jetties impacts the shoreline by blocking the predominant north-to-south longshore drift. There is no beach nourishment program in place, and none has been identified or requested. Occasionally, the partially confined PA 2 adjacent to the channel on San Jose Island is used as a placement area for sandy maintenance material from a portion of the Lower Bay and can be directed to overflow onto the beach area just north of the jetty. A pipeline dredge is used to clear maintenance material from the Lower Bay on those infrequent occurrences when the rest of the Entrance Channel does not need dredging. PIE (2001b) concluded that, currently, the main factors contributing to shoreline erosion in this area were wind-generated waves and sea level rise.

The preferred alternative would deepen and extend the channel into the Gulf of Mexico with no change to the width of the channel at the jetties (i.e., outlet to the Gulf); however, the channel would be widened by 100 feet on the north side near the Inner Basin to allow a greater turning radius into the Redfish Bay portion of the channel. Beach nourishment is not part of the proposed BU program, so the preferred alternative does not differ from the current practice in this regard. Wind-generated waves and sea level rise would not change as a result of the preferred alternative. The amount of sediment that could pass seaward due to the extension of the channel will not increase significantly. However, deepening of the channel may result in an approximately 5 percent increase in the trapping efficiency of the channel translating into a sediment loss of 3,000 to 5,000 cubic yards per year from the longshore drift system (PIE, 2001b). This impact is expected to be insignificant to the adjacent shoreline. The preferred alternative may increase the peak velocities in the Lower Bay reach of the CCSC, indicating a marginal increase in tidal flux causing an increase in the sediment input from the ocean to the bay. Shoreline erosion or accretion due to the preferred alternative will not be significantly or noticeably impacted according to PIE (2001b).

4.4 FISH AND WILDLIFE RESOURCES

4.4.1 Finfish and Shellfish

Under the No-Action alternative, finfish and shellfish communities will continue as described in Section 3.5.1.

One impact that would increase during project construction is water column turbidity, but it would be local. Several field studies of turbidity from TSS associated with dredging operations have concluded that dredging had no substantial effects on nekton (Flemer et al., 1968; Ritchie, 1970; Stickney, 1972; Wright, 1978); however, other studies have shown that elevated turbidities can suffocate and reduce growth rates in adult and juvenile nekton and reduce viability of eggs (Moore, 1977; Stern and Stickle, 1978). Detrimental effects were generally recognized at TSS concentrations greater than 500 milligrams per liter (mg/l) and for durations of continuous exposure ranging from several hours to a few days. Turbidities exceeding 500 mg/l have been observed around maintenance dredging and placement operations (EH&A, 1980), and such turbidities may affect some aquatic organisms. For example, Clark and Wilbur (2000) include a figure that shows some mortality to estuarine and anadromous fish eggs and larvae at concentrations of 500 mg/l for durations as short as 24 hours. Adult estuarine and anadromous fish exhibited no effects, even sublethal, with one exception, at concentrations ≤500 mg/l for up to 16 days. In a study in Corpus Christi Bay, Schubel et al. (1978) reported TSS values greater than 300 mg/l but only in a relatively small area near the bottom. They also stated that TSS in Corpus Christi Bay from maintenance dredging is not greater than that from shrimping and affect the bay for much shorter time periods. May (1973) found that TSS was reduced by 92 percent within 100 feet of the discharge point, by 98 percent at 200 feet, and that concentrations above 100 mg/l were seldom found beyond 400 feet from the placement point. Turbidities can be expected to return to near ambient conditions within a few hours after dredging ceases or moves out of a given area.

The benthos at the proposed BU sites, which would have been used as a food source by local predators, would be temporarily lost due to burial, but the area of the BU sites is small compared with the entire project area and overall productivity recovers very quickly. Notwithstanding the potential harm to some individual organisms, compared with the existing condition, no significant impact on nekton populations is anticipated from the construction and maintenance dredging and placement operations with the preferred alternative.

The preferred alternative represents a small increase in habitat for those nekton species common in deeper offshore waters, which periodically invade the bay through the deep channel corridor (Breuer, 1962). Channel deepening and widening would also result in a slight increase in the availability of feeding and nursery area for demersal fish (Breuer, 1972).

The effects of maintenance dredging for the preferred alternative would generally be the same as those discussed for the No-Action alternative. Maintenance material would be primarily silt or sandy silt, which settles less readily and causes more turbidity than construction material which would be largely clay and sand. The overall effect would be reflective of the current maintenance dredging with the addition of the volume of the La Quinta extension and widening of the Corpus Christi Ship Channel.

In the unlikely event of an oil spill, however low the probability (see Section 2.2.2 for discussion of spill analysis), adult crustaceans such as shrimp, crabs, and adult finfish are probably mobile enough to avoid most areas of high oil concentrations. Their behavior, however, may be affected by some of the aromatic constituents of oil and become lethally disoriented. Larval and juvenile finfish and shellfish tend to be more susceptible to oil than adults. Juveniles could be affected extensively by an oil spill during their period of active immigration. Serious impacts to shrimp could also affect the commercial shrimping industry in the area, particularly the Laguna Madre if the oil spill is severe and widespread.

Although potentially severe damage could result from an oil spill, the chances of one occurring actually decrease with a wider and more efficient channel that increases navigation safety. This is from the use of fewer, more-heavily-ladened vessels instead of numerous smaller vessels to import the projected crude oil needs of existing and planned refineries. Since oil spills are a function of ship traffic, modern hull designs, and probability for accidents, the fewer trips made with the preferred alternative would decrease the threat of spills.

4.4.2 Recreational and Commercial Fisheries

Under the No-Action alternative, recreational and commercial fisheries will continue as described in Section 3.5.1.1.

Temporary and minor adverse effects on recreational and commercial fisheries may result from altering or removing productive fishing grounds and interfering with fishing activity. However, the evaluation of effects on the aquatic communities of the region (Section 4.4.1.3) concluded that no significant impacts to food sources for nekton were likely. Therefore, reductions of nekton standing crops would not be expected from the preferred channel expansion plans. In particular, major species of the nekton assemblage, including the sciaenid fishes and penaeid shrimp, should not suffer any significant losses in standing crop. Recreational and commercial fishing would, therefore, not be expected to suffer from reductions in the numbers of important species.

Dredging associated with the construction of the preferred alternative would result in temporary adverse effects on bay bait shrimping by displacing the bait shrimp along the channel, possibly interfering with trawling. Shrimpers may move their efforts, but less productive shrimping in other portions of the channel may result. Thus, loss of revenues to both bait shrimpers and dealers may occur. However, this would be similar to what occurs during maintenance of the channels under the No-Action alternative, with the exception of the extension into the Gulf and the La Quinta extension. Dredging associated with the maintenance of the preferred alternative would essentially be the same as the No-Action alternative.

The temporary adverse effects on bait shrimping resulting from construction dredging will be countered by the fact that an expanded channel is expected to result in a decrease in oceangoing ship traffic through the CCSC, due to the use of more-heavily-ladened vessels carrying the projected future throughputs. A decrease in oceangoing ship traffic will result in less interference to all recreational and commercial fishing activity taking place in the CCSC, particularly bay bait shrimping.

Repeated dredging and placement operations may temporarily reduce the quality of recreational and commercial fisheries in the vicinity of dredging operations. This may result from decreased water quality and increased turbidity during dredging and loss of attractiveness to game fish in the area resulting from loss of benthic animals. This is not a permanent condition; the quality of fishing in the vicinity of the channel and the placement areas should steadily improve after dredging is completed and would likely be similar to maintenance dredging under the No-Action alternative.

The direct effects of construction dredging on bay recreational fishing will again be similar to existing maintenance dredging except for the BU sites and the La Quinta Channel extension. The impact will be temporary, potentially resulting in local disturbances to both boat and wade-bank fishing, particularly along the edges of the channels. After initial construction, disturbed boat and wade-bank fishing areas along the CCSC and the La Quinta Channel extension should return to preconstruction conditions. However, recreational fishing at these locations, while locally important, does not constitute a significant portion of the overall recreational fishing effort in the study area. The additional habitat created by construction in the BU sites should provide additional recreational fishing opportunities. Construction activity in this portion of the channel should not significantly affect overall fishing in the general project area.

Construction dredging in and near the Aransas Pass inlet can potentially interfere with recreational fishing activity which is often concentrated there. The physical activity of dredging and the resulting local turbidity increases would combine to temporarily decrease the success rate and aesthetics of fishing in this area. However, impacts are expected to be similar to existing routine maintenance dredging operations.

The placement of dredged material in the designated offshore placement site may result in a localized effect on shrimp trawling and bottom fishing, as well as a slight disturbance to sport fishing for pelagic species. The topographic relief created by offshore placement in BU Site ZZ will result in the temporary loss of 1.83 square miles of Gulf bottom during construction of BU Site ZZ. However, NOAA charts indicate a sunken vessel exists in the site, which may inhibit shrimping there due to the possibility of hangs. In addition, the size of the area is small when compared with the total remaining similar bottom habitat available for fishing and shrimping. Creation of the topographic relief features at BU Site ZZ and Site MN should provide more diversity of habitat, which has the potential to become a fish haven. The placement of maintenance material in EPA-designated PA 1 may result in an isolated effect on shrimp trawling and bottom fishing, as well as a slight disturbance to sport fishing for bottom fishes. However, this effect should be similar to the No-Action alternative.

4.4.3 Aquatic Communities

Under the No-Action alternative, aquatic communities will continue as described in Section 3.5.1.2.

Benthic organisms will be buried and epibenthic nekton may be excluded from the immediate area of the open-bay PAs 14A – 17B by the deposition or flow of material across the bay bottom. The majority of these PAs have been used for construction and maintenance dredged materials placement for at least 25 years, and many for a longer period. Because of the prior use history, changes in sediment texture, and frequency of maintenance dredging, the PAs may not be similar to undisturbed areas of equivalent depth (Ray and Clarke, 1999). Ray and Clarke (1999), comparing PAs 15A – 17B with reference sites located on the opposite side of the CCSC from the PAs, also found evidence for long-term impacts from dredged material placement but found that the differences were rather subtle, and might be attributable to changes in depth (PAs were shallower) and grain size (PAs' sediments were coarser). They note that PA and reference areas had similar benthic assemblages but that the PAs "have a greater proportion of surpulid polychaetes and less echinoderm biomass than reference areas." Confined PAs that have become emergent as a result of prior use constitute a permanent loss of aquatic habitat at that location. Except for the use of construction and maintenance materials for habitat creation, protection, and enhancement as a consequence of construction of the BU sites, only existing open-water, unconfined- or confined-in-bay, and upland sites are proposed for use in the preferred alternative. Consequently, new permanent loss of aquatic habitat is avoided or minimized.

Turbidity in estuarine and coastal waters is generally credited with having a complex set of impacts on a wide array of organisms (Thompson, 1973; Hirsch et al., 1978; Stern and Stickle, 1978; EH&A, 1978). Suspended material can play both beneficial and detrimental roles in aquatic environments. Turbidity from TSS tends to interfere with light penetration and thus reduce photosynthetic activity by phytoplankton and seagrasses. Such reductions in primary productivity would be localized around the immediate area of the maintenance dredge operations in the CCSC and at the offshore and open-bay placement sites, and would be limited to the duration of the plume at a given site. Conversely, the decrease in primary production, presumably from decreased available light, has been found to be offset by increased nutrient content (Morton, 1977). In past studies of the impacts of dredged material placement from turbidity and nutrient release, the effects are both localized and temporary (May, 1973; Odum and

Wilson, 1962; Brannon et al., 1978). Thus, due to the reproductive capacity and natural variation in phytoplankton populations, the impacts of dredged maintenance material placement anywhere within the project area are not expected to be significant.

Dredging represents two problems for aquatic communities: excavation and placement. Excavation removes organisms, but organisms can rapidly recolonize a hole (Montagna et al., 1998). Approximately 352 acres of deep-water bay bottom will be lost to construction of barge lanes (7 acres) and channel widening (352 acres). Placement of dredged material may cause ecological damage to benthos in three ways: 1) physical disturbance to benthic ecosystems; 2) mobilization of sediment contaminants, making them more bio-available; and 3) increasing the amount of suspended sediment in the water column (Montagna et al., 1998). Organisms that are buried must vertically migrate or die (Maurer et al., 1986). Although vertical migration is possible, most organisms do not survive (Maurer et al., 1986). Studies show that open-water placement in Mobile Bay, Alabama, resulted in reduced benthic biomass, reduced redox potential discontinuity depth, and altered sediment relief. However, effects were confined to within 1,500 meters of the discharge point, and benthos recovered within 12 weeks (Clarke and Miller-Way, 1992). In a study of open-bay PAs 14A – 17B, Ray and Clarke (1999) found that "although dredged material placement initially had substantial impacts on placement area sediments and infauna, the deposited materials were worked into the existing sediment and community recovery was complete within a year of the dredging operation." An example of the impact and recovery can be found at Ray and Clarke's Plot E, which had a pre-dredging biomass of 41 g/m^2. After dredging, the biomass dropped to 5 g/m^2 and then rose back to 41 g/m^2, while the reference area remained constant, near 79 g/m^2.

Repeated dredging in one place may prevent benthic communities from full development (Dankers and Zuidema, 1995). Excavation destroys the community that previously existed but creates new habitat for colonization (Montagna et al., 1998). Excavation can actually maintain high rates of macrobenthos productivity (Rhoads et al., 1978). By repeatedly creating new habitat via disturbance, new recruits continually settle and grow. However, these new recruits are always opportunistic, small, surface-dwelling organisms with high growth rates and densities. Large, deep-dwelling organisms that grow slower and live longer are lost to the area of repeated excavation. In this way, excavation may not cause a decrease in production, but rather a large shift in community structure (Montagna et al., 1998).

Placement of construction and maintenance material in the proposed offshore placement site would bury those benthic organisms incapable of escaping or burrowing up through the dredged material. Burial of benthic organisms will occur during initial construction placement but the material is virgin ocean bottom, similar to that which presently exists in the BU site and recolonization should be rapid. Benthic community structure and abundance will eventually return to pre-placement levels since these sites will be used once only for placement of construction material. Additionally, the BUW and the RACT determined that creation of the topographic relief feature would be beneficial overall. The offshore maintenance PA (PA 1) is a currently used, EPA-designated site and future maintenance impacts should be similar to existing impacts. Potential beneficial effects of the suspended material associated with dredging operations include a resuspension of nutrients, absorption of contaminants in the water column, and addition of a protective cover allowing certain nekton to avoid predation (Stern and Stickle, 1978). As with the various potential detrimental effects, the importance of each of these latter effects would vary among groups and with the physiochemical parameters existing at the time and location of dredging and placement operations.

Effects of elevated turbidities on the adult stages of various filter-feeding organisms such as oysters, copepods and other species include depression of pumping and filtering rates and clogging of filtering mechanisms (Stern and Stickle, 1978). These effects are pronounced when TSS range from 100 mg/l to 1,000 mg/l and higher, but are apparently reversible once turbidities return to ambient levels.

A few scattered oyster reefs exist in Corpus Christi Bay as described in Section 3.4.3 and most of the reefs are dead. The nearest is Long Reef, which is approximately 3,000 feet away from PA 13 and 4,000 feet away from PA 15. No live oysters occur on Long Reef, but it is a valuable hard-structure resource. PA 13 is a UCPA and the effluent is returned to La Quinta Channel. Although PA 15 is an unconfined, open-water site, it is located in deeper water and is presently used frequently for maintenance dredging. Furthermore, the discharge point is submerged to minimize the spread of dredged material. There are some additional scattered reefs in the vicinity of PA 18, but this site is not presently in use and will not be used with the preferred alternative. Therefore, adverse impacts to oyster resources are not expected to occur as a result of construction or maintenance dredging and placement operations.

In the unlikely event of an oil spill, benthic fauna may be killed, but phytoplankton may be adversely or favorably affected by oil spills. It is unlikely that an oil spill in the Corpus Christi area would result in significant, long-term impact to either phytoplankton, zooplankton, or benthic communities since these organisms have the ability to recover rapidly from a spill due primarily to their rapid rate of reproduction and to the widespread distribution of dominant species. Additionally, as noted above, the chances of a spill occurring actually decrease with the more efficient channel in the proposed project.

4.4.4 Essential Fish Habitat

Under the No-Action alternative, EFH will continue as described in Section 3.5.1.3.

EFH for adult and juvenile white shrimp, brown shrimp, red drum, Spanish mackerel, Gulf stone crab, juvenile pink shrimp, and gray snapper occur in the project area including estuarine emergent wetlands, estuarine mud, sand, sand and shell substrates, SAV, and estuarine water column. However, there is no shell substrate in the areas to be dredged for the preferred alternative. Only a few, scattered, mostly dead oyster reefs exist in Corpus Christi Bay and the nearest is Long Reef, which is approximately 3,000 feet from PA 13, a UCPA from which the discharge is returned to La Quinta Channel. The placement of the maintenance material will bury bay bottom presently used as open-water, unconfined PAs. On the other hand, construction of the preferred alternative will have more beneficial than detrimental impacts since, for example, the proposed BU sites are strategically placed to prevent shoreline erosion and preserve and create seagrasses.

Approximately 5 acres of seagrasses and 40 acres of shallow-bay bottom will be lost to the preferred alternative dredging operations. For mitigation, approximately 15 acres of seagrass will be planted at Site GH and 40 acres of shallow-bay bottom will be created. The BU sites will create approximately 935 acres of habitat suitable for recolonization by submerged aquatic vegetation and 26 acres of marsh creation. BU Sites MN and ZZ will create 1,590 acres of offshore topographic relief for marine habitat as well. However, creation of the breakwaters and fringe levees to protect the BU site and existing special habitats will cause the permanent loss of 1,782 acre-feet of water column and 108 acres of existing bay bottom.

Juvenile brown shrimp and white shrimp will be temporarily and locally impacted by the loss of seagrasses and open-bay bottom, but will benefit by the creation of 935 acres of unvegetated and vegetated shallow water and marsh. Red drum are found throughout the project area in all life stages and will be temporarily and locally impacted from dredging and placement activities and permanently excluded from the lost water column, but will benefit from the creation of BU sites in the bay and offshore. Juvenile Spanish mackerel nurseries may be impacted temporarily and locally by dredging activities, but will benefit by a greater number of nursery sites created by the BU plan and adults will benefit from the offshore sites. Adult stone crabs may be impacted temporarily and locally by turbidity, but should not be permanently impacted by the preferred alternative dredging activities. They may, however, benefit from the creation of the stone breakwaters. Postlarvae and juveniles of pink shrimp will incur temporary and localized impacts in estuarine areas, but will benefit from the creation of BU sites. Adults inhabiting offshore waters near the project may be impacted by temporary turbidity, but will benefit from the creation of Sites MN and ZZ providing topographic relief. All life stages of gray snapper occur throughout the project area and may be temporarily and locally impacted from dredging activities, but will benefit from the creation of bay and offshore BU sites.

4.4.5 Wildlife Resources

The No-Action alternative would result in no immediate direct impacts to the terrestrial wildlife species or wildlife habitats at or near the proposed study area. Some of the habitats may change over time independent of the project. Commercial development and continued dredging and placement of dredged material occurring in the area could result in increased sedimentation and altered hydrology, which could have an impact on the aquatic community and, thus the food source of many coastal birds. The number of vessels in the area would decrease due to the preferred alternative, thereby decreasing the possibility of accidental oil or chemical spill in the area.

4.4.5.1 Dredging/Construction Activities

While dredging activities from the proposed project are unlikely to have a direct impact on terrestrial wildlife species, they may have an indirect impact. Such activities may cause temporary, local impacts to aquatic communities and habitats, including increased turbidity, which in turn may indirectly impact birds in the immediate vicinity of the activities by potentially reducing the availability of the food supply. These impacts are local and temporary and are not expected to be significant considering the size of the bay and the mobility of birds. The slightly increased possibility of accidental spills of oil, chemicals, or other hazardous materials during construction dredging activities also poses a threat to the aquatic community and, thus, the food source of many coastal birds in the area. Phytoplankton and zooplankton assemblages, which make up the foundation of the aquatic food chain, could be affected by a spill. While adult shrimp, crabs and fish are mobile enough to avoid areas of high concentrations of pollutants, larval and juvenile finfish and shellfish are more susceptible. Decreased marine traffic would reduce the potential for accidents and spills, and is otherwise not expected to have a direct effect on aquatic habitat. These effects would be short-term, however.

The noise of equipment and increased human activity during dredging activities may disturb some local wildlife, particularly birds, especially during the breeding season. Such impacts, however, should be temporary and without significant long-term implications. Salinity effects are not anticipated. Most infaunal organisms in the area are relatively tolerant of salinity fluctuations and would probably remain unaffected by any salinity changes related to dredging activities.

Dredging activities for the channel improvement would occur within 1,500 feet of several rookeries, most of which are infrequently used by a small number of birds. Table 4.4-1 provides information on nesting activities at these rookeries. Pelican Island, located just south of the CCSC, is a major brown pelican nesting area (see Section 4.5.2). Apart from the brown pelican, several species of heron, egret, tern, and gull also nest there. The Point of Mustang rookery occurs just to the east of Pelican Island. However, this rookery has not been active since 1994, when 30 pairs of least terns and 56 pairs of black skimmers were recorded. The Corpus Christi Channel rookery lies just to the west of Pelican Island. Seven pairs of great blue herons, 8 pairs of gull-billed terns, 160 pairs of least terns, and 60 pairs of black skimmers nested at this rookery in 2000. No birds have nested at the West Harbor Island rookery just north of Point of Mustang on the north side of the CCSC since 1994 when 42 pairs of least terns were recorded (GLO, 2000; FWS, 2001; TXBCD, 2001).

Rookeries occur on two placement areas adjacent to La Quinta Channel: Ingleside Point (Berry Island) and La Quinta (Table 4.4-1). Eight great blue heron nests, 2 great egret nests, 5 gull-billed tern nests, 15 least tern nests, and 170 black skimmer nests were recorded at these two rookeries in 1999. Least terns have not nested at the Castors Cut rookery since 1990, when 5 nests were recorded (FWS, 2001; TXBCD, 2001). A least tern colony is located at Tule Lake just south of and adjacent to the Tule Lake turning basin (TXBCD, 2001). However, this rookery has been used just twice since 1973: 14 nests were recorded in 1983 and 6 nests in 1993 (FWS, 2001).

The dredged material would be deposited in several areas as DMM/BU sites. At several sites, these beneficial use areas will be bordered by levees. Construction of these sites and levees would have similar impacts to the dredging activities in that they would be unlikely to have a direct impact on terrestrial wildlife species but may have an indirect impact. Temporary impacts to aquatic communities and habitat from increased sedimentation and turbidity would be expected. This in turn may impact birds in the area by potentially reducing the availability of their local food supply temporarily. This impact may be more noticeable at sites located near known bird rookeries. For example, sites R and S would be located adjacent to and on the south side of the Corpus Christi Channel rookery, while sites CQ and GH would be located to the south of the Ingleside Point rookery and to the west of the La Quinta rookery, respectively. Noise and increased human activity during construction may temporarily impact terrestrial wildlife in areas adjacent to the BU sites. These impacts are expected to be minor and short term.

TABLE 4.4-1

NUMBER OF NESTS OF COLONIAL WATERBIRDS AT SELECTED ROOKERIES IN THE STUDY AREA

Rookery / ID	Common Name	Scientific Name	1995	1996	1997	1998	1999	2000
Tule Lake / 614-142	Least tern	*Sterna antillarum*						
La Quinta Spoil Islands / 614-160 (PA 13)	Great blue heron	*Ardea herodias*	1			8	7	
	Great egret	*Ardea alba*					2	
	American oystercatcher	*Haematopus palliatus*				2		
West Harbor Island / 614-181	Least tern	*Sterna antillarum*						
Ingleside Point/Berry Island / 614-182	Great blue heron	*Ardea herodias*			5		1	
	Gull-billed tern	*Sterna nilotica*			3		5	
	Least tern	*Sterna antillarum*			56		15	
	Black skimmer	*Rynchops niger*			95	70	170	
Point of Mustang / 614-183	Least tern	*Sterna antillarum*						
	Black skimmer	*Rynchops niger*						
Pelican Island / 614-184	Brown pelican	*Pelecanus occidentalis*	1,500	900	1,350	1,375	1,100	873
	Great blue heron	*Ardea herodias*	58	30	103	62	50	31
	Great Egret	*Ardea alba*	26	50	130	25	116	33
	Snowy egret	*Egretta thula*	66	30	130	59	84	40
	Little blue heron	*Egretta caerulea*	13	20	7	36	33	
	Tricolored heron	*Egretta tricolor*	378	150	550	343	261	301
	Reddish egret	*Egretta rufescens*	124	30	115	48	34	10
	Cattle egret	*Bubulcus ibis*	1,000	120	234	109	165	70
	Black-crowned night-heron	*Nycticorax nycticorax*	130	50	200	82	86	36
	White ibis	*Eudocimus albus*	68	40	81	75	311	140
	White-faced ibis	*Plegadis chihi*	309	15	123	63	47	53
	Roseate spoonbill	*Ajaia ajaja*	110	100	66	48	62	100
	Laughing gull	*Larus atricilla*	11,400		9,310	8,000	5,700	4,600
	Gull-billed tern	*Sterna nilotica*	4	5			8	3
	Caspian tern	*Sterna caspia*		1			18	
	Royal tern	*Sterna maxima*	20	10			218	660
	Sandwich tern	*Sterna sandvicensis*	10	5			108	780
	Forster's tern	*Sterna forsteri*						
	Least tern	*Sterna antillarum*					1	2
	Black skimmer	*Rynchops niger*	200	100	30	70	56	140
Corpus Christi Channel Spoil / 614-185 (PA 9, PA 10)	Great blue heron	*Ardea herodias*	10			1		7
	Gull-billed tern	*Sterna nilotica*						8
	Least tern	*Sterna antillarum*					110	160
	Black skimmer	*Rynchops niger*			75			60
Castors Cut / 614-203	Least tern	*Sterna antillarum*						

Source: Texas Colonial Waterbird Database (FWS, 2001).

4.4.5.2 Operational Activities

Once the initial dredging activities associated with the project have been completed, little further impact is anticipated. Maintenance dredging activities would have similar temporary impacts as the initial dredging, but on a much smaller scale and for a shorter term. A decrease in the number of vessel trips in the project area for the with-project conditions as compared with the without-project conditions would reduce the potential for erosion of some of the PAs with rookeries. Decreased vessel traffic would also reduce the potential for accidental chemical or oil spills. Such spills pose a threat to the aquatic community and, thus, the food source of many coastal birds in the area. Impacts from noise and human activity are unlikely to be a factor.

The BU sites would provide a substrate for seagrass beds, thus increasing the habitat for some aquatic species, which in turn could locally increase the food source for birds in the area. In addition, BU Site Pelican is expected to have a beneficial impact on the Brown Pelican. Placement of maintenance dredged materials will continue on the south side of Pelican Island for ongoing rookery island enhancement. Also, rock revetment on the northeastern corner of the island for erosion protection will be replaced. A 2,200-linear-foot hydraulically filled embankment will extend bayward from the east end of the island for shoreline erosion protection and to prevent a land bridge from forming across Pelican Island to Mustang Island to keep predators away.

4.5 THREATENED AND ENDANGERED SPECIES

A Biological Assessment (BA) has been prepared for this project for the purpose of fulfilling the USACE requirements as outlined under Section 7(c) of the Endangered Species Act of 1973 as amended and can be found in Appendix C. The BA will be reviewed by NMFS and FWS for their Biological Opinion and to ensure that all potential project impacts have been discussed and coordinated with the appropriate agencies during various workgroup meetings.

4.5.1 Flora

There are no records of occurrence in the TXBCD database for any Federally endangered, threatened or Species of Concern in areas likely to be impacted by the current ship channel including dredged material placement areas (i.e., No-Action alternative). The habitats of the endangered species in the bay area's county lists are not likely to occur in areas impacted by the current practice. Of the SOC species, only roughseed purslane habitat (dunes and brackish swales and marshes) might be affected by dredged material placement on PA 2 (San Jose Island by the jetty) which can overflow to the beach. However, this species is not known to occur at PA 2.

The TXBCD database (Element Occurrence Records on USGS quads) was reviewed and no Federally endangered, threatened or SOC species that appear in the county lists for the study area were noted in areas that may be impacted by the proposed project. The proposed project would not impact the habitats of any of the endangered species. Of the SOC species, only roughseed purslane, which occurs in dunes and brackish swales and marshes along the coast, might be in the Gulf shore beach dune habitat close enough to the dredging activities to be affected by disturbances (from dredged material placement) in this area. However, there is no difference from the potential impacts of the current practice.

4.5.2 Fauna

The No-Action alternative would result in no immediate direct impacts to any endangered species or endangered species habitat at or near the proposed project site, although some of the habitats may change over time independent of the project. Commercial development and continued dredging and placement of dredged material occurring in the area could result in increased sedimentation, which could have an impact on the brown pelican and other birds, as well as sea turtles. A decrease in the number of vessels in the area would reduce the potential for collision with any sea turtles in the area. Decreased erosion would also be expected from the decrease in boat traffic. Such increase in sedimentation or decrease in boat traffic would be less under the No-Action alternative than under the preferred alternative.

4.5.2.1 Construction Activities

A major brown pelican colony is located on Pelican Island, which is approximately 1,500 feet south of the CCSC (GLO, 2000; FWS, 2001; TXBCD, 2001). A total of 1,100 pairs of nesting brown pelicans was recorded at this rookery in 1999 and 873 pairs in 2000 (FWS, 2001; Table 4.4-1). Because of the proximity of this island to the CCSC, erosion from boat traffic may be a problem; however, the reduction in the number of vessels due to the project would lead to a decreased possibility of chemical or oil spills, diminishing the effect on the nekton community and, thus, the food source of the brown pelican. Loafing brown pelicans were encountered on Pelican Island outside of the nesting season as well as during the nesting season during PBS&J's surveys for the piping and snowy plover (PBS&J, 2001). Pelican Island is a designated PA for maintenance material only and will not receive construction material.

The white-faced ibis, a Federal SOC and State-threatened species, and the State-threatened reddish egret also nest on Pelican Island. In 1999, 47 nesting pairs of white-faced ibis and 34 pairs of reddish egret were recorded at this rookery, while in 2000, 53 pairs of white-faced ibis and 10 pairs of reddish egret were recorded (FWS, 2001; Table 4.4-1). Dredging activities in the area could indirectly impact these two species if they take place during the nesting season by potentially reducing the availability of the food supply. Noise during construction may also have an impact on the rookeries. The decreased possibility of chemical or oil spills would reduce impacts to the nekton community and, thus, the food source of the white-faced ibis and reddish egret.

PBS&J conducted a piping plover survey in the Corpus Christi Bay study area between September 2000 and April 2001 (PBS&J, 2001). The USACE and PBS&J met with the FWS and TPWD in Corpus Christi in the summer of 2000 to discuss the methods and areas of interest, relative to a piping plover and snowy plover survey. One-meter color infrared digital orthophoto quarter quadrangles of the study area were examined and potential areas of tidal elevation change were discussed. Areas within the study area, for which there was a paucity of data or where the resource agencies felt there might be impacts, were selected by the FWS and TPWD for an intensive 8-month survey. Results of the survey are in Appendix C. The piping plover and snowy plover have been recorded at several places near the CCSC, including East Flats, Harbor Island, Point of Mustang, and Pelican Island (PBS&J, 2001) (Figure 4-1). The minor changes in salinity and tidal amplitude as a result of the preferred alternative are

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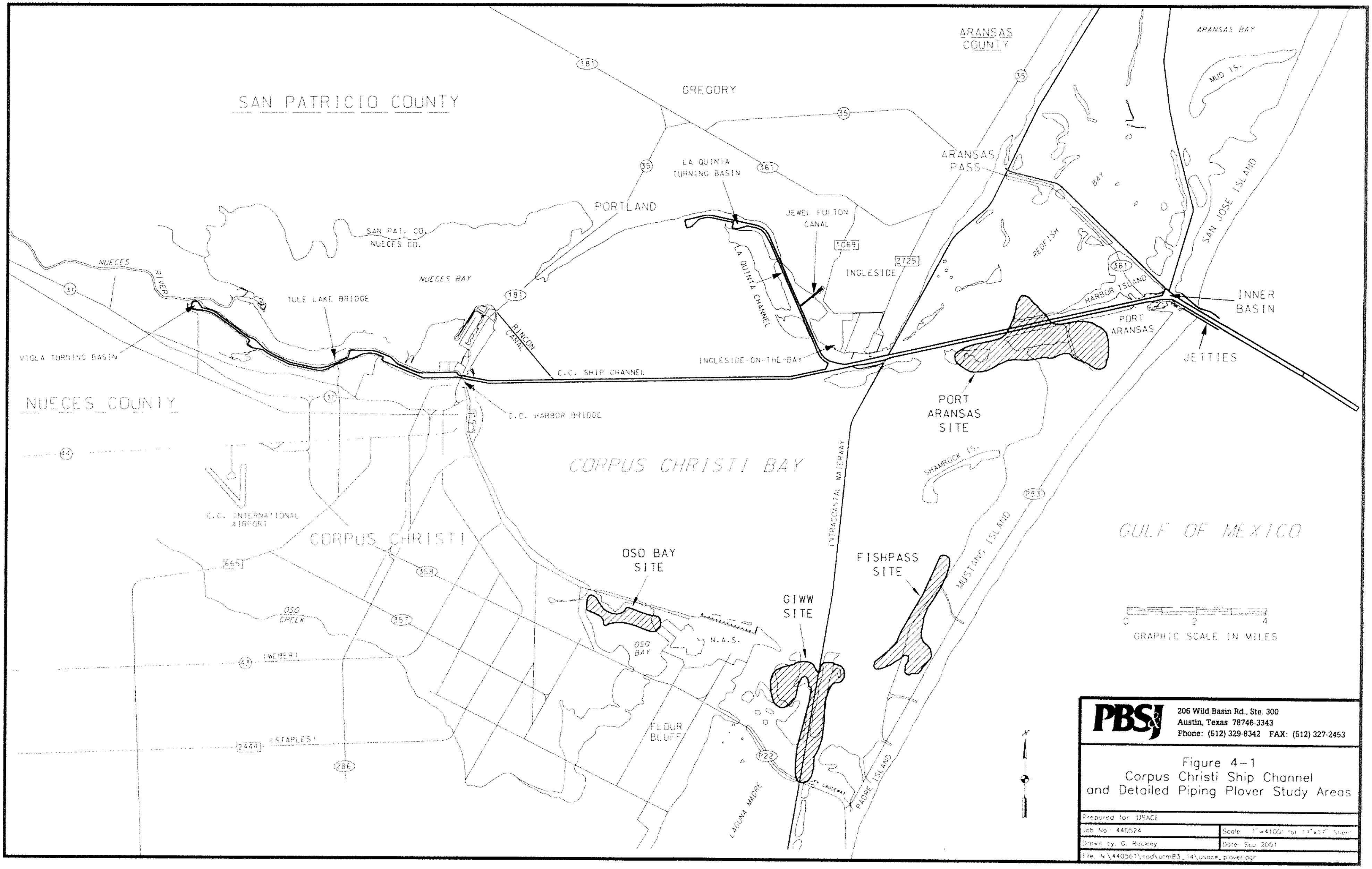

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Figure 4-1
Corpus Christi Ship Channel
and Detailed Piping Plover Study Areas

Prepared for USACE

Job No: 440524	Scale 1"=4100' for 11"x17" Sheet
Drawn by: G. Rockley	Date: Sep 2001

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expected to have no impact on these two plovers. No designated critical habitat for the piping plover would be impacted and none of the above areas will receive any construction material.

Four species of sea turtle, Kemp's ridley, loggerhead, green turtle, and hawksbill have been recorded from Corpus Christi Bay (Shaver, 2000). In offshore waters, in addition to these species, leatherback sea turtles have also been recorded. Leatherback sea turtle strandings were also found in the project area (Heinly, 1990). If present in the area, sea turtles may be in danger of being sucked into the hopper during dredging in the entrance channel. Dredging activities could have an impact on these species through an increase in sedimentation and turbidity. Sedimentation may impact food sources for the turtles, and turbidity could affect primary productivity. This would be short term, however. No concerns relative to chemical compounds in new work materials were noted in sections 3.2 and 3.3. The decreased possibility of chemical or oil spills would be expected to have a positive effect on turtles both directly and indirectly through a reduced threat to their food source. A decrease in the number of vessels would result in a lower incidence of collision with sea turtles. Nesting habitat for sea turtles is confined to the Gulf beaches. Hence, nesting habitat and nesting activities are not expected to be negatively impacted by dredging.

Terrestrial reptiles such as the Gulf salt marsh snake (a Federal SOC) and the State-threatened Texas tortoise have been recorded from areas in the study area (TXBCD, 2001). No impact on these species is anticipated, however. The Texas diamondback terrapin (SOC), an inhabitant of brackish and saltwater coastal marshes, lagoons, and tidal flats, has also been recorded in the study area (TXBCD, 2001). The minor changes in salinity and tidal amplitude as a result of the project are expected to have no impact on this terrapin.

The No-Action alternative appears to have no significant detrimental effect on the listed candidate species. The PA located offshore could be beneficial to the dusky shark, sand tiger shark, night shark, and goliath grouper. The change in the bathymetry has the potential to aggregate fish, which would be a food source to these species. The TXBCD State-threatened opossum pipefish is not common in the dredged or placement areas, therefore no impacts are expected.

As noted for the No-Action alternative above, the preferred alternative appears to have no significant detrimental effect on the listed candidate species. The BU site located at the offshore placement area, could be beneficial to the dusky shark, sand tiger, night shark, and goliath grouper. The change in the bathymetry has the potential to aggregate fish, which would be a food source to these species. The deepened and widened channel area represents an increase in habitat for those nekton species common in deeper offshore waters which periodically invade the bay through the deep channel corridor (Breuer, 1962). The TXBCD State-threatened opossum pipefish has the potential to be positively impacted through the creation of emergent wetlands planted with *Spartina* in the BU sites. This fish has been reported in *Spartina* marshes and in *Sargassum* mats in the Gulf of Mexico (Hoese and Moore, 1998).

4.5.2.2 Operational Activities

Once the initial dredging activities associated with the project have been completed, little further impact is anticipated. Maintenance dredging activities would have similar temporary impacts as the existing without project practices. A decrease in the number of vessels in the area and the erosion protection features there may reduce the potential for erosion of the Pelican Island brown pelican rookery. Additionally, the proposed placement of routine maintenance material on Pelican Island, as at present, will be beneficial. Decreased boat traffic compared with future without-project traffic projections would also reduce the potential for accidental chemical or oil spills, as well as the potential for collision mortality for sea turtles. Impacts from noise and human activity are unlikely to be a factor.

Impacts to fish from operational activities would be the same as those discussed above for construction activities.

4.6 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE

4.6.1 Hazardous Material Impacts to the Existing Environment from Project Activities

The impacts from hazardous material use and handling during dredging activities associated with the preferred alternative pose a minimal risk of impacts to the environment. Typical impacts may include leaks or small spills associated with excavation and dredging equipment. However, these impacts would be minimal and typically do not pose a significant risk to the environment. The owners/operators of the pipelines located within the ship channels will be notified of the proposed dredging activities, and relocations will occur to comply with USGS regulations. The pipeline relocations have a potential for temporarily impacting the transportation of petroleum.

A review of a regulatory agency database information search, an aerial photographic review, interviews with regulatory officials, and a site reconnaissance was conducted to determine the location and status of sites regulated by the State of Texas and the EPA. This assessment identified 257 regulated properties in the study area. The environmental impacts that have resulted from these facilities vary greatly. The vast majority of these facilities do not appear to pose an environmental concern to the project. However, according to TNRCC officials, the industrial activity adjacent to the Inner Harbor of the CCSC and the La Quinta Channel has caused measurable impacts to the groundwater adjacent to these waterways.

Although the discharge of groundwater containing chromium and petroleum hydrocarbons has been documented in the Inner Harbor, all dredged materials from the Inner Harbor will go to UCPAs.

Groundwater seepage which reportedly contains carbon tetrachloride and perchloroethane has migrated and is discharging into La Quinta Channel. This discharge has potentially impacted the sediment of the ship channel. However, chemical analysis of La Quinta Channel sediments has indicated no cause for concern.

A total of 57 petroleum pipelines are reported to cross the CCSC, and six pipelines are reported to cross La Quinta Channel Extension. The proposed project could impact each of the pipelines located within the proposed dredging depth. Therefore, pipeline relocations have been made part of the project and would occur before dredging has begun.

A total of 1,568 permitted well sites are reported in the project area. Since dredging operations will be limited to existing ship channels, no impacts to oil and gas wells are expected.

4.6.2 Hazardous Material Impacts to the Project from Operation Activities

According to the regulatory agency database review, the historic utilization of the existing channels has not resulted in significant impacts to the environment. Future use of the deeper channels is not expected to result in greater impacts to the environment.

4.7 HISTORIC RESOURCES

All project impact areas have been evaluated for potential effects to historic properties. High probability areas that had not been surveyed during previous archaeological investigations, including Ricklis (1999), Highley et al. (1977), Hoyt (1990) and James and Pearson (1991), were investigated in conjunction with preparation of this FEIS (Enright et al., in preparation). The investigations reported by Enright et al. were performed to aid in the assessment of environmental consequences to historic properties for the proposed CCSCCIP and included multiple marine remote-sensing surveys and diver assessments. Scopes of work for historic properties investigations were coordinated with the Texas SHPO. Copies of agency correspondence are provided in Appendix D. Certain project impact areas were excluded from survey due to their low potential to contain significant historic properties or because of extensive prior disturbance. Such areas include landlocked portions of the Inner Harbor Reach, existing upland placement areas, previously designated and approved open-bay and offshore placement areas, and BU's MN, ZZ, L, Pelican, and the western 20 percent of BU Site GH.

Cultural resource investigations conducted in conjunction with this study have determined that proposed improvements will impact one significant historic property, the wreck of the *SS Mary* (41NU252), which is located immediately adjacent the Entrance Channel between the Port Aransas Jetties. Site 41NU252 was determined eligible for the NRHP based on SHPO concurrence with investigations by Hoyt (1990) and Pearson and Simmons (1995). One other potential NRHP property, an unidentified shipwreck (41NU264), is located immediately adjacent the Entrance Channel just beyond the end of the Port Aransas Jetties. No adverse impacts to Site 41NU264 are expected due to the fact that the channel has been naturally scoured to exceed the project depth, and no additional dredging is anticipated adjacent the wreck. No impacts are anticipated to terrestrial cultural resources.

Proposed improvements to navigation for the CCSC and La Quinta Channel include a channel extension offshore at Aransas Pass, deepening of the entire CCSC from the Entrance Channel to the Inner Harbor, widening of the CCSC across the Upper and Lower Bay reaches, and the addition of a channel extension and a turning basin at the head of the La Quinta Channel. In conjunction with improvements, dredged material will be placed in existing mid-bay PAs and in new BU sites that will be created in the bay and offshore areas. The proposed CCSC improvements (described in Section 2.2.2) include deepening the existing channel from –45 feet MLT to –52 feet MLT, plus 2 feet over-dredging allotment and 2 feet advanced maintenance, and widening the toe-to-toe measurement to 530 feet along all reaches except the Inner Harbor and Entrance channels. A 200-foot wide, 12-foot deep barge shelf additionally will be added to either side of the CCSC from the La Quinta Junction to the Harbor Bridge.

The Entrance Channel will be dredged to the –56-foot isobar which will extend the channel approximately 10,000 feet into the Gulf of Mexico. The proposed channel widening and the addition of the barge shelves will increase the impact zone width to approximately 770 feet from the inner end of the Entrance Channel to the La Quinta Junction (the Lower Bay Reach) and to approximately 1,000 feet from the La Quinta Junction to the bay end of the Inner Harbor Channel (the Upper Bay Reach). The La Quinta Channel proposed improvements include extending the existing channel 7,200 feet, at a depth of –39 feet MLT and a width of 300 feet, and the creation of a turning basin.

The placement plan for new work and dredged material (Section 2.2.2) involves using a combination of existing upland and open-water PAs, existing and new BU's in Corpus Christi Bay and the Gulf of Mexico, and the creation of one new upland BU north of La Quinta Channel, The proposed creation of BU sites in the bay and offshore areas will total approximately 935 acres of the bay bottom and 1,590 acres of the Gulf of Mexico. A variety of BU sites are proposed for use (Figure 1-3), including breakwaters, new marsh areas protected by breakwaters, a new upland natural area, the enlargement of existing bird islands, and the use of existing offshore feeder berms. Descriptions of individual BU sites are provided in Sections 1.6 and below as they apply to each channel reach.

All open-bay, offshore, and terrestrial PAs (Figure 1-2) were designated and cleared for continuous use by the CCSC 45-Foot Project (U.S. Army Engineer District, Galveston, Texas 1979). PAs are listed below in the context of the channel reach to which each applies. The footprints of existing PAs are not expected to change as a result of the CCSCCIP; therefore, no new impacts are anticipated in those areas. Existing unconfined PAs proposed for use in Corpus Christi Bay total 4,050 acres. PA 1, a 500-acre unconfined placement area, previously designated in the Gulf of Mexico, is also proposed for use by the CCSCCIP. Existing upland PAs total approximately 2,300 acres.

4.7.1 Entrance Channel

The Entrance Channel segment of the CCSCCIP is comprised of several distinct elements for which potential effects to historic properties must be evaluated. These include the existing Jetty and Outer Bar channels, the proposed Offshore Channel Extension, creation of BU sites MN and ZZ, and use of the existing PAs 1 and 2. Existing channel segments are addressed together below, since the proposed improvements are the same to both the jetty and outer bar channel segments.

4.7.1.1 Previous Investigations

Five historic properties investigations have been conducted within portions of the Entrance Channel as defined above. EH&A's 1989 survey (Hoyt, 1990) covered the immediate vicinity of the *SS Mary* wreck (Site 41NU252). That study included a remote-sensing survey, diver evaluation, and a NRHP assessment of the site. The site was recommended as eligible for the NRHP based on their work.

CEI's 1991 survey (James and Pearson, 1991) included a remote-sensing survey of the Jetty and Outer Bar channels (from Station 210+00 to Station –30+00) and diving at several anomalies. CEI recommended 7 remote-sensing targets along the Entrance Channel, in addition to the known wreck site of the *SS Mary,* for archaeological avoidance or further investigation. Those 7 targets were designated with the numbers 16, 20, 23, 24, 25, 31 and 32. A diving assessment of Target 31, conducted by CEI as part of the same project, revealed the presence of a potentially significant shipwreck, which was recorded as Site 41NU264. The other six targets were investigated by divers in 1993 (Pearson and Simmons, 1995). More extensive diver investigations of Target 31 (41NU264) and the *SS Mary* (41NU252) also were conducted during CEI's 1993 study.

In 1994, EH&A conducted additional diver investigations of Site 41NU264, believed incorrectly at the time to be the wreck of the *Utina* (Schmidt and Hoyt 1995). The site was thoroughly documented and was recommended as not eligible for the NRHP based upon the fact that better preserved examples of the *Utina* vessel type exist elsewhere. That site was recently proved by PBS&J to be misidentified. A shipwreck more closely matching the description of *Utina* has since been found south of 41NU264. The actual location of *Utina* is located well outside of the CCSCCIP impact area.

PBS&J's 2000 survey (Enright et al., in preparation) was conducted specifically for the CCSCCIP. That study included a remote-sensing survey of three areas: the proposed Outer Bar Channel Extension, the margins of the existing Outer Bar Channel, and the margins of the Inner Basin. The latter is located at the junction of the Jetty Channel and the Lower Bay Reach. PBS&J recommended four remote-sensing targets as potentially significant. Those targets were designated as anomalies M1, M2, M3 and M39. PBS&J conducted a close-order remote-sensing on the three targets that are located with the CCSCCIP impact area (M1, M2 and M3) and diver assessments of anomalies M1 and M3, both of which proved not to be archaeologically significant. Anomaly M2 is associated with the unidentified shipwreck at Site 41NU264. Anomaly M39 is associated with the suspected *Utina* wreck site and will not be affected by the CCSCCIP.

4.7.1.2 Environmental Consequences

Channel Extension

No adverse effects to historic properties are anticipated within the proposed Outer Bar Channel Extension Area. This area was surveyed by PBS&J in June 2000 (Enright et al., in preparation), and no potentially significant remote-sensing targets or historic properties were identified in this area. No adverse effects to historic properties are anticipated as a result of the channel extension.

Deepening of Existing Entrance Channel

Locations of three shipwrecks are known along the existing Entrance Channel. These vessels include Site 41NU252 (*SS Mary*), 41NU264 (unidentified vessel) and a vessel associated with Anomaly M39 (suspected location of the *Utina*; no site number yet assigned). Site 41NU252 is eligible for the NRHP. It is located along the south side of the Jetty Channel and will be adversely impacted by the CCSCCIP. Site 41NU264 is potentially eligible for the NRHP. It is located along the south side of the Outer Bar Channel, a short distance beyond the end of the jetties; however, no adverse impacts are anticipated at this site. The shipwreck at Anomaly M39 is located immediately adjacent the submerged seaward end of the southern jetty. The latter wreck is situated well clear of the Entrance Channel and will not be adversely impacted by the CCSCCIP.

The wreck of the *SS Mary* (41NU252) is located between the jetties at the base of the existing channel slope on the south side of the Jetty Channel. Although the exposed wreckage of the *SS Mary* is in very poor condition, it is eligible for designation as a State Archaeological Landmark under the criteria specified in The Antiquities Code of Texas, Section 191.091. The wreck was recommended by Hoyt (1990) as eligible for nomination to the National Register of Historic Places. Hoyt's recommendation was based on the *Mary*'s historic context, including the vessel's association with the Morgan Line steamship company owned by Charles Morgan (NRHP Criterion B: association with the lives of significant persons in the past), its service as a typical coastal steamer of the period (NRHP Criterion C: embodies the distinctive characteristics of a type, period or method of construction), and its construction by the innovative H&H Corporation (NRHP Criterion C). The THC subsequently concurred with that recommendation, thus the *Mary* is considered eligible for the NRHP.

Proposed channel deepening will adversely affect the wreck of the *Mary*. Based upon the position of the magnetic anomaly (Enright et al., in preparation), combined with positions of wreckage reported by Hoyt (1990), it appears that at least 16 feet of the *Mary's* stern should lie within the proposed dredging impact area of the CCSCCIP. Since the stern was never identified by divers, that portion of the vessel may have been impacted by the existing CCSC 45-Foot Project; however, a significant portion of the *Mary's* hull remains on the channel slope. The existing Jetty Channel depth at this location averages 52 feet MLT. On the south side of the channel, in the vicinity of the *Mary,* the channel has scoured to a depth of 55 feet MLT. Dredging to deepen the channel will impact sediments to a maximum depth of 56 feet MLT. Only minor slumping is expected before the channel slope again reaches equilibrium. Nevertheless, even minor slumping will adversely impact the *Mary* due to its proximity to the proposed new dredging.

Mitigation options for the *Mary* have been discussed in consultation with the Texas State Marine Archaeologist and the Texas SHPO (Stokes and Hoyt, 2000; Hoyt and Stokes, 2001). Data recovery is not feasible due to dangerous diving conditions, including currents in excess of 4 knots, proximity to ship traffic and near-zero visibility. The Galveston District USACE, therefore, recommends alternative mitigation measures, such as the preparation of a Texas maritime history curriculum module for use in public schools and construction of a museum display. A Memorandum of Agreement will be negotiated with the Texas SHPO, which details these alternative mitigation requirements.

A second shipwreck site (41NU264), considered potentially eligible for the NRHP, was discovered near the Outer Bar Channel by remote-sensing and diver investigations (James and Pearson, 1991; Pearson and Simmons, 1995). Site 41NU264 is located immediately adjacent the south side of the channel slightly seaward of the Aransas Pass jetties. This site was tentatively identified as the shipwreck of the *Utina* (Pearson and Simmons, 1995). Schmidt and Hoyt (1995:74-77) agreed with CEI's tentative identification of the site as the *Utina* and recommended that Site 41NU264 was not archaeologically significant based largely on the fact that several better-preserved examples of the *Utina* vessel type exist in the Sabine River. Recent information has come to light, however, which calls into question the identity of the vessel wrecked at Site 41NU264.

A more likely candidate for the *Utina* was discovered inadvertently by PBS&J during the summer of 2000 when, during a close-order magnetometer survey of Site 41NU264, another wreck was discovered at the end of the south jetty. PBS&J designated the latter wreck site as Anomaly M39. A trinomial site number has not been assigned as of this writing. Dimensions of the side-scan sonar target associated with M39 closely match the size of the *Utina*. Furthermore, the *Utina* is known from historic documents, including photography, to have stranded on the Gulf end of the south jetty (Schmidt and Hoyt, 1995), precisely where M39 is located. Site 41NU264, on the other hand, is located in deep water between the jetties on the southern margin of the ship channel. A strong case can now be made that the vessel at Site 41NU264 is not the *Utina*. Given this new information, however, Site 41NU264 must once again be considered potentially eligible for the NRHP until such time as its identity can be firmly established.

No additional research or mitigation is recommended for Site 41NU264, as the project is not expected to impact the wreck. The northern limit of wreckage, as seen on recent side-scan sonar images recorded by PBS&J, is located 14 feet south of the proposed channel toe. A recent cross-section of the existing channel in the vicinity of the site documents scouring to a depth of 65 feet MLT. No additional dredging is anticipated adjacent the wreck, since deepening of the channel will only impact sediments to a depth of 56 feet MLT.

The potential for impacts to this Site 41NU264 from erosion associated with the draw-down effects of more heavily laden ships also was evaluated using the results of a shoreline erosion study prepared by the Port of Corpus Christi for this project (Shepsis, 2001). From that study, it can be deduced that pressure field waves created by the draw-down of passing ships will play a relatively minor role in shoreline erosion, as compared to sea level rise, for example, over the next 50 years. The erosional effects of draw-down are most significant in shallow water and along steep slopes. Bottom water velocity increases as the energy from the draw-down and return waves becomes concentrated by the narrowing water column in shoal areas. Post-project bottom slopes in the vicinity of 41NU264 are not expected to differ significantly from present conditions. Ships are expected to displace more water following completion of the project due to heavier loads; however, no appreciable change in erosion rates is expected at this site. Shallow areas having relatively flat slopes, tend to experience sediment movement both toward and away from the channel (Shepsis, 2001: 2-32). Extrapolating to a flat slope in deep water, where draw-down and return wave velocities should be significantly less, the net sediment transport under such conditions is expected to result in minimal erosion of the site.

BU Site MN

BU Site MN is proposed to be approximately 440 acres. It would be located just outside of the 30-foot isobath (approximately 6,500 feet offshore) and 10,000 feet south of the project channel centerline. No shipwrecks are charted in the area of BU Site MN. Communication with the Texas State Marine Archaeologist determined that no remote-sensing survey would be required over BU Site MN because of the low potential for wrecks in the area (Murphy, 2001). No environmental consequences are anticipated for historic properties within the proposed BU Site MN (Hoyt and Stokes, 2001).

BU Site ZZ

Creation of BU Site ZZ originally was proposed as part of the Navy Homeport Project. It is proposed to be approximately 1,150 acres and is located approximately 15,300 feet southeast of the southern Aransas Pass jetty. One shipwreck is recorded within the limits of BU ZZ on NOAA Chart 11307. The AWOIS database reports this wreck (AWOIS Record 7907) as a 42-foot modern fishing vessel, lying in approximately 51 feet of water. The wreck was first reported by a Local Notice to Mariners in 1986 and is not considered a potential historic resource. A remote-sensing survey was not conducted over BU ZZ as a previous EIS, prepared by the EPA (1988), found that the use of BU ZZ will not impact sites of historical importance. No environmental consequences are anticipated for historic properties within the proposed BU Site ZZ (Hoyt and Stokes 2001).

Existing PAs

Two existing PAs (1 and 2) would be used for placement of dredged material from the Entrance Channel Reach. PA 1 is an existing offshore placement area which was previously approved for use as part of the CCSC 45-Foot Project (USACE, 1979). It covers approximately 500 acres and is located 5,300 feet southeast of the southern Aransas Pass jetty. No shipwrecks are recorded in the vicinity of PA 1, and no significant historic properties are expected to exist there (Hoyt and Stokes, 2001). A remote-sensing survey was not conducted over PA 1 as a previous Environmental Impact Statement, prepared by the EPA (1989), found that use of PA 1 would not impact sites of historical importance. PA 2 is an existing upland placement area on San Jose Island, which was approved for continuous use as part of the CCSC 45-Foot Project (USACE, 1979). No modifications of the existing PA footprints are proposed. No adverse effects are anticipated for historic properties due to the use of either PA 1 or PA 2.

4.7.2 Lower Bay

The Lower Bay Reach of the CCSCCIP is comprised of several distinct elements for which potential effects to historic properties must be evaluated. These include widening and deepening of the existing CCSC, creation of BU Sites I, R, S, L and Pelican, and use of the existing PAs 4-10. BU Site I would be located on the north side of the ship channel between Dagger Island and Pelican Island and would involve approximately 163 acres of bay bottom. BU sites R (201 acres) and S (121 acres) would be located on the south sides of existing PAs 9 and 10, respectively. BU Site L, proposed for the north side of Mustang Island east of Piper Channel, would consist of a rock revetment to serve as a marsh/ecosystem protection site. BU Pelican would consist of an armored barrier on the north and east sides of Pelican Island, to protect habitat from wind and wave erosion of PAs 7 and 8 and containment of routine placement of maintenance dredged material.

4.7.2.1 Previous Investigations

Four archaeological investigations have been conducted along the Lower Bay Reach. A remote-sensing survey conducted by CEI (James and Pearson, 1991) partially covered the CCSCCIP in the Lower Bay Reach using a 164-foot survey line interval. CEI recommended a single side-scan target (Sonar Target 40) as potentially significant. Target 40 did not have an associated magnetic anomaly and was recorded in 50 feet of water. It was investigated by archaeological divers as part of the same project;

however, divers were unable to locate an object at that location. Since Target 40 was mapped in an area which had been disturbed by dredging, no further investigation was recommended.

CEI conducted a remote-sensing survey along the GIWW across Corpus Christi Bay in 1994 (Pearson and Wells, 1995). One potentially significant target was identified at the intersection of the GIWW and the CCSC by their study. Target 1, as it was designated, was considered potentially associated with the wreck of the steamboat *Dayton* which occurred in the vicinity in 1845. CEI divers investigated Target 1 in 1996 (Pearson and James, 1997), determining that it was, instead, associated with a section of discarded dredge pipe. No further investigation of the target was recommended to follow that study.

PBS&J conducted a series of remote-sensing surveys, followed by diver investigations in 2000 and 2001 (Enright et al., in preparation). Those investigations were performed for the CCSCCIP and included, in the Lower Bay Reach, a remote-sensing survey of the area to be affected by channel widening and deepening, a remote-sensing survey of BU sites I, R and S, a close-order remote-sensing survey of 11 magnetic anomalies, and archaeological diver investigations on 7 anomalies. A total of 10 magnetic anomalies, designated M4-M13, were recommended as potentially significant following the survey along the CCSC through the Lower Bay Reach in June 2000. During the close-order survey of those 10 anomalies in December 2000, one additional potentially significant anomaly (M38) was discovered mid-way between M12 and M13. M38 also was surveyed using a close line interval at that time. Two additional anomalies (I1 and I3) were recommended as significant based on the results of BU surveys in June 2001.

Anomalies M4-M6, M8, and M10-M11 were recommended as not significant based on the results of the close-order survey. Archaeological divers investigated the remaining 7 anomalies, including M7, M9, M12, M13, M38, I1 and I3. Potentially significant archaeological remains were found at one location, Anomaly M38. All of the other anomalies have been recommended as not archaeologically significant based upon the results of diver investigations.

Anomaly M38 marks the location of a buried shipwreck which is consistent in its location, water depth, hull width and construction materials with the wreck of the steamboat *Dayton.* The *Dayton* is known from historic documents to have sunk in this vicinity in 1845 following a boiler explosion. Because of this possible associate, Anomaly M38 is recommended as potentially eligible to the NRHP.

4.7.2.2 Environmental Consequences

Channel Widening and Deepening

The location of one shipwreck has been documented in the vicinity of the CCSC along the Lower Bay Reach. Diving investigations conducted by PBS&J in 2001 at Anomaly M38 revealed suspected historic vessel remains buried beneath 6 feet of sediment. The identity of those remains has not been firmly established; however, they are consistent with the historic steamboat *Dayton* which blew up and sank in this vicinity in 1845. This site is considered potentially eligible for the NRHP. The northern edge of Anomaly M38 is located approximately 95 feet south of the projected new top of channel slope, thus the shipwreck associated with Anomaly M38 will not be adversely affected by the CCSCCIP.

BU Site I

BU Site I is proposed to be approximately 163 acres and is located on the north side of the CCSC between Dagger Island and Pelican Island. No shipwrecks are plotted in the vicinity of BU Site I. PBS&J's 2001 survey recommended avoidance or further investigation of two magnetic anomalies (I1 and I3) within Site I. Diver investigations cleared these sites as modern debris (Enright et al., in preparation). No adverse effects to historic properties are anticipated due to the creation of BU Site I.

BU Site R

BU Site R is proposed to be approximately 201 acres and is located on the south side of PA 9. PBS&J's 2001 survey of BU R did not locate any potential historic properties. No adverse effects to historic properties are anticipated due to the creation of BU Site R.

BU Site S

BU Site S is proposed to be approximately 121 acres and is located on the south side of PA 10. No shipwrecks are plotted in the vicinity of BU Site S. PBS&J's 2001 survey did not locate any potential cultural resource sites in this area. No adverse effects to historic properties are anticipated due to the creation of BU Site S.

BU Site L

The area proposed for construction of this rock revetment consists of made land. This location was not subjected to a cultural resource survey, as no disturbance of the natural bay bottom is expected. No adverse effects to historic properties are anticipated due to the creation of BU Site L.

BU Pelican

BU Pelican consists of a geotube placement atop previously deposited dredged material. The geotubes are meant to prevent material runoff from an adjacent placement area. A remote-sensing survey was deemed unnecessary as the natural bay bottom has already been covered by dredged material from the adjacent placement area. The presence of the geotubes will not impact the natural bay bottom in this area further (Hoyt and Stokes, 2001). No adverse effects to historic properties are anticipated due to the creation of BU Pelican.

Existing PAs

Seven existing PAs (4, 5, 6, 7, 8, 9 and 10) would be used for placement of dredged material from the Lower Bay Reach. These PAs were previously approved for continuous use as part of the CCSC 45-Foot Project (USACE, 1979). No modifications of the existing PA footprints are proposed, and no adverse effects are anticipated for historic properties due to their continued use.

4.7.3 Upper Bay

The Upper Bay Reach of the CCSCCIP is comprised of several distinct elements for which potential effects to historic properties must be evaluated. These include widening and deepening of the existing CCSC, creation of barge lane shelves on each side of the widened channel, creation of BU Site CQ, and use of the existing PAs 14A, 14B, 15A, 15B, 16A, 16B, 17A, and 17B (see Figure 1-2). BU Site CQ would be located south of Berry Island and west of the CCSC/La Quinta Channel junction (see Figure 1-3). Site CQ would use new work materials to create approximately 250 acres of shallow water habitat and emergent flats and 6 to 10 mounds of material placed in a northwest to southeast direction to decrease fetch.

4.7.3.1 Previous Investigations

Two archaeological investigations have been conducted along the Upper Bay Reach. A remote-sensing survey conducted by CEI (James and Pearson, 1991) partially covered the CCSCCIP in the Upper Bay Reach using a 164-foot survey line interval. CEI recommended a single side-scan target (Sonar Target 47) as potentially significant along this reach of channel. Target 47 did not have an associated magnetic anomaly and was recorded in 47 feet of water. It was investigated by archaeological divers as part of the same project; however, divers were unable to locate an object at that location. It was determined that Target 47 was a bottom scar. Target 47 was located in an area which had been disturbed by dredging. No further investigation was recommended.

PBS&J conducted a series of remote-sensing surveys, followed by diver investigations in 2000 and 2001 which included the Upper Bay Reach (Enright et al., in preparation). Those investigations were performed for the CCSCCIP and included a remote-sensing survey of the areas to be affected by channel widening and deepening and by construction of barge lane shelves along each side of the channel, a close-order remote-sensing survey of 9 magnetic anomalies, a remote-sensing survey of BU Site CQ, and archaeological diver investigations of 3 anomalies. A total of 9 magnetic anomalies, designated M14-M22, were recommended as potentially significant following the survey along the CCSC through the Upper Bay Reach in June 2000. No additional anomalies were recommended as significant based on the results of the BU Site CQ survey in June 2001. Anomalies M15-M16, M18-M20 and M22 were recommended as not significant based on the results of the close-order survey. Archaeological divers investigated the remaining 3 anomalies, including M14, M17 and M21. All three anomalies were recommended as not archaeologically significant based upon the results of diver investigations.

4.7.3.2 Environmental Consequences

Channel Widening and Deepening and Barge Lane Creation

There are no known historic properties or potentially significant remote-sensing targets located in this area. Four remote-sensing targets have been investigated by divers along the Upper Bay Reach (1 by CEI and 3 by PBS&J); however, all of those anomalies were determined not to be archaeologically significant. No adverse effects to historic properties are anticipated as a result of the proposed new dredging along this channel reach.

BU Site CQ

BU Site CQ (Figure 1-3) is proposed to be approximately 250 acres and is located to the south of Berry Island and west of the CCSC/La Quinta Channel junction. No potential historic properties are known to exist in this area, and PBS&J's 2001 remote-sensing survey did not locate any potentially significant remote-sensing targets there. No adverse effects to historic properties are anticipated due to the creation of BU Site CQ. .

Existing PAs

Eight existing, unconfined open-bay PAs (14A, 14B, 15A, 15B, 16A, 16B, 17A, and 17B) would be used for placement of maintenance material from the Upper Bay Reach. These PAs were previously approved for continuous use as part of the CCSC 45-Foot Project (USACE, 1979). No modifications of the existing PA footprints are proposed, and no adverse effects are anticipated for historic properties due to their continued use.

4.7.4 La Quinta

The La Quinta Reach is comprised of several distinct elements for which potential effects to historic properties must be evaluated. These include extending the existing channel 7,200 feet, construction of a turning basin adjacent the channel extension, creation of BU sites P, GH and E, and use of existing PA 13. Under the preferred alternative, no deepening of the existing La Quinta Channel would occur.

4.7.4.1 Previous Investigations

Two marine archaeological investigations have been conducted along the La Quinta Reach. A remote-sensing survey conducted by CEI (James and Pearson, 1991) partially covered the La Quinta Reach using a 164-foot survey line interval. CEI recommended one side-scan target (Target 53) and one magnetic anomaly (Target 84) as potentially significant along this reach of channel. Target 53 did not have an associated magnetic anomaly and was recorded in 50 feet of water. Target 84 did not have an associated sonar target and was recorded in 49 feet of water. Both targets were investigated by archaeological divers as part of the same project. Divers located only braided steel cable at both locations. No further investigations were recommended.

PBS&J conducted a series of remote-sensing surveys, followed by diver investigations in 2000 and 2001 which included the La Quinta Reach (Enright et al., in preparation). Those investigations included a remote-sensing survey of a 200-foot-wide area along each side of the channel, a remote-sensing survey of the proposed channel extension and turning basin (including the easternmost 80 percent of BU Site GH), a close-order remote-sensing survey of 14 magnetic anomalies, a remote-sensing survey of BU Site P, and archaeological diver investigations of 1 anomaly. A total of 14 magnetic anomalies, designated M24-M37, were recommended as potentially significant following the survey in June 2000. One additional anomaly (P1) was recommended as significant based on the results of the BU Site P survey in June 2001. Anomaly P1 is located in an area that will not be affected by creation of BU Site P. Anomalies M24 and M26-M37 were recommended as not significant based on the results of the close-order survey. Archaeological divers investigated the remaining anomaly, M25. Anomaly M25 was recommended as not archaeologically significant based upon the results of diver investigations.

Previous terrestrial archaeological investigations encompassing portions of BU Site E include Corbin's (1963) investigations, a survey by McDonald and Dibble (1973), and survey and excavation conducted by Ricklis (1999). Ricklis revisited all of the sites recorded by the earlier two surveys. All ten sites investigated by Ricklis were deemed ineligible for NRHP listing or SAL designation. The THC concurred with this assessment (Ricklis, 1999).

4.7.4.2 Environmental Consequences

Channel Extension and Turning Basin Creation

There are no known historic properties or potentially significant remote-sensing targets located in any of these areas. Three remote-sensing targets have been investigated by divers along the existing La Quinta Channel (2 by CEI and 1 by PBS&J); however, all of those anomalies were determined not to be archaeologically significant. Furthermore, since no modifications are planned for the existing channel under the preferred alternative, there would be no adverse effects to historic properties there, should they exist. No adverse effects to historic properties are anticipated in association with either the channel extension or turning basin construction.

BU Site GH

BU Site GH is proposed to be approximately 200 acres and is located adjacent the south side of the proposed La Quinta Channel extension and west of PA 13. PBS&J's 2000 remote-sensing survey (Enright et al., in preparation) encompassed the easternmost 80 percent of BU Site GH. PBS&J did not survey the remaining 20 percent during the 2001 survey, because it was determined that no potentially significant anomalies were recorded by the 2000 survey and because THC's shipwreck database contained no indication of a wreck in the area (Murphy, 2001). The Texas SHPO concurred that a survey of the western 20 percent was not necessary due to the low probability for historic properties in the area. No adverse effects are anticipated for historic properties due to the creation of BU Site GH.

BU Site P

BU Site P is a rock breakwater proposed to be approximately 2,400 feet long. It would be located on the east side of the La Quinta Channel adjacent Ingleside-On-The-Bay. No historic properties are known to exist in this area. PBS&J's 2001 remote-sensing survey located one potentially significant remote-sensing target, designated P1; however, that target is located in an area which will be unaffected by project-related bottom disturbances. No adverse effects to historic properties are anticipated due to the creation of BU Site P.

BU Site E

BU Site E is located on the upland bay margin, northwest of the La Quinta Channel extension. Site E would involve the creation of a 100-acre upland natural area buffer between lands to the west and the La Quinta Gateway Project. Portions of the area have been previously surveyed for terrestrial cultural resource sites, and all recorded sites have been determined not eligible for inclusion to the NRHP or as SALs. Coordination with the Texas SHPO concluded that those portions not surveyed have a low probability for the occurrence of significant archaeological sites; therefore, no further investigations are required. No adverse effect to significant historic properties are expected due to the creation of BU Site E.

Existing PAs

One existing PA (PA 13) would be used for placement of maintenance material dredged from the La Quinta Channel. PA 13 was previously approved for continuous use as part of the CCSC 45-Foot Project (USACE, 1979). No modifications of the existing PA footprints are proposed, and no adverse effects are anticipated for historic properties due to their continued use.

4.7.5 Inner Harbor

The Inner Harbor Reach is comprised of several distinct elements for which potential effects to historic properties must be evaluated. These include deepening the existing channel and use of existing confined upland PAs (IH-PA 1, IH-PA 3A, B, C, IH-PA 4, IH-PA 5, IH-PA 6 (Tule Lake), IH-PA 2 (Rincon), and IH-PA 8 (Suntide)).

4.7.5.1 Previous Investigations

Previous terrestrial archaeological investigations of the Inner Harbor area were conducted by Highley et al. (1977) for the Tule Lake Tract Project. The survey was conducted prior to disposal of fill resulting from harbor dredging activities (Highley et al., 1977). Two archaeological sites (41NU157 and 41NU158) were identified and recorded during that survey. Site 41NU157 was recommended for avoidance and was not to be covered. Site 41NU158 was recommended for intensive survey and shovel testing. It is not known whether the THC concurred with those recommendations. A later survey, conducted for a proposed dredge material site in Nueces County, overlapped a small portion of the western end of the Tule Lake survey area. The area resurveyed included previously recorded site 41NU157. Based on the reconnaissance results of the latter survey, the authors reported that no potential conflict with cultural resources was documented (Black and Highley, 1985).

PBS&J conducted a series of remote-sensing surveys, followed by diver investigations in 2000 and 2001 which included the Corpus Christi Bay portion of the Inner Harbor Reach east of the Harbor Bridge (Enright et al., in preparation). Those investigations were performed for the CCSCCIP and included a remote-sensing survey of a 200-foot-wide area along each side of the channel and a close-order remote-sensing survey of one magnetic anomaly. Anomaly M23 was recommended as potentially significant following the survey in June 2000; however, that recommendation was changed to not significant based on the results of the close-order survey. No marine remote-sensing surveys were required in the landlocked portion of this reach because the channel did not exist prior to 1934 and was not completed in it's present form until 1958. Historic navigation in this reach was not possible prior to 1934 and occurred under controlled circumstances after that date. The potential for occurrence of significant historic shipwrecks along this reach, therefore, is considered to be low. The Texas SHPO has concurred that no marine remote-sensing survey is necessary along this reach.

4.7.5.2 Environmental Consequences

Channel Deepening

There are no known historic properties or potentially significant remote-sensing targets located in this area. One remote-sensing target, Anomaly M23, was recorded by PBS&J along the bay portion of this reach, between Light Beacon 82 and the Harbor Bridge; however, a close-order survey of that anomaly suggested that it was not archaeologically significant. Deepening of the existing channel will not impact the existing exposed shoreline; therefore, a terrestrial cultural resource survey of the shoreline was not required. The Texas SHPO did not require a remote-sensing survey of the Inner Harbor Reach west of the Harbor Bridge, due to the low probability that significant submerged historic properties would be present in that area. No adverse effects to historic properties are anticipated as a result of the Inner Harbor channel deepening.

Existing PAs

Nine existing, upland confined PAs (IH-PA 1, IH-PA 3A, B, C, IH-PA 4, IH-PA 5, IH-PA 6 (Tule Lake), IH-PA 2 (Rincon), and IH-PA 8 (Suntide)) will be used for placement of new material dredged to deepen the Inner Harbor Channel. Most of these existing PAs were created prior to any legal requirement for archaeological surveys, thus they were never surveyed for cultural resources. One exception is IH-PA 6 (Tule Lake). IH-PA 6 is proposed to cover 400 acres between Tule Lake and the Viola Channel. IH-PA 6 was surveyed for cultural resources as reported by Highley et al. (1977) and by Black and Highley (1985). Several cultural resources sites were recorded by those surveys; however, none of the recorded sites are located within the boundaries of IH-PA 6. The closest cultural resource site to IH-PA 6 is 41NU157. No modification of the existing PA footprints or levees will occur as a result of the CCSCCIP, and no adverse effects to historic properties are anticipated due to their continued use.

4.8 AIR QUALITY

Under the No-Action alternative, air quality would continue as described in Section 3.9.

Impacts on air quality from the project would result during construction and follow-on maintenance dredging activities.

4.8.1 Construction Dredging

The combustion of diesel fuel during construction dredging operations would result in air emissions of primarily nitrogen oxides (NO_x), carbon monoxide (CO), volatile organic compounds (VOC), particulate matter (PM), and sulfur dioxides (SO_2). The amount of fuel combustion emissions would be directly related to the type and size of equipment and the amount of dredging required. The total amount of new dredged material is estimated to be about 41 mcy. Based on the construction schedule under consideration, the construction dredging would be completed in segments with the first segment completed in 2003 and the last in 2007. Emissions are estimated for each segment as summarized in Table 4.8-1.

4.8.2 Maintenance Dredging

Routine dredging would be required to maintain the channel at a depth authorized to accommodate larger vessels and tankers. Maintenance dredging would occur along different segments with each segment being relatively independent of the other. It is estimated that about 208 million cubic yards of sediment would be excavated over 50 years (i.e., an average of 4 mcy per year). The resulting emissions from this operation are estimated as shown in Table 4.8-2.

4.8.3 Expected Air Quality Impacts

Atmospheric dispersion modeling of emissions was not performed. There are dispersion modeling tools available to estimate local air quality impacts; however, these models are most accurate at estimating impacts from those facilities from which emissions occur at well-defined, stationary emission points. In the case of this project, local dispersion of emissions cannot be characterized with any degree of accuracy because they would be emitted from a variety of mobile sources that would operate intermittently. Additionally, the level of activity would be variable.

Regional dispersion models available to characterize VOC and NO_x, which are O_3 precursors and result in regional impacts, are not intended to estimate a specific project's contribution to regional O_3 concentrations. Therefore, regional dispersion models would not be useful in estimating the projects construction and operational impact on regional O3 concentrations.

It is expected that air contaminant emissions from construction dredging activities will result in minor short-term impacts on air quality in the immediate vicinity of the dredging site. Each dredging operation would be relatively independent of the other, although, there may be some overlap. In addition, these activities are considered one-time activities (i.e., the construction dredging activities would not continue past the date of completion). As a result, the impact on ambient air from construction dredging emissions would be of generally intermittent and relatively short-term duration. VOCs and nitrogen oxides can combine under the right conditions in a series of photochemical reactions to form ozone, possibly increasing ozone concentrations in the region. However, these reactions take place over a period of several hours with maximum concentrations of ozone often far downwind of the precursor sources. Due to the phased, one-time construction dredging, it is expected that there will be no long-term impacts to air quality in the area.

It is expected that air contaminant emissions from maintenance dredging activities will result in minor short-term impacts on air quality in the immediate vicinity of the dredging site. As previously noted, VOCs and nitrogen oxides can combine under the right conditions to form ozone, possibly increasing the concentration of ozone in the region. However these reactions take place over a period of several hours with maximum concentrations of ozone often far downwind of the precursor sources. The estimated emission rates for these and the other products of combustion are relatively minor and would be intermittent and of relatively short-term duration for each segment. Therefore,

TABLE 4.8-1

ANNUAL CONSTRUCTION DREDGING EMISSIONS
(TONS PER YEAR)

Activity	Completion Year	Estimated Duration (days)	PM	SO_2	NO_x	VOC	CO
La Quinta Extension and Turning Basin	2003	97	6.78	78.4	233	6.8	53.3
Entrance Channel Deepening	2004	31	2.29	26.4	78.4	2.30	17.97
Port Aransas to La Quinta Junction	2005	121	8.45	97.7	290	8.51	66.4
La Quinta Junction to Harbor Bridge Deepening and Widening	2006	224	13.6	157	466	13.7	107
Deepening of Inner Harbor	2007	49	5.02	58.0	172	5.1	39.5

TABLE 4.8-2

ANNUAL MAINTENANCE DREDGING EMISSIONS (TONS PER YEAR)

Activity	Estimated Annual Duration (days)	PM	SO_2	NO_x	VOC	CO
Entrance Channel	5	0.39	4.52	13.42	0.39	3.07
Port Aransas to La Quinta Junction	10	0.68	7.81	23.16	0.68	5.31
La Quinta Junction to Harbor Bridge	13	0.80	9.23	27.39	0.80	6.28
Harbor Bridge to Turning Basin	4	0.45	5.20	15.42	0.45	3.53
La Quinta Channel	3	0.22	2.5	7.38	0.22	1.69
Total	35	2.53	29.3	86.77	2.55	121

emissions from the maintenance dredging are not expected to result in a serious impact to the regional air quality and they are not expected to differ significantly from present maintenance dredging.

Airshed pollutant loading determined by the magnitude of emissions expected to result from the project compared to area emissions can be used to estimate air quality impacts of the criteria pollutants. Based on available air emissions inventory information provided on the EPA's AIRData website (EPA, 2002b), the following tables (tables 4.8.3 and 4.8.4) provide a summary of emissions for the Nueces County and San Patricio County. The emissions data are available for area plus mobile source and for point source emissions, based on emissions inventory information for 1999. This emissions inventory provides a basis from which to compare the proposed project emissions.

TABLE 4.8-3

SUMMARY OF PEAK AIR EMISSIONS FROM CONSTRUCTION DREDGING ACTIVITIES COMPARED WITH NUECES AND SAN PATRICIO COUNTY EMISSIONS FOR 1999

Air Contaminant	Area and Mobile Source (tpy)	Point Source (tpy)	Total (tpy)	Estimated Peak Project Dredging Emissions (tpy)	Site Emissions % of Nueces County Emissions
NO_x	29,342	32,739	62,081	466	0.75
VOC	26,495	8,601	35,096	13.7	0.04
CO	119,655	9,465	129,120	107	0.08
SO_2	6,067	7,932	13,999	157	1.1
PM_{10}	41,227	1,748	42,975	13.6	0.03

TABLE 4.8-4

SUMMARY OF AIR EMISSIONS FROM MAINTENANCE DREDGING ACTIVITIES COMPARED WITH NUECES AND SAN PATRICIO COUNTY EMISSIONS FOR 1999

Air Contaminant	Area and Mobile Source (tpy)	Point Source (tpy)	Total (tpy)	Estimated Peak Project Dredging Emissions (tpy) *	Site Emissions % of Nueces County Emissions
NO_x	29,342	32,739	62,081	86.8	0.14
VOC	26,495	8,601	35,096	2.55	0.007
CO	119,655	9,465	129,120	121	0.09
SO_2	6,067	7,932	13,999	29.3	0.2
PM_{10}	41,227	1,748	42,975	2.53	0.006

* Assumes all maintenance dredging may occur in 1 year.

As shown on Table 4.8-3, construction dredging for the proposed project would result in an increase in emissions above those resulting from existing sources in the Nueces/San Patricio County area. Emissions of SO_2 may result in an increase of about 1.0 percent over existing area emissions. Emissions of NO_x, VOC, CO, and PM_{10} are expected to result in a less than 1 percent increase over existing emissions based on available air emissions inventory information provided on the EPA's AirData website (EPA, 2002b).

As shown on Table 4.8-4, emissions during maintenance dredging are estimated to contribute less than 1 percent to total existing emissions for these counties.

The TNRCC and EPA's air quality permitting program applies to stationary sources of air emissions, and would therefore, not apply to emissions from the dredging activities. However, emissions are expected to comply with the National Ambient Air Quality Standards and the rules and regulations of the EPA and the TNRCC promulgated in support of the State's State Implementation Plan.

4.9 NOISE

Under the No-Action alternative, noise would continue as described in Section 3.10.

Impacts to the noise environment from the proposed project would result primarily during construction and maintenance dredging activities. The noise associated with construction and maintenance activities of this project is difficult to quantify. Heavy machinery, the major source of noise in construction, would move along the project route as construction and maintenance activities proceeded; these levels would thus vary and be intermittent. However, construction normally occurs during daylight hours when occasional loud noises are more tolerable. Noise sensitive areas include residential areas at Ingleside-On-The-Bay and recreational areas in the vicinity of Port Aransas and the jetties. These areas range from 400 to 800 feet from the CCSC. None of the noise sensitive areas is expected to be exposed to the construction and maintenance dredging activities for a long duration; therefore, any extended disruption of normal activities is not expected. Provisions and specifications that require the contractor to make reasonable efforts to control construction and maintenance dredging noise will be included in all plans. Since maintenance dredging will not increase significantly in comparison with existing conditions, relative to present maintenance, noise from maintenance dredging is not expected to increase significantly with the preferred alternative.

4.10 SOCIOECONOMIC RESOURCES

The following sections address economic impacts from the construction and operations and maintenance (O&M) phases of the proposed project. The Methodology section provides details on how socioeconomic impacts were estimated based on project details, an input-output model approach, research, and interviews.

4.10.1 No-Action Alternative

Without the preferred alternative, the Corpus Christi area (Nueces and San Patricio counties) would continue on its present course of economic development and diversification, of moderate population growth, and of fairly rapid commercial, residential, and industrial land development. The PCCA would continue to function as an important port for its industrial facilities and international commerce. The PCCA would also continue to develop its industrial properties but at a slower rate than it would with the preferred alternative. The container terminal would not be built in its proposed location without the extension of the La Quinta Channel. Without the channel widening of the CCSC, safety concerns related to large vessel meetings would continue as would delays. Without the preferred alternative, the area would not take advantage of additional economic benefits related to the project in terms of an increase in the number of jobs, increased employee compensation, expanded indirect business taxes, increased value-added, and increased industrial housing development. No aesthetic or environmental justice impacts would occur with the No-Action alternative.

4.10.2 Methodology

Within the Socioeconomic Resources section, environmental consequences have been estimated through a variety of methods. One such method is qualitative analysis, which was conducted through review of government agency and private sector reports and other materials, review of local planning documents, research conducted over the internet, and through telephone discussions. Another technique includes quantitative analysis, through review of Census and economic data that pertains to the project study area. Also, a visual survey of the vicinity surrounding the proposed project area was conducted on August 16 and 17, 2001, as a source of information for land use analysis. The last technique (which is the main focus of this Methodology section) involves the use of an Input-Output Model for predicting project-related impacts to the economies of Nueces and San Patricio counties. A detailed discussion provided below outlines the approach taken by the Input-Output Model to estimate economic impacts within the two counties (Nueces and San Patricio) that encompass the project study area.

The analysis utilized a computer-based modeling program called Implan Professional (Version 2.0) (Implan). Implan uses industry and employment data from the target counties to predict indirect and induced effects from project implementation. This input-output model allows the analyst to develop a set of assumptions related to project details and predict how project-related expenditures would impact the economies of the target counties. The model predicts how dollars spent on the proposed project would affect specific industries within the regional economy as dollars are spent and re-spent locally. The results are expressed as indirect and induced impacts to employment, value-added, total output, the tax base, and employee compensation.

Indirect and induced impacts occur as goods and services are provided to the sectors that provide the goods and services directly for the industries that directly benefit from project-related expenditures. Value Added is a measurement of the value that is added to intermediate goods and services. It is equal to the total of employee compensation, proprietor income, other property income, and indirect business taxes. Total Output is a measure of the total value of purchases by intermediate and final consumers, or by intermediate outlays plus value-added. Employment impacts show the number of new jobs that would be created as a result of the project as project-related dollars are spent and re-spent within the regional economy, and new jobs are created in other industries within the target counties. Indirect business tax impacts measure the amount of local (county, city and other local taxing entities), and State sales taxes (combined) that would occur as a result of project-related expenditures.

Implan was used, along with specific proposed project-related information and a detailed set of assumptions, to predict the impacts. The details of the proposed project were analyzed to determine which portions of project-related expenditures would have an effect on the economies of the two counties. It was determined that expenditures on dredging of the CCSC and the extension of the La Quinta Channel, and O&M expenditures would have an impact on economic activity within Nueces and San Patricio counties only as a secondary effect. The secondary effects of the dredging work would occur through expenditures for fuel for the dredges and through local spending by dredge employees. The expenditures on dredge fuel and local economy expenditures by dredge employees represents a relatively small percentage (approximately 12 percent of annual construction costs, and 14 percent of annual O&M costs) of the overall construction and O&M costs. The remainder of the dredging construction costs would very likely leak out of the regional economy as the dredging contractors hired for this project (chosen through a competitive-bid process) would likely be based outside of Nueces and San Patricio counties.

However, non-dredging construction activities that are part of the proposed project are likely to be conducted by locally-based contractors and locally-based workers. These construction activities include bank stabilization, levee building, dock and pipeline modifications/relocations. Expenditures on these non-dredging construction activities represent approximately 44 percent of the proposed-project construction budget.

Employment, output, value-added, and indirect business tax impacts from the proposed La Quinta container ship terminal are considered beyond the scope of this FEIS. The proposed La Quinta container ship terminal is not part of the proposed project considered in this FEIS.

To predict project-related impacts to the economies of Nueces and San Patricio counties, research was conducted to gather detailed project-related information, and a set of assumptions was developed to further clarify the details. The assumptions involved discussions with Port of Corpus Christi personnel and other key persons, and review of relevant dredging industry information, information relating to the Nueces and San Patricio County economies, and historical USACE data (La Rue, 2001). Below is a list of key assumptions and project-related details that were used as a basis for predicting economic impacts. All dollars presented in the Socioeconomics section are presented in 2001 dollars.

- The construction phase of the proposed project would be conducted over a 5-year period (from 2003 to 2007) and would involve a total construction cost of $190 million.
- The O&M phase would occur over a 45-year period from 2008 to 2053. O&M would be conducted once every 2 years and would take 2 months of work each time. Total expenditures on O&M would be $107 million.
- All construction and O&M operations would be completed by two types of dredges: a pipeline dredge and a hopper dredge. The pipeline dredge would be used for about 90 percent of the work (for both construction and O&M) and would be used for all work except the entrance channel. The hopper dredge would perform approximately 10 percent of the work (for both construction and O&M) and would work only on dredging of the entrance channel. During both construction and O&M, the ships would work 18- to 20-hour days, with workers working in shifts.
- The pipeline dredge would employ 50 people, and these employees would make an average wage of $300 per day (including all benefits). The hopper dredge would employ 20 people, and these employees would make an average wage of $425 per day (including all benefits). All dredge employees would not need housing, since they would be housed on the ships. All dredge employees would spend an average of $1,500 per month on groceries, entertainment, clothing, and other goods and services

bought within Nueces and San Patricio counties. These expenditures would be 70 percent in Nueces County and 30 percent in San Patricio County.

- The pipeline dredge would use 10,000 gallons per day of diesel fuel. The hopper dredge would use 4,000 gallons per day of diesel fuel. The current price of this fuel is 80 cents per gallon, and the fuel would be provided by fuel barges based in the Port of Corpus Christi (Nueces County).
- Construction related to levee building, bank stabilization, dock and pipeline modifications/relocations would occur over a 5-year period and would be conducted by locally-based contractors and workers (60 percent from Nueces County and 40 percent from San Patricio County).

Based on these project-related details and assumptions, the following data were used with Implan to predict project-related impacts within Nueces and San Patricio Counties.

- During the 5-year construction phase, dredge employees would spend $1.3 million per year in Nueces County and $589,000 per year in San Patricio County on local goods and services. During the 45-year O&M phase, dredging ship employees would spend $63,500 per year in Nueces County and $30,000 per year in San Patricio County on local goods and services. These dollar amounts were applied to employee compensation (within Implan), and indirect, induced, and total impacts to the two counties were predicted.
- During the 5-year construction phase, $2.7 million would be spent annually on diesel fuel for the dredges. During the 45-year O&M phase, $231,000 would be spent annually on diesel fuel for the dredges. All fuel expenditures were applied to Implan sector #38, Natural Gas and Crude Petroleum, and applied to Nueces County only.
- During the 5-year construction phase, $16.7 million would be spent annually for the construction budget for bank stabilization (rip-rap), levee building (geotube), and dock and pipeline modifications/relocations. Approximately $3.3 million would be awarded annually to contractors that would be based in Nueces County, and approximately $2.2 million would be awarded annually to contractors that are based in San Patricio County. All non-dredging construction costs were applied to Implan industry sector #51, New Highways and Streets (which most closely represents these industries).

4.10.3 Population

Approximately 70 workers would be needed annually for the dredging portion of the proposed project. These dredge workers would have little effect on the capacity of local communities to provide adequate housing, schools, and other services. Most of these workers' essential needs would be provided on-board the dredges. An estimated 170 non-dredging construction workers would be needed annually for the proposed project. Most of the non-dredging construction workers (excludes indirect and induced employment) are likely to come from the labor force that is already living within the two counties. Inmigration to the Nueces County and San Patricio County area would be fairly minimal.

The total employment (direct, indirect, and induced) that would occur in the two counties (excluding the dredge workers) would likely cause a very small increase in population. In Nueces County, approximately 205 total jobs would be created annually during the 5-year construction period. This employment increase represents less than 0.1 percent of the year 2000 county population (pop. 313,645). During the 45-year O&M period, approximately 1 total job would be created annually in Nueces County. In San Patricio County, approximately 95 total jobs would be created annually during the 5-year construction period. This employment represents 0.1 percent of the year 2000 county population (pop. 67,138). During the 45-year O&M period, less than 1 total job would be created annually in San Patricio County.

The proposed project would produce a relatively small number of jobs during the short and long term and would not affect population growth beyond the capacity of the communities to provide adequate housing, schools, and services or otherwise adapt to growth-related social and economic changes. Also, there would be no displacement of residents or users of affected areas. There would be no project-related effects that would negatively affect community cohesion.

However, when the proposed project is completed, it is likely that new industrial development would occur within the Inner Harbor and along the north side of Corpus Christi Bay. The deeper and wider ship channels would provide an additional benefit to industry, which would likely attract new companies to locate within the Corpus Christi Bay area. New industrial development would likely include petrochemical plants, bulk grain facilities, petroleum and natural gas refineries. Also, with the extension of the La Quinta Channel, there is a strong likelihood that a container ship terminal would be built on the land adjacent to the end of the channel extension (La Rue, 2001). The impact of these new industries on population growth (mostly through in-migration) within the two counties should be considered to be substantial. Reasonable, foreseeable, future actions are discussed in Section 5.0. If new industrial facilities are built as an indirect result of the proposed project, it is likely that a substantial increase in single-family homes would occur in San Patricio County (within and near the cities of Portland, Gregory, Ingleside, and Aransas Pass) where vacant land is available for such development and is located near such available industrial sites. Also, some new housing development would likely occur within the City of Corpus Christi (especially on the west side, along the IH 37 corridor). This increase in new residents within the two counties would also substantially increase the demand for commercial development, schools, roads, and other services.

4.10.3.1 Life, Health, and Safety

The channel widening aspect of the proposed project would provide relief of safety concerns and the associated vessel delays for ships traveling through the CCSC. Currently, the Port Aransas-Corpus Christi Pilots limit vessel meetings to combined beam width of 251 feet in the 400-foot reach. Additional criteria are that meetings are not permitted between vessels with combined loaded drafts in excess of 80 feet, and that vessels should have 3 feet of underkeel clearance. The proposed project to widen the CCSC to 530 feet and to deepen it to 52 feet would easily accommodate the vessels that are forecasted to use the CCSC, in a safe manner, and with minimal delays.

4.10.4 Employment

All dredging construction work would be performed over a 5-year period, from 2003 to 2007. Approximately 70 full-time dredge workers would be needed for the duration of this construction period. Of these 70 workers, approximately 50 full-time workers would be necessary for operations of a pipeline dredge (or cutter head dredge), and approximately 20 full-time workers would be needed for the operations of a hopper dredge. Indirect and induced employment would occur within the two counties as dredge workers spend some of their disposable income locally and as operation of the dredges would necessitate expenditures on fuel that would be purchased from firms located in Nueces County (based in the Inner Harbor).

Within Nueces County, annual dredging worker expenditures would be approximately $1.2 million, and annual fuel expenditures would be approximately $2.6 million. From these local expenditures, indirect and induced job creation would result in approximately 40 new jobs annually, or 200 labor-years of employment during the 5-year construction period. Total employee compensation in Nueces County would be an estimated $1,021,000 annually, or $5,105,000 during the 5-year period. In San Patricio County, annual dredging worker expenditures would be approximately $589,000. From these local expenditures, indirect and induced job creation would result in approximately 5 new jobs annually, or approximately 20 labor-years of employment during the 5-year construction period. Total employee compensation in San Patricio County would be an estimated $71,500 annually, or $357,500 during the 5-year period.

Non-dredging construction jobs would likely be filled by locally-based construction companies and workers. During the 5-year construction period, approximately 175 full-time workers would be required to complete this work (within the two counties), and construction expenditures would be approximately $16.6 million (or $83 million for the 5-year period). In Nueces County, these construction expenditures would create approximately 165 total jobs (includes direct, indirect, and induced jobs) annually, or approximately 825 total labor-years of employment during the 5-year period. Total employee compensation in Nueces County would be an estimated $4.1 million annually, or $20.5 million during the 5-year period. In San Patricio County, these construction expenditures would create approximately 90 total jobs (includes direct, indirect, and induced jobs) annually, or approximately 450 total labor-years of employment during the 5-year period. Total employee compensation in San Patricio County would be an estimated $2.7 million annually, or $13.5 million during the 5-year period.

Dredging O&M activities would occur approximately every 2 years and would last for approximately 2 months, during the 45-year O&M phase. During these 2-month periods, approximately 70 full-time dredge workers would be required. It is likely that the dredging companies and workers hired for this work would not come from the two counties.

Within Nueces County, annual O&M dredge worker expenditures would be approximately $63,500 and annual fuel expenditures would be approximately $230,800. From these local expenditures, indirect and induced job creation would result in approximately 1 new job annually, or approximately 45 labor-years of employment during the 45-year O&M period. Total employee compensation in Nueces County would be an estimated $17,300 annually, or $778,500 during the 45-year period. In San Patricio County, annual O&M worker expenditures would be approximately $30,000. From these local expenditures, indirect and induced job creation would result in less than one job annually, or approximately 10 labor-years of employment during the 45-year O&M period. Total employee compensation in San Patricio County would be an estimated $3,600 annually, or $162,000 during the 45-year period.

The industries that would benefit directly (in terms of employment) from the proposed project during the construction and O&M phases would be dredging contractors and other construction contractors that would be involved in non-dredging activities. Indirect and induced jobs created within the two counties would occur primarily in the following industries: Natural Gas and Crude Petroleum, Eating and Drinking, Miscellaneous Retail, Hospitals, Food Stores, Real Estate, Wholesale Trade, General Merchandise Stores, Auto Dealers and Service Stations, Banking, and Doctors and Dentists.

When the proposed project is completed, it is likely that new industrial development would occur within the Inner Harbor and along the north side of Corpus Christi Bay. The deeper and wider ship channels would provide an additional benefit to industry, which would likely attract new companies to locate within the Corpus Christi area. With the new channels in place, it would be more likely that new petrochemical plants, bulk grain facilities, petroleum and natural gas refineries would be built within the area. Also, with the extension of La Quinta Channel, it is very likely that a proposed container ship terminal would be built (La Rue, 2001). The impact of these new industries on employment within the two counties is unknown but would likely be substantial. This increase in employment may substantially increase the rate of inmigration, the demand for housing, schools, and other services within the two counties.

In summary, the proposed project would create approximately 370 total new jobs (direct, indirect, and induced employment) annually, or 1,850 labor-years of employment during the 5-year construction period. However, at least 70 of these would likely be filled by workers from outside the two-county area. During the O&M phase of the proposed project, approximately 71 total new jobs would be created annually, or approximately 3,195 labor-years of employment throughout the O&M phase. However, 70 of these total jobs would likely be filled by workers from outside the two counties.

Within Nueces County, all construction activities associated with the proposed project would create approximately 205 total jobs (direct, indirect, and induced jobs) annually, or 1,025 labor-years of employment during the 5-year construction period. This would represent a 0.1 percent impact on Nueces County annual employment. Employment associated with dredging during the 45-year O&M period would create approximately 1 job annually, or 45 labor-years of employment during the 45-year O&M period. This would represent a less than 0.1 percent impact on Nueces County employment.

Within San Patricio County, all construction activities associated with the proposed project would create approximately 95 total jobs (includes direct, indirect, and induced) annually, or 475 labor-years of employment during the 5-year construction period. This would represent a 0.6 percent impact on San Patricio County annual employment. Employment associated with dredging during the 45-year O&M period would create less than 1 total job annually, or approximately 10 labor-years of employment during the 45-year O&M period. This would represent a less than 0.1 percent impact on San Patricio County employment.

4.10.5 Economy

Economic effects to the Nueces County and San Patricio County economies would be moderate at the least, and substantial at best. Much of the construction budget would likely leak from the local economy, as construction dollars spent on dredging work would likely go to dredging companies that are located outside of the local economy. However, it is anticipated that most of the non-dredging subcontractor work would be done locally, dredge workers would spend some of their disposable income locally, and dredge fuel would be purchased locally. Based on these assumptions, the following economic effects would accrue within Nueces and San Patricio counties.

In Nueces County, dredge employee expenditures and fuel expenditures would result in a total output (direct, indirect, and induced) effect of approximately $5.9 million on the county economy, or a $29.5 million effect for the 5-year construction period. These same expenditures would result in a total value-added effect of approximately $3.2 million on the county economy, or a $16 million effect for the 5-year construction period.

In San Patricio County, dredge employee expenditures would result in a total output effect of approximately $555,000 on the county economy annually, or a $2.8 million effect for the 5-year construction period. These expenditures would result in a total value-added effect of approximately $142,000 on the county economy, or a $710,000 effect for the 5-year construction period.

Within Nueces County, annual O&M dredge worker expenditures would result in a total output effect of approximately $76,000 on the county economy annually, or a $3.4 million effect for the 45-year O&M period. These expenditures would result in a total value-added effect of approximately $32,500 on the county economy annually, or a $1.5 million effect for the 45-year construction period.

Within San Patricio County, annual O&M dredge worker expenditures would result in a total output effect of approximately $3,600 on the county economy annually, or a $162,000 effect for the 45-year O&M period. These expenditures would result in a total value-effect of approximately $7,200 on the county economy, or a $324,000 effect for the 45-year construction period.

In Nueces County, during the 5-year construction period non-dredging construction expenditures would result in a total output effect of approximately $15.3 million on the county economy annually, or a $76.5 million effect for the 5-year construction period. These expenditures would result in a total value-added effect of approximately $7.0 million on the county economy, or a $35.0 million effect for the 5-year construction period. In San Patricio County, during the 5-year construction period construction expenditures would result in a total output effect of approximately $8.1 million on the county economy annually, or a $40.5 million effect for the 5-year construction period. These expenditures would result in a total value-added effect of approximately $3.3 million on the county economy, or a $16.5 million effect for the 5-year construction period.

4.10.5.1 Historical Perspective/Community Growth

Within Nueces and San Patricio counties, the social and economic effects accruing from the proposed project would simply contribute to the current development trends that have historically affected the regional economy. The increase in jobs, economic output, and the tax base would be fairly moderate and consistent with historical growth trends. The Port of Corpus Christi and its associated industries and international commerce currently serve an important role for the Corpus Christi area economy. These industries provide jobs, income, and a tax base for the area, and the effects reverberate within other industries such as housing, retail services, and wholesale trade. The proposed project would likely provide a boost to the development of industrial sites along the Inner Harbor and in San Patricio

County, near the cities of Portland, Ingleside, and Aransas Pass. Larger ships would be able to navigate the CCSC; providing cost savings for commercial vessels. In short, the Port of Corpus Christi would become a more attractive location for companies involved in industry and international commerce to conduct their business. This goal would be consistent with a steady historical trend towards increased reliance on these industries and these types of development within the region.

4.10.5.2 Tax Base

Within Nueces County, all construction activities associated with the proposed project would result in a total (direct, indirect, and induced effects) indirect business tax impact effect of approximately $745,000 on the county economy annually, or a $3.7 million effect for the 5-year construction period. During the O&M period, dredging-related expenditures would result in a total indirect business tax effect of approximately $3,000 on the county economy annually, or a $135,000 effect for the 45-year O&M period.

Within San Patricio County, all construction activities associated with the proposed project would result in a total indirect business tax impact effect of approximately $151,000 on the county economy annually, or a $755,000 effect for the 5-year construction period. During the O&M period, dredging-related expenditures would result in a total indirect business tax effect of approximately $700 on the county economy annually, or a $31,500 effect for the 45-year O&M period.

4.10.6 Land Use

The proposed project would have a very minimal impact on land use. Neither the CCSC channel improvements nor the La Quinta Channel extension would affect any shoreline land uses. All channel improvements would occur in open-water locations. The only land use implications for the proposed project relate to proposed DMM/BU sites (see sections 1.6 and 2.2.2) and indirect future land development that may occur as a result of the proposed project.

The BU sites would be created from dredged material in seven open-water locations near the Entrance Channel, and in Corpus Christi Bay and Redfish bays (see Figure 1-3). These BU areas would vary in their design but would generally consist of shallow water aquatic habitat areas surrounded by wave breaks created from construction material. The BU sites are located in areas of open water that would not create significant conflicts with recreational or commercial boating or other uses. The BU sites would positively impact the commercial and recreational boating and fishing industries or other uses, as they would create habitat for fledgling fish and other aquatic species leading to an increase in their populations. Each BU site is discussed briefly below in the Aesthetics section, and in more detail in Section 1.6.

The greatest long-term land use consequence of the proposed project would likely be a change in future land uses that would occur in response to the improvements to the CCSC and the extension of the La Quinta Channel. These future land uses are not considered part of the proposed project but would be far less likely to occur without it. The PCCA currently owns property along the Inner Harbor, along the north side of the Corpus Christi Bay, Harbor Island, San Jose Island, and along the western shoreline of Redfish Bay that is available for development for industrial sites. When the proposed project is completed, the PCCA would have the deepest and widest ship channel along the Gulf of Mexico coast, providing a large incentive for new industrial development at all of the PCCA properties, based on navigation cost savings. Future industrial development may include oil and gas refineries, petrochemical plants, bulk grain facilities, offshore oil-platform construction companies, and/or a container terminal (La Rue, 2001). The long-term land use effects of these industrial facilities are largely unknown (and beyond the scope of this report); however, they would likely lead to a substantial increase in demand for new housing development, new roads, commercial services, schools, and other services within the two-county area. Below is a brief discussion of the possible land use implications of the proposed container terminal.

The PCCA has outlined, in its "La Quinta Gateway Preliminary Master Plan," a proposal for a container terminal to be located on an 1,100-acre tract of land known as the La Quinta property, and located adjacent to the proposed La Quinta Channel extension. The proposed container terminal site is bordered by the Sherwin Alumina plant to the east, and SH 361 to the north, and is between the cities of Portland (to the west) and Ingleside (to the east). The proposed project includes a containerized cargo marine terminal, consisting of a 295-acre marine terminal, 3,800 linear feet of wharf, nine gantry cranes, a 75-acre intermodal rail terminal, and a 127-acre buffer zone. The container terminal project would also require expanded road and rail capacity within the general area. Indirect consequences of the proposed container terminal would be an increase in demand for new housing development, new roads, commercial services, schools, and other services mostly within San Patricio County (within Portland, Gregory, Ingleside, and Aransas Pass) and, to a lesser extent, in Nueces County (PCCA, 2001b).

4.10.6.1 Aesthetics

The proposed project would have a minimal effect on the overall visual quality within the study area. There would be no significant effect to the appearance of the shorelines that are adjacent to the proposed channel improvements. Existing PAs, as discussed in Section 2.2.2, utilized for maintenance dredged material will not affect the visual quality of the study area. The only aspects of the proposed project that would affect the visual quality of the study area would be the BU areas.

BU Site GH consists of an armored levee and shallow water habitat. The shoreline areas that are closest to this BU site are existing industrial sites and areas that are slated for future industrial development. The BU site would also be visible from the Northshore Golf Course and other subdivisions along the southeastern shore of the City of Portland.

BU Site CQ would consist of a shallow lagoon area bordered on three sides by a rock breakwater. This feature would be visible looking southwest from homes and the marina located along the shoreline of Ingleside-On-The-Bay, but would not block views of other portions of the Corpus Christi Bay.

BU Site P would be a rock breakwater, visible from homes facing south along the Ingleside-On-The-Bay shoreline.

BU Site I consists of a triangular-shaped lagoon area (mix of open water, shallow water, and high marsh habitat), bordered on two sides by a breakwater/shore protection berm in Redfish Bay.

This feature would be directly visible from the Ingleside shoreline, which consists of industrial land uses in this area.

BU sites R and S consist of C-shaped armored wave breaks on the perimeter of shallow lagoon areas. These beneficial use areas would not be visible from the Ingleside-On-The-Bay shoreline but possibly would be visible from much more distant shorelines along the western shore of Mustang Island.

BU Site Pelican consists of a geotube breakwater and shoreline armor. This site will receive periodic maintenance material to maintain the existing rookery island. No impact to the visual quality of the area is expected.

BU Site L would consist of a shoreline protection armor on the south shore of the channel near Port Aransas to protect existing shoreline and habitat. This site will be visible from the channel and industrial sites at Harbor Island, as well as the county pier near Port Aransas.

BU Site E is an upland site northwest of the La Quinta Channel extension. It was requested by area residents as a buffer between the Northshore Golf Course and the proposed Gateway Terminal. Therefore, it will provide a benefit to the aesthetics of the area.

BU Site ZZ is completely submerged and would have no impact on the visual quality of the area.

BU site MN is completely submerged and would have no impact on the visual quality of the area.

4.10.6.2 Community Services

The proposed project would not affect the delivery of local services, including water, wastewater, or other utilities. No disruption to roads or rail transportation would result from the preferred alternative. The preferred alternative would result in no changes in traffic demand on local roads or highways and would not affect the delivery and quality of local services to the population living within the vicinity of the study area.

4.10.7 Environmental Justice

Within the study area, ethnicity and poverty figures are generally consistent with those of the region, with only a few notable exceptions. For example, there are seven of thirty-two census tracts within the study area, where the percentage of ethnic minorities is substantially higher than in either county or the state. Also, there are five census tracts within the study area where the percentage of the population living below the poverty line is substantially higher than for either county or the state. Therefore, the study area does have some areas that have disproportionately high percentages of ethnic minorities and persons of poverty status. However, this does not constitute a disproportionate impact under Executive Order 12898, as there are no disproportionately high and adverse human health or environmental effects that would accrue to these populations. The minority populations living within these census tracts would likely experience no adverse changes to the demographic, economic, or community cohesion characteristics within their neighborhoods as a result of the proposed project. Also, there would be no physical changes to the environment or to land use within these census tracts. Generally speaking, the population living within these census tracts would benefit from the proposed project. These benefits would be manifested mainly in a slight increase in economic output, value added, jobs, and tax base within these communities.

No low-income or minority populations have been identified to experience disproportionately high and adverse human health or environmental effects as a result of the preferred alternative.

4.11 ANY ADVERSE ENVIRONMENTAL IMPACTS WHICH CANNOT BE AVOIDED SHOULD THE PREFERRED ALTERNATIVE BE IMPLEMENTED

The preferred alternative will result in adverse impacts to the benthos and fish of Corpus Christi Bay from dredging and placement of dredged material at the BU sites. Five acres of seagrass will also be impacted during construction. However, the BUW and the RACT determined that the BU sites will potentially provide higher value habitat; the impacted seagrasses will be mitigated by the creation of 15 acres of new seagrass area. Shoreline protection will provide benefits to existing marsh and seagrass habitats.

4.12 ANY IRREVERSIBLE OR IRRETRIEVABLE COMMITMENTS OF RESOURCES INVOLVED IN THE IMPLEMENTATION OF THE RECOMMENDED PLAN

The labor, capital, and material resources expended in the planning and construction of this project are irreversible and irretrievable commitments of human, economic, and natural resources. The loss of 5 acres of seagrass from extending the La Quinta Channel is irreversible; however, this loss will be compensated in a mitigation plan prepared and accepted by the RACT. Deep-water bay bottom loss due to deepening and widening the channel, construction of barge lanes, and extension of La Quinta will be irretrievably lost.

4.13 RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

The preferred alternative would eliminate approximately 45 acres of shallow-water bay bottom including 5 acres of seagrass during construction of the channel and approximately 40 acres of bay bottom. Productivity of the sites removed during construction would be permanently lost from the ecosystem, while much of the bottom buried during construction of the BU sites will recover or be transformed into more productive seagrass habitat. The 5 acres of seagrass lost during construction will be mitigated by the construction and planting of 15 acres of seagrasses in BU Site GH. However, there will be a time lag before the BU sites become established and ecologically functional. There will be a temporary loss of productivity during that interim period. Creation of the BU site will, over the long-term, provide substantial long-term gains in productivity of the Corpus Christi Bay system.

4.14 MITIGATION

The Mitigation Workgroup (MW) was formed to assess the unavoidable direct impacts to productive estuarine habitats due to the preferred alternative and to propose the mitigation for those unavoidable impacts. Based on the conclusions of the RACT and MW, the USACE determined that impacts to seagrass and bottom shallower than –4 feet MLT (potential seagrass habitat) would be mitigated.

Impacts to estuarine habitats are estimated to be 45 acres of bottom shallower than –4 feet MLT. All potential direct impacts would be due to the proposed La Quinta Channel extension and a minimal area (less than 0.05 acre) on the western shoulder of PA 10. Eight of the 45 acres are located along the south side of the extension near PA 13. The balance, 37 acres, is located farther west along the north side of the channel extension and the new turning basin. An estimated 5 acres of seagrass vegetation are included in the total 45-acre estimate. The seagrass vegetation is predominantly shoalgrass and occurs within an 8-acre area located on the south side of the extension near PA 13. No impacts to bay bottom shallower than –4 feet MLT were identified at any other location within the proposed deepening, widening, and channel extension project or the proposed barge shelf.

Of the 45 acres of shallow-water habitat (>–4.0 feet MLT) that will be removed during project construction, 5 acres consist of seagrass habitat and 40 acres consist of shallow, unvegetated bay-bottom habitat. According to ER 1105-2-100, wetland resources must be fully mitigated to meet the administration's goal of no net loss of wetlands. Also, the significance of the resource shall be established based on monetary and non-monetary values. Seagrass is a significant resource based on non-monetary criteria, such as scarcity on a national or regional scale and institutional and public recognition of the ecological and aesthetic attributes.

While it may be argued that seagrass and shallow, nonvegetated bay-bottom habitat is not considered a wetland habitat, the FWS (1979) determined that wetland and subtidal aquatic habitat (seagrass) must be considered together in an ecological system. Furthermore, the FWS has a strong interest in preserving seagrass habitat because their policy designates this habitat as Resource Category 2 which is high value habitat for estuarine and marine species that is relatively scarce on a national scale or in the ecoregion. Their mitigation policy for this resource category is no net loss of in-kind habitat value.

In addition to resource agency recognition of seagrass habitat as a significant resource, the public has repeatedly expressed a strong desire to maintain and expand seagrass beds in the Corpus Christi Bay system. Evidence of this was provided by the Coastal Bend Bays & Estuaries Program (CBBEP) which has noted the public's desire for providing more of this valuable resource during their coordination efforts under the National Estuarine Program. More recent evidence was provided by the project non-Federal sponsor, which also recorded high public interest in protecting and expanding this resource during numerous project public meetings.

Seagrass habitat is important to the estuarine ecosystem in the project area, because the Corpus Christi Bay system is located in a region of relatively low rainfall, high evapotranspiration, and has limited freshwater inflow. As a result of these limitations, there are few areas of emergent marsh (traditional wetland habitat) that can serve as nursery habitat and food source for many estuarine and marine species. Seagrass beds generally serve this purpose, but are restricted to shallow, clear, protected waters. Corpus Christi Bay, especially in the project area, does not provide optimal seagrass habitat because it is a relatively deep bay subject to high southeast winds for much of the year that create turbid conditions along the south facing shorelines. Therefore, seagrass beds are a relatively scarce resource in this area that should be preserved to the extent practicable. If preservation is not possible, loss of this resource should be fully mitigated.

The proposed La Quinta Channel Extension has been aligned to avoid most of the seagrass beds, leaving only 5 acres of loss to be mitigated in-kind. The 40 acres of shallow, nonvegetated bay-bottom habitat does not have as high a habitat value and can be mitigated out-of-kind, if necessary.

Based on requirements for in-kind mitigation for seagrass losses, the project area has little to offer for traditional mitigation in-kind. There are three possible options available: (1) buy nearby, privately-owned upland shoreline, scrape it down to the same elevation as the existing habitat, and transplant seagrass in the site; (2) scrape down upland habitat in the nearby fully confined PA 13 to the same elevation as the existing habitat and transplant seagrass in the site; or (3) transplant seagrass into the nearby BU Site GH being constructed with new work material dredged from the La Quinta Channel extension.

During coordination with the RACT and MW, the USACE determined that the third option was the most feasible for this project. The first option was not feasible because of the cost of the waterfront land and site preparation. The site consists of a high bluff facing the bay and would require removal of about 712,000 cy of material. More importantly, there is no assurance that landowners would be willing sellers since waterfront property possesses a high commercial or residential development value. Even though there is no land acquisition fee associated with the second option, it is even less viable since all of the capacity remaining in the fully confined PA 13 is needed for maintaining the La Quinta Channel throughout the 50-year life of the project.

The RACT and MW, which include the non-Federal sponsor and USACE, concluded the best mitigation plan would be to transplant seagrass into BU Site GH that would provide the necessary protected, shallow-water habitat. The USACE, in close coordination with the RACT and MW, determined that because it will take time for the transplanted seagrass to develop the same density and provide habitat values equivalent to natural seagrass beds, a ratio of 3:1 would be used for mitigation. This is a common ratio used by the resource agencies in other mitigation actions. This equates to transplanting a 15-acre seagrass bed inside BU Site GH as compensation for 5 acres of seagrass lost to project construction. To ensure success of the mitigation plan, the USACE, in close coordination, with the RACT and MW, prepared a seagrass monitoring plan with success criteria to use in evaluating the progress in seagrass development. This plan is described below.

MITIGATIVE PROCEDURES/CONDITIONS FOR SEAGRASS TRANSPLANTING EFFORTS

1. After final construction of beneficial use Site GH and following a sediment conditioning time of at least 90 days, an appropriate location for the mitigation will be selected within the eastern portion Site GH, and the mitigation area will be planted with shoal grass (*Halodule wrightii*). Prior to mitigation site selection or planting, a survey will be performed in the candidate mitigation site area to determine the topographic condition and elevation of the deposited material. If excessive relief is encountered then planting will occur after a subsequent survey indicates that the topographic relief, elevation and sediment stability is conducive to shoal grass transplant survival. Prior to conducting planting, the USACE (the Federal sponsor) will coordinate the results of the survey(s) and sediment stability appraisal(s) with the USACE, FWS, TPWD, NMFS and the non-Federal sponsor.

   If the topographic and elevation survey or sediment stability appraisal is determined to be unsuitable for seagrass growth, then the proper course of action will be taken after coordination has taken place. Agency recommendations may include allowing for additional site conditioning time prior to conducting a full scale planting of the site, relocation of the planting effort within the candidate mitigation area, grading of the area, or even conducting a pilot planting effort.

2. Transplant source areas will be identified and applicable permits obtained from the TPWD and/or GLO and/or private landowners. Staking of the approved transplant harvest areas will be in accordance with applicable permits.

3. Shoalgrass planting may be conducted between mid-March and mid-June, or between mid-September and mid-October. Plantings outside of these times will need to be coordinated between the USACE, FWS, TPWD, NMFS and non-Federal sponsor at least two weeks prior to commencement of those plantings. The transplanting technique will be coordinated with the USACE, NMFS, FWS, TPWD and the non-Federal sponsor when the specific location and configuration of the mitigation site is being established. Initial shoalgrass planting shall be completed within one year of completion of the mitigation site or during the first suitable planting time following determination that site is conducive to transplant survival. The location of the mitigation site will be marked by PVC pipe.

4. A planting unit will consist of live shoalgrass material contained in a 3-inch-diameter plug. No more than three 3-inch plugs of source material per square yard will be obtained from the designated transplant source areas. Incidental damage to source areas will be avoided. Alternate harvest techniques may be considered but they will require prior coordination with USACE, NMFS, FWS, TPWD and the non-Federal sponsor and, as necessary, permitted through TPWD and/or GLO and/or private landowners.

5. A transplant survival survey of the planted site will be conducted between 60 and 90 days after completion of the initial planting effort. Using acceptable survey methods, a minimum of 15 percent of all transplant units will be surveyed for the initial transplant survival survey. A written report detailing the survival results shall be submitted to the USACE within 30 days of survey completion. The report will be distributed by the USACE to the NMFS, TPWD, FWS and non-Federal sponsor. If at least 50 percent survival is not achieved, then the resource agencies shall be consulted to determine if the site should be modified prior to initiating a replanting

effort. If it is determined that site modifications are not necessary and that the site should be replanted, then replanting shall commence within 30 days (or within the next suitable planting period) once the agency-coordinated decision to replant the site has been made.

6. At least six transects will be established for the purposes of pre-construction, pre-plant plant elevation, or existing-bed condition surveys, and for post-planting monitoring surveys. The ends of each transect will be marked by PVC pipe. More transects may be established depending on the size or shape of the site selected, the transplanting plan and/or planting schedule. A minimum of two transects outside of the mitigation site in nearby seagrass beds and a minimum of four transects which cross the mitigation site is to be established and surveyed. The number and configuration of transects within the planting area will be coordinated with the USACE, NMFS, FWS, and TPWD and non-Federal sponsor after the size and configuration of the mitigation site has been established.

7. All transects located within the mitigation site shall be surveyed post-planting, at 6 months, 1 year, 2 years, and 3 years to determine success of mitigation. To determine success, three samples will be taken at 10-foot intervals along the transects; one on the interval and one three feet to each side of the interval. Seagrass will be identified to species. Coverage of seagrasses will be to species and will be calculated by using the frequency of occurrence of live seagrass at each sample along the transect. In addition to the percentage of vegetative cover, the monitoring surveys at all transects will note water depths (elevation) and any unusual sediment variations or other deposits.

8. If 2 years following planting the mitigation site is not as least 70 percent covered with shoalgrass, an additional planting effort will be made and those areas of the site not vegetated will be replanted to original specifications. The occurrence of manatee grass, if any, can be included in meeting the 70 percent coverage requirement.

9. The mitigation effort will be considered successful if the mitigation site is 70 percent covered by shoalgrass and/or manatee grass within three years following shoalgrass planting and if at least 48 percent of the total vegetative coverage is shoalgrass. If the mitigation is determined to be unsuccessful at the end of the three-year monitoring period, the Federal sponsor will be required to consult with the USACE, NMFS, FWS, TPWD and the non-Federal sponsor in order to determine if corrective measures are warranted. If it is apparent that the site is unlikely to support seagrass vegetation then a determination may be made to re-locate the mitigation project.

10. Some seagrasses currently exist nearby the proposed beneficial use Site GH. The survey of the transects established outside the mitigation area will be performed prior to constructing Site GH. The survey shall use a survey method similar to that used for the transects within the mitigation area and will also obtain information on the areal extent of the existing grassbeds. One purpose of the survey in the nearby seagrass beds is to obtain data to aid in the selection of the planting area within the mitigation site. This survey will be repeated within 30 days of completing construction of those portions of Site GH that could reasonably affect the existing nearby seagrass beds. If the survey results show that impacts have occurred to the existing seagrass beds, then the results will be provided within 30 days of completion of the survey to the USACE, TPWD, FWS and NMFS and the non-Federal sponsor. These agencies will

be consulted in order to determine an appropriate course of action to restore and/or mitigate the impacts.

11. The Federal sponsor will prepare monitoring reports detailing all required surveys. These monitoring reports will be submitted to the FWS, TPWD, and NMFS and non-Federal sponsor within 60 days of survey completion.

The mitigation plan also provides compensation for the loss of 40 acres of shallow, nonvegetated bay-bottom habitat in the 200-acre BU Site GH. Since this habitat is not considered to have as high a value as seagrass habitat, a ratio of 1:1 was used for compensation. This mitigation will be considered complete once the 40 acres of the 200-acre BU Site GH is constructed. There is no additional cost to construct the BU site that can be attributed to this mitigation plan since the BU site was designed to contain the remaining material from the proposed channel extension after completing upland BU Site E and stockpiling stiff clay material for future use in raising the levees in PA 13.

ER 1105-2-100 also requires that an incremental cost analysis of all recommended mitigation plans be performed to display variation in costs and identify and describe the least cost plan so that rational decisions regarding mitigation can be made. However, since only one feasible plan (as described above) is available that meets all mitigation requirements and is acceptable to the USACE, in close coordination with the RACT and MW, an incremental cost analysis is not possible. An alternative to the structured incremental cost analysis for seagrass mitigation that will provide a cost comparison for justifying the recommended plan is to calculate the costs for Options 1 and 2 and compare them to the cost for Option 3. This comparison is presented in Table 4.14-1. A cost analysis for mitigating shallow, nonvegetated bay bottom is not needed since there is no cost associated with designating this mitigation as part of BU Site GH.

TABLE 4.14-1
COST COMPARISON OF THREE OPTIONS TO MITIGATE THE
LOSS OF SEAGRASS DUE TO PROJECT CONSTRUCTION

Cost Factors (in dollars)	Option 1	Option 2	Option 3
Acquire Land	225,000	0	0
Acquisition Fees	12,000	0	0
Scrape Down/Prepare Site	5,340,000	2,040,400	0
Survey Elevations	58,000	58,000	0
Shoreline Protection	490,000	490,000	0
Transplant Seagrass on 15 Acres	67,500	67,500	67,500
Monitor Site for 3 Years	50,000	50,000	50,000
Total Cost	6,242,500	2,705,500	117,500

As shown in Table 4.14-1, Option 3 is the most economical mitigation plan of the three possible mitigation plans identified in the area. Options 1 and 2 have higher costs due to cost of acquiring privately owned land (Option 1) and the amount of material that must by removed to create a seagrass habitat. Option 2 has no acquisition fee since it would be constructed inside PA 13, which is owned by the non-Federal sponsor through a State land patent. Another cost identified for Options 1 and 2, but not included in Option 3, is shoreline protection needed to provide a sheltered environment for seagrass growth. Seagrass transplanted into BU Site GH in Option 3 will be protected by a geotube/riprap barrier incorporated into the BU site design. The monitoring cost identified for all three options include only surveys to document seagrass survival and does not include any retransplanting costs, if needed. Therefore, Option 3 is the most economical and acceptable plan for mitigating the loss of seagrass during project construction.

Most of the in-bay BU sites will be protected from erosion by breakwaters and islands and should also be further stabilized by natural colonization by seagrasses, *Spartina*, and other estuarine organisms. The existing open-water, unconfined PAs are dispersive and the remainder are UCPAs, releasing no dredged material back into the environment, except small amounts as suspended solids. The offshore sites are dispersive, but BU Site MN and the topographic relief feature at BU Site ZZ are designed to provide variable elevation bottom structure providing in-place mitigation for lost bottom habitat.

Nonmotile organisms occurring in the sediments in the areas to be dredged will be placed in PAs or BU sites and will likely be buried. Benthos at the BU sites, existing open-water PAs, and the offshore sites will be buried during placement. However, the BU sites are designed to create more diverse habitat than presently exists in the deep-water, open-bay areas, providing in-place mitigation, and benthos at all open-water sites should rapidly recover to pre-placement conditions (Ray and Clarke, 1999).

4.15 ENERGY AND NATURAL OR DEPLETABLE RESOURCE REQUIREMENTS AND CONSERVATION POTENTIAL OF VARIOUS ALTERNATIVES AND MITIGATION MEASURES

NEPA regulations in 40 CFR 1502.16 (e) and (f) requires a discussion of project energy requirements and natural or depletable resource requirements, along with conservation potential of alternatives and mitigation measures in an EIS.

Under the No-Action alternative, the energy requirements for maintaining the channel will continue as before. However, the navigation requirements for energy (fuel) to transport commercial products will increase in the future as commerce increases and more one-way traffic increases congestion and navigation time into and out of the port. Air quality impacts are likely to increase with an increase in navigation traffic congestion and travel time along the channel.

The recommended alternative is expected to reduce energy (fuel) requirements for transporting products on a ton/mile basis by deepening and widening the channel. Ships can be more heavily loaded with cargo and two-way traffic in the channel will decrease congestion and reduce transit time into and out of the port.

Energy (fuel) will be required to construct the improved channel, but this is a short-term impact. Energy to maintain the improved channel is expected to increase slightly with the small increase in shoal material expected for the larger channel. This increase in fuel requirement is expected to be more than offset by fuel savings in ship traffic in the larger channel and should help reduce air quality impacts slightly over the No-Action alternative.

Increased efficiency in moving petroleum and other petroleum-based commodities to the local refineries is expected to help conserve natural or depletable resources in the future. The reduced energy requirements will result in lower (or at least a smaller increase in) transportation costs in the future, which reduces overall production costs for the consumer.

5.0 CUMULATIVE IMPACTS

5.1 INTRODUCTION

Cumulative impact has been defined by the President's Council on Environmental Quality (CEQ) as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or persons undertakes such action." Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time. Impacts include both direct effects, which are caused by an action and occur at the same time and place as the action, and indirect effects, which are also caused by the action and occur later in time and are farther removed in distance, but which are still reasonably foreseeable. Ecological effects refer to effects on natural resources and on the components, structures, and functioning of affected ecosystems, whether direct, indirect, or cumulative.

In assessing cumulative impact, consideration is given to (1) the degree to which the proposed action affects public health or safety, (2) unique characteristics of the geographic area, (3) the degree to which the effects on the quality of the human environment are likely to be highly controversial, (4) the degree to which the possible effects on the human environment are highly uncertain or involve unique or unknown risks, and (5) whether the action is related to other actions with individually insignificant, but cumulatively significant impacts, on the environment.

Cumulative effects can result from many different activities including the addition of materials to the environment from multiple sources, repeated removal of materials or organisms from the environment, and repeated environmental changes over large areas and long periods. More complicated cumulative effects occur when stresses of different types combine to produce a single effect or suite of effects. Large, contiguous habitats can be fragmented, making it difficult for organisms to locate and maintain populations between disjunctive habitat fragments. Cumulative impacts may also occur when the timings of perturbations are so close that the effects of one are not dissipated before the next occurs, or when the timings of perturbations are so close in space that their effects overlap.

The CAW developed a scope of work encompassing 36 parameters for 9 past, present, and reasonably foreseeable future projects (base projects) viewed as pertinent to the future condition of Corpus Christi Bay and the surrounding area. Parameters to be addressed include biological, physical, chemical, socioeconomic, and cultural attributes. The methodology described below was developed with the guidance and agreement of the CAW and the RACT.

5.1.1 Cumulative Impact Assessment Methodology

This discussion describes the application of the cumulative impact assessment methodology to the preferred alternative. Projects evaluated in the preferred alternative assessment include the following:

Reasonably foreseeable future actions:

- Packery Channel
- JFK Causeway
- Joe Fulton International Trade Corridor
- La Quinta Gateway Project
- The Coastal Bend Regional Water Plan update as required by Senate Bill 1
- Kiewit Offshore Services Project

Past or present actions:

- Corpus Christi Ship Channel 45-foot Project
- Rincon Channel Federal Assumption of Maintenance
- Gulf Coast Strategic Homeport Navel Station Ingleside – Corpus Christi, Texas
- Mine Warfare Center of Excellence – Corpus Christi Bay, Texas
- Jewel Fulton Channel Federal Assumption of Maintenance

The CAW agreed that the following projects or documents were not in the foreseeable future or did not have any documents available. Impacts from these projects were not addressed due to the lack of available information.

- Multipurpose Deepwater Port and Crude Oil Distribution System at Port Aransas Safeharbor Project
- Baker's Port
- State of Texas Regional Water Plan for Region L
- Harbor Island Master Plan
- Rerouting of GIWW from Ingleside across Corpus Christi Bay (Feasibility Report due 2003)
- Modifications to GIWW between Ingleside and Rockport (Feasibility Report due 2003)

The study area for the cumulative impact assessment was limited to the north portion of Upper Laguna Madre, Corpus Christi Bay, Nueces Bay, Redfish Bay, and offshore waters from Aransas Pass to Packery Pass.

Direct impacts that could be quantified in acreage were considered for habitat assessment when information was available. Habitats for cumulative impact assessment were identified from reports developed for the above proposed projects and include SAV, wetlands, estuarine sand flats/mud flats/algal mats, open water, reef habitat, coastal shore areas/beaches/sand dunes. In addition to habitats, impacts to specific resource categories were addressed in a more qualitative manner based on information provided by documents reviewed for each project. These were described as biological attributes (bay bottom habitat, terrestrial habitat, plankton, benthos, finfish, shellfish, mammals, reptiles/amphibians, threatened and endangered species, and EFH), physical environment (air quality/noise, topography/bathymetry, sediment quality, water quality, freshwater inflow, circulation, and tides), and cultural/socioeconomic attributes (recreation, commercial and recreational fisheries, ship accidents/spills, oil/gas production on submerged lands, cultural resources, public health, safety, and parks/beaches).

5.1.2 Evaluation Criteria

Cumulative effects were determined by reviewing impacts as described in the project documents and determined from recent habitat information obtained from Section 3.0. Acreage of each habitat in the study was determined from this assessment, if available.

5.1.2.1 Individual Project Evaluation

Individual project documents were reviewed for impacts to selected habitats based on the evaluation criteria described above. No attempt was made to verify or update published documents, nor were the disposal practices proposed in reviewed documents verified for current ongoing projects. In addition, no field data were collected to verify project impacts described in reviewed documents. Mitigation outlined in individual project documents may be in place or proposed. This analysis recognizes that some of the projects assessed are undergoing revisions that may alter their environmental impact. This analysis relied only on existing published documents. If acreage was available, it was summed for each habitat to obtain a cumulative acreage impact. It should be noted that because of the diverse mix of documents that were reviewed for cumulative impacts and because of the fact that not all documents used the same definitions or even the same categories of resources, it was sometimes necessary to lump or modify categories so that the quantities in this section may not be exactly comparable with those presented in sections 3 and 4 of this FEIS. However, every attempt has been made to make this section internally consistent, so that all projects included in Cumulative Impacts are evaluated comparably.

5.1.2.2 Resource Impact Evaluation

Biological/ecological, physical/chemical, and cultural/socioeconomic resource impacts were evaluated based on individual project reviews. In Table 5.1-1, a quantitative assessment of biological/ecological resources was prepared. A qualitative discussion of biological/ecological, physical/chemical resources, and cultural/socioeconomic resources were presented using information published in reviewed documents. The following is a brief description of the evaluated projects.

5.2 REASONABLY FORESEEABLE FUTURE ACTIONS

5.2.1 Packery Channel

Packery Channel is a potential environmental enhancement project that would provide a dredged channel across Padre Island between the Upper Laguna Madre and the Gulf of Mexico. The channel is located roughly north-northeast of the JFK Causeway, which crosses the Laguna Madre between the City of Corpus Christi and North Padre Island. The existing channel is largely the result of the modern dredging of a historically shallow cut between the historical pass and Laguna Madre.

In addition to opening Packery Channel to the Gulf, the project will add two rock jetties at the Gulf end of the Channel and deepen and widen the existing channel and Inner Basin. The project also

TABLE 5.1-1
CUMULATIVE IMPACTS

Project	Kiewit Offshore Services	Packery Channel	Raising Kennedy Causeway	Joe Fulton International Trade Corridor	La Quinta Gateway Project	Rincon Channel Federal Assumption of Maintenance	Gulf Coast Strategic Homeport Naval Station Ingleside	Mine Warfare Center of Excellence	Corpus Christi Ship Channel 52-foot Project	Total
RESOURCE IMPACTS										
Topography/Bathymetry	12,000 ft	3.5 statute miles	0.9 statute miles	NI	NI	NI	8.4 statute miles	NI	43 statute miles	55.8 statute miles
Shore/Beach/Dunes	NI	61 ac	NI	NI	1.8 ac	NI	NI	NI	NI	62.8 ac
Salt Marsh	NI	17.8 ac	11.5 ac	NI	2.1 ac	NI	1.2 ac	NI	NI	32.6 ac
Flats	NI	1.9 ac	NI	NI	NI	NI	112 ac	NI	NI	113.9 ac
Open Water	NI	7.1 ac	NI	NI	32 ac	NI	NI	NI	NI	39.1 ac
Oyster Reef	NI	NI	NI	NI	NI	NI	NI	NI	NI	
Upland Wetlands	NI	NI	NI	11.2 ac	NI	NI	38.6 ac	NI	NI	49.8 ac
Shallow Bay Bottom Habitat (0 to –12 MLT)		33.3 ac	NI	NI	27.1 ac	20 ac	207 ac	18 ac	40 ac (0 to –4 MLT)/ 359 ac (–4 to –12 MLT)	345.4/359 ac
Gulf of Mexico Bottom Habitat	NI	69.1 ac	NI	NI	NI	NI	NI	NI	526 ac	595.1 ac
Terrestrial Habitat		42.2 ac	NI	45 ac	245 ac (excludes 869 ac cropland)	NI	614 ac	NI	NI	946.2 ac
Submerged Aquatic Vegetation (SAV)	NI	5.4 ac	NI	NI	2.4 ac	NI	1.1 ac	3.5 ac	5 ac	17.4 ac
Essential Fish Habitat (subtotal of salt marsh, flats, shallow bay bottom habitat, and SAV)	NI	58.4 ac	11.5 ac	NI	31.6 ac	20 ac	321.3 ac	21.5 ac	404 ac	868.3 ac
MITIGATION/BENEFITS *										
Upland Habitat	NI	NI	NI	1.1 ac	NI	5 ac	NI	NI	120 ac	126.1 ac
Bay Bottom Habitat	NI	NI	5 ac	NI	NI	NI	NI	NI	NI	5 ac
Shallow-Water Habitat	NI	NI	11 ac	5.2 ac	27.1 ac	NI	5.5 ac	NI	935 ac	983.8 ac
Submerged Aquatic Vegetation	NI	16.2 ac	NI	NI	7.2 ac	NI	1.6 ac	10 ac	15 ac	50 ac

TABLE 5.1-1 (Concluded)

Project	Kiewit Offshore Services	Packery Channel	Raising Kennedy Causeway	Joe Fulton International Trade Corridor	La Quinta Gateway Project	Rincon Channel Federal Assumption of Maintenance	Gulf Coast Strategic Homeport Naval Station Ingleside	Mine Warfare Center of Excellence	Corpus Christi Ship Channel 52-foot Project	Total
Wetlands (salt marsh, brackish, fresh)	NI	18 ac	NI	NI	5.9 ac	28 ac	42 ac	NI	26 ac	119.9 ac
Beach Nourishment	NI	91.3 ac	NI	NI	NI	NI	NI	NI	NI	91.3 ac
Dune Mitigation	NI	1.5 ac	NI	NI	NI	NI	NI	NI	NI	1.5 ac
SOCIOECONOMICS										
Environmental Justice		NI	NI	NI	NI	NI	NI	NA	NI	NI
Community Cohesion		NI	NI	NI	NI	NI	NI	NA	NI	NI
Relocations		NI	1 business	NI	NI	NI	NI	NA	NI	1 business
Demand for Housing Units		3,150	NA	NA	4,600	NA	3,700	NA	Negligible	11,450
Population Increase		5,200	NA	NA	9,000	NA	14,900	NA	Negligible	29,100
BENEFITS										
Temporary (Construction Phase)										
Employment (avg. annual)		350	1,700	100	4,250	NA	535	NA	370	7,305
Wages (avg. annual)		NA	$26.9 M	NA	$210 M	NA	NA	NA	$1.1 M	$238 M
Total Output (avg. annual) (Nueces and San Patricio counties)		NA	$114.3 M	NA	$460 M	NA	NA	NA	$23 M	$597 M
Indirect Business Tax Impact (avg. annual)		NA	NA	NA	$15 M	NA	NA	NA	$900,000	$15.9 M
Permanent										
Employment (avg. annual)		2,500	NI	90	6,400	NA	8,470	NA	71	17,530
Wages (avg. annual)		$220 M	NI	$38 M	$233.4 M	NA	$150 M	NA	$21,000	$641.4 M
Total Output (avg. annual) (Nueces and San Patricio counties)		NA	NI	$115 M	$680 M	NA	NA	NA	$85,000	$795.1 M
Indirect Business Tax Impact (avg. annual)		NA	NI	$3.7 M	$21.8 M	NA	NA	NA	$3,700	$25.5 M

NI = No impacts; NA = Not Available; M = million (dollars).

* Except for CCSCCIP, all gains in the Mitigation/Benefits section of this table are from mitigation. For CCSCCIP, the only mitigation is the 15 acres of submerged aquatic vegetation; all others are from beneficial uses. Mitigation is determined based on Habitat Suitability Indices, while others were based on ratios to direct impacts. Mitigation may be completed or proposed.

involves the establishment of six dredged material PAs, including the use of some new work material for beach nourishment to counter the effects of wave erosion, providing storm damage reduction. The City of Corpus Christi has proposed recreational development in conjunction with the project; however, recreation is not part of the Federally cost-shared project.

The length of the proposed channel from the Gulf end of the jetties to the GIWW is approximately 18,500 feet (3.5 miles). The Packery Channel alignment follows an existing channel southeast of the GIWW for approximately 2.6 miles to a basin southeast of SH 361. From this basin the proposed new channel will extend approximately 0.9 mile toward the Gulf following a historic washover channel. Packery Channel will allow recreational and small commercial boats access between the GIWW and the Gulf. Traffic will not include large commercial ships, tows, deepwater draft barges, or any floating vessel with a draft greater than 4 feet.

The proposed channel opening involves dredging a new channel from the Gulf into the existing basin area located southeast of the SH 361 bridge. Two rock jetties will extend from the shoreline southeastward approximately 1,400 feet paralleling the channel. The basin will be reconfigured and deepened to a consistent depth of –12 feet mean lower low water level (MLLW). The existing Packery Channel west of SH 361 that extends to the GIWW will be increased to 80 feet in bottom width and 7 feet in depth (USACE, 2003).

5.2.2 JFK Causeway

The JFK Causeway is located in southeast Nueces County in the City of Corpus Christi on the northern end of the Laguna Madre providing a connection between the mainland and North Padre Island. The current causeway is approximately 4 feet mean sea level (MSL) with a 3,280-foot-long bridge, which provides a clear roadway width of 54 feet, including a divided four-lane road with a concrete median barrier and a vertical clearance of 80 feet above the water surface.

The proposed project would raise the existing JFK Causeway (Park Road 22) to a minimum of 9 feet above MSL from O'Connell Street on the mainland to a point 1,740 feet east of Aquarius Drive on Padre Island. The new portion of the bridge would be 2,850 feet with a 2,550-foot water opening at the west end of the causeway. No new through lanes would be added by the project, and the existing two lanes in each direction would remain upon completion of the project. Between O'Connell Street and the Laguna Madre, the existing four-lane divided highway would be converted to an urban freeway with four main lanes and frontage roads to provide access to abutting properties. A turnaround at the western bank of the Laguna Madre would aid local traffic access. During construction, one lane in each direction would remain open to traffic. The westbound traffic lanes would be completed first to ensure safe evacuation in case of an emergency during construction. The GIWW high bridge would not be modified as part of this project since it is already well above the 9-foot minimum elevation needed for safe evacuation during storm events. (Hicks & Company, 1999)

5.2.3 Joe Fulton International Trade Corridor

The Joe Fulton International Trade Corridor (JFITC) is a proposed intermodal project to connect road, rail and marine traffic between IH 37 and US 181. The proposed project area is located along the Port of Corpus Christi Inner Harbor in Nueces County, Texas, and is located north of the City of Corpus Christi, south of Nueces Bay, and west of Corpus Christi Bay. It would result in the construction of a two-lane roadway (one 12-foot lane in each direction and 10-foot shoulders) approximately 11.8 miles in length and a railroad corridor approximately 6.0 miles in length, parallel to a portion of the proposed roadway.

The JFITC would provide improved road and rail access to existing facilities on the north side of the Inner Harbor from the Tule Lake Lift Bridge to US 181. It would also facilitate development of approximately 1,100 acres of PCCA and Driscoll Foundation land between the Lift Bridge and Carbon Plant Road/IH 37. The new rail link would provide alternative service to the north bank area, eliminating the need for all rail traffic to pass over the Lift Bridge. The proposed road would provide alternative routing for industrial vehicles between US 181 and IH 37 and PCCA facilities, thus eliminating the need for traffic to traverse the downtown Corpus Christi area and the Harbor Bridge. The proposed route would provide an alternative for general traffic, including hurricane evacuation traffic from areas east of Corpus Christi Bay, independent of the Harbor Bridge and the Lift Bridge (Shiner, Moseley and Associates, 2001).

5.2.4 La Quinta Gateway Project

The proposed La Quinta Gateway project involves the construction and operation of an intermodal container terminal and associated deep draft docking facility. The project would be located on PCCA-owned property (approximately 1,114 acres) in San Patricio County, Texas, between Reynold's Metals Company to the east, SH 361 and the City of Gregory to the north, US 181 and the North Shore Country Club Estates to the northwest and west, respectively, and Corpus Christi Bay to the south. The Corpus Christi Bay portion of the site is in Nueces County, Texas, adjacent to the La Quinta channel extension. The objectives of the modern container facility are to facilitate the need for increased container terminal capacity in the rapidly growing Gulf market and provide diversification for the PCCA.

The proposed cargo facility for the La Quinta Gateway project would be constructed over three phases to include: highway access via improvements to SH 35 and US 181, rail access via the Union Pacific Railroad ROW, water access via extension of the La Quinta Channel and a new 1,500-foot turning basin, a 295-acre marine terminal with stacked container and wheeled storage areas, a 3,800-linear-foot container wharf capable of accommodating three post-Panamax containerships simultaneously, nine gantry cranes with a boom reach capable of handling loading/off-loading activities, a 75-acre intermodal rail terminal along the east edge of the La Quinta property, four 6,000-foot loading tracks, a warehousing and distribution facility, and two dredged material placement areas totaling nearly 300 acres, including a 100±acre buffer zone located along the western boundary of the site (PCCA, 1999). Approximately 819 acres of the 1,114-acre project area is in row crop production, while 295 acres is predominantly in brushland used for grazing.

5.2.5 Regional Water Plan

Senate Bill 1, passed in 1997, directed the TWDB to designate regional water planning areas, which were designated Regions A through P. Region N, the Coastal Bend Region, includes Aransas, Bee, Brooks, Duval, Goliad, Jim Wells, Kenedy, Kleberg, Live Oak, McMullen, Nueces, and San

Patricio counties. The CAW was interested in the impact of the preferred alternative on the Coastal Bend Regional Water Plan update and vice versa because of a potential substantial change in tidal amplitude and a substantial increase in population, and thus water needs, from the preferred alternative. As an examination of Sections 4.1.1 and 4.10 will reveal, changes in tidal amplitude are predicted to be minimal, as is the added need for infrastructure, since the projected increase in population with the preferred alternative is a fraction of 1 percent. Therefore, the Coastal Bend Regional Water Plan update will not be carried thorough the rest of the analysis of cumulative impacts.

5.2.6 Kiewit Offshore Services Project

Kiewit Offshore Services, located north of the intersection of La Quinta Channel and Jewel Fulton Canal, plans to bring in large components of a proposed floating oil/gas platform and then tow the fabricated structure to the Gulf of Mexico. The existing depth of –45 MLT is adequate for vessel draft, however the channel width is too narrow. Kiewit Offshore Services proposes to widen 12,000 linear feet of the bottom width of the La Quinta Channel from the existing 300 feet to 400 feet. Widening would begin just north of Station 57+00, which is approximately 4,000 feet north of its intersection with the CCSC. Dredging would end at Station 174+10 on the east side of the channel and Station 180+00 on the west side of the channel. Widening of the channel would be box cut on a 1:1 side slope template, which should stabilize to approximately 2:1 or steeper. However, the bottom width of the channel can be extended about 50 feet on either side with limited relative change anticipated at the top of each slope. The approximately 800,000 cy of hydraulically dredged material would be placed on PA 13. To accommodate components of the platform, an area measuring 385 feet wide by 850 feet long would also be hydraulically dredged to a depth of –85 feet MLT from its existing depth of –45 feet MLT. Approximately 500,000 cy of material would be placed either on uplands located on Kiewit Offshore Services property or in PA 13. The channel widening is not expected to have any effect on SAV observed adjacent to the channel.

5.3 PAST OR PRESENT ACTIONS

5.3.1 Corpus Christi Ship Channel 45-Foot Project

The existing channel extends from deep water in the Gulf of Mexico through a jettied entrance channel in Aransas Pass to Harbor Island and across Corpus Christi Bay to a land-locked channel south of Nueces Bay. A branch channel to La Quinta extending from the main channel along the north shoreline of Corpus Christi Bay is included in the project. According to the USACE (1975) the Corpus Christi Ship Channel was deepened from the existing 40-foot depth to an authorized depth of 45 feet. The 40-foot dimensions were authorized by the Rivers and Harbors Act of 1958, and the 45-foot dimensions were authorized by the Rivers and Harbors Act of 1968.

The 45-foot project provides maintenance dredging of the CCSC to authorized dimensions. Maintenance dredging is required periodically to insure sufficient carrying capacity in the channels for efficient and safe movement of commercial navigation. Shoaling within the channels would seriously hamper or halt deep-draft shipping within 2 or 3 years if maintenance dredging were discontinued. The outer bar and jetty channel to Harbor Island are normally maintained by a hopper dredge, with the dredged material placed in a designated open water placement area in the Gulf of

Mexico. The remaining portions of the CCSC are maintained by hydraulic pipeline dredge and materials placed in UCPAs, confined placement areas, and open-water placement areas in Corpus Christi Bay. Materials dredged from the landlocked portion of the channel south of Nueces Bay are placed in UCPAs. Variations of these procedures could occur as a result of improvements in dredging techniques and equipment or possible emergency conditions. Resource impact evaluation of the 45-foot project was not conducted due to the proposed impacts of the CCSCCIP.

5.3.2 Rincon Canal Federal Assumption of Maintenance

The USACE proposes to assume responsibility for maintenance of the Rincon Canal and Canal A in Corpus Christi Bay and the Rincon Industrial Park (RIP), and to use the dredged material for BU sites in the project area, where possible.

The Corpus Christi Rincon Canal System (CCRCS) is composed of several connecting channels constructed between 1967 and 1974. The Rincon Canal is a channel measuring 100 feet in width, 12 feet in depth, and 14,256 feet in length, and connects the CCSC to the RIP. The canal passes under US 181/Nueces Bay Causeway east of the northern end of the RIP. The CCSC serves as a connection between the CCRSC and the GIWW. The RIP is served by Canal A (150 feet in width, 12 feet in depth, and 4,980 feet in length), and Canals B and E, all of which connect to the Rincon Canal. Rincon Canal and Canal A compose that part of the system proposed for assumption of maintenance dredging by Federal entities. The proposed BU sites are located in Nueces County along the southwestern margin of Corpus Christi Bay, adjacent to the City of Corpus Christi and the RIP, which is part of the PCCA.

The channels are currently maintained using a cutterhead pipeline dredge. No changes in historical dredging practices would be proposed as a result of this action (USACE, 2000).

5.3.3 Gulf Coast Strategic Homeport Naval Station Ingleside (Naval Station Ingleside)

The U.S. Navy proposed a strategic homeporting action for 27 battleship surface vessels at eight locations on the U.S. Gulf Coast, including Naval Station Ingleside, Texas. Very little information was available regarding the execution of this project. Of the proposed actions, only dredging of navigation channels and turning basins are known to have occurred in the region. Additionally, waterfront facilities were constructed to support the homeported vessels. The following information is taken largely from the project EIS (US Navy, 1987).

The Naval Station Ingleside project site is located in and adjacent to the CCSC, from La Quinta to Harbor Island. Approximately 8.4 miles of the CCSC was proposed to be widened from 500 to 600 feet. The CCSC was to be hydraulically dredged to a depth of –46.5 feet MLT. A 105-acre turning basin was to be dredged to a depth of –41 feet MLT in the western 42 acres and –46.5 feet MLT in the eastern 63 acres. Dredging depths include 2 feet advance maintenance and 2 feet allowable over depth.

Approximately 13.2 mcy of material was proposed to be dredged, including 5.9 mcy from the CCSC and 7.3 mcy from the turning basin. Maintenance dredging is expected to occur every 5 years with an estimated volume of 6.4 mcy of material being removed from the CCSC and 6.5 mcy of material being removed from the turning basin over the 50-year life of the project. The dredged material was proposed to be hydraulically removed and pumped to USACE-designated placement sites (EPA, 1987). Additionally, the EPA designated the Navy Homeport ODMDS, under MPRSA, for the placement of virgin and maintenance material from the Entrance Channel. The physical location of the Navy Homeport ODMDS coincides with BU Site ZZ.

5.3.4 Mine Warfare Center of Excellence

Dredging approximately 400,000 cy for the U.S. Navy facilitated the construction of a Magnetic Silencing Facility (MSF) for use by the Mine Warfare Center of Excellence at Ingleside, Texas. This MSF is required to measure the magnetic signature of the mine warfare ships for utilization in mine warfare training. Construction of an entrance channel, turning basin and slip was required for the Avenger and Osprey Class Naval Vessels.

The entrance channel measured 150 feet wide and approximately 700 feet in length and will be dredged to –17 feet MLW. The turning basin measured 500 feet by 500 feet and was dredged to –17 MLW. To allow for placement of the MSF, a corridor measuring 520 feet by 270 feet was dredged to –25 feet MLW. The MSF consists of piers and sensor tubes. Two piers 300 feet in length were constructed parallel to one another 66 feet apart to allow docking of naval vessels between them. A walkway measuring 800 feet in length connects these piers to the shoreline.

An additional small craft pier was constructed adjacent to Naval Station Ingleside and CCSC. The pier measures 600 feet in length and accommodates utility boats used to support the mine warfare exercises and existing boats assigned to the station.

The small craft pier facilities are near Naval Station Ingleside, San Patricio County, Texas. The dredging portion of the project was performed at the confluence of the Jewel Fulton Canal and La Quinta Channel west of Ingleside, Texas (EPA, 1987).

5.3.5 Jewel Fulton Canal Federal Assumption of Maintenance

The Jewel Fulton Canal is a small canal off La Quinta Channel located adjacent to Kiewit Offshore Services, Ltd. and Navy-owned property in Ingleside, Texas, which continues into Kinney Bayou. Channel improvements for this area are currently being planned.

5.4 RESULTS

5.4.1 Ecological/Biological Resources

Biological and ecological resources will experience a net negative impact from increased turbidity associated with the dredging and dredged material placement required in the majority of the projects evaluated. Temporary disturbance of bay bottom due to open bay placement and channel dredging is anticipated to provide temporary negative impacts to benthos and SAV. Loss of freshwater marsh and upland habitat due to construction is expected to reduce food and nutrient sources. Not all projects will impact freshwater marsh or upland habitat. Long-term positive impacts from the preferred alternative for the CCSCCIP are anticipated from the creation of seagrass, marsh, and shallow aquatic habitat, which will increase nursery habitat for finfish/shrimp and provide rich substrate for benthic organisms. Birds will benefit by the periodic placement of dredged material on existing upland sites due to creation of temporary unvegetated nesting substrate. However, construction operations attributed to almost all evaluated projects may disturb nesting activity. Mammals, reptiles/amphibians, and terrestrial vegetation will be negatively impacted, temporarily, by placement of material on existing upland placement sites. Threatened/endangered species are not expected to be negatively impacted; in fact, some benefit may be realized from creation of marsh and unvegetated nesting substrate on existing placement sites. Although wetland vegetation will be negatively impacted where wetlands are damaged or destroyed by project construction, marsh creation projects will benefit wetland vegetation, resulting in an overall positive cumulative impact in the general study area. Except for the CCSCCIP, all gains in the Mitigation/Benefits section of Table 5.1-1 are from mitigation. For the CCSCCIP the only mitigation is for SAV; all others are from beneficial uses.

5.4.1.1 Wetlands

The CCSCCIP preferred alternative will not impact any freshwater or brackish wetlands. Wetlands evaluated included salt marsh, freshwater, and brackish wetlands. Negative impacts (totaling 82 acres) are expected to wetland habitat from Packery Channel (17.8 acres); JFK Causeway (11.5 acres); the JFITC (11.2 acres), La Quinta Gateway Project (1.7 acres); and Naval Station Ingleside (39.8 acres). Mitigation for negative impacts associated with these projects include creation of 18 acres of wetlands for Packery Channel, 28 acres of salt marsh proposed for the Rincon Canal Project, 42 acres for Naval Station Ingleside; and 5.3 acres for La Quinta. The CCSCCIP preferred alternative will provide a BU of 26 acres of wetlands. A net gain of 44 acres for the Corpus Christi Bay area is predicted, based on the above totals.

According to studies conducted within the CCBNEP study area (that includes Aransas Bay, Corpus Christi Bay, and the Upper Laguna Madre) (White et al., 1998), marsh habitat constitutes approximately 97 percent (116,041 acres) of total vegetated wetland areas (119,425 acres) (marshes, scrub-shrub, and forested wetlands). Some of the findings in these studies reveal that salt and brackish marshes compose approximately 48 percent of the marsh system. As presented in these studies, the trend in vegetated wetlands is one of net gain from the 1950s to 1992 (including photointerpretation inconsistencies). However, loss of marsh habitat has resulted from agricultural or urban land conversion with additional loss due to dredging, filling, and draining. According to the studies, the greatest changes in habitat between the 1950s to 1979 has occurred in tidal flats due to permanent inundation. The response to permanent inundation has primarily resulted in conversion to open water or seagrass beds. Some losses included conversion to smooth cordgrass marshes along the upper reaches of the tidal flats that became more frequently flooded. According to the CCBNEP studies (White et al., 1998), some of the largest losses in tidal flats was in the Corpus Christi/Nueces Bay-Laguna Madre system.

5.4.1.2 Finfish/Shellfish

Shallow water nurseries and spawning grounds are sensitive sites within the general study area. Shrimp and finfish production would be temporarily displaced due to dredging activity and open water placement of dredged material, and periodic loss of production would occur during maintenance dredging. These areas will recover after activity has ceased, but the quality of the habitat will be reduced by repeated placement of dredged material. Dredging and placement activity will increase turbidity, which may impede gill function in finfish and shrimp not able to leave the area. Damage to marshes from placement of dredged material will reduce nursery areas available for finfish and shrimp. Potential contaminants that may be in bottom sediments will be retrained when dredging occurs, potentially exposing finfish and shrimp to contaminated materials. No contaminants in bottom sediments have been identified to date except from the Inner Harbor which will go to UCPAs. These impacts, except damage to marshes (Section 5.4.1.11), are associated with all dredging projects reviewed, as well as the CCSCCIP preferred alternative. Shallow bay bottom habitat (0 to –12 MLT) will be impacted by the following projects: Packery Channel (33.3 acres), La Quinta Gateway (27.5 acres), Rincon Channel Federal Assumption of Maintenance (20 acres), Naval Station Ingleside (207 acres), and the Mine Warfare Center of Excellence (18 acres). The CCSCCIP preferred alternative will impact 40 acres of shallow bay bottom (0 to –4 MLT) and 359 acres of bay bottom (–4 to –12 MLT). The CCSCCIP is the only project that identifies shallow bay depth differences; thus, all other impacts of shallow bay habitat are assumed at 0 to –12 MLT. BU sites for the preferred alternative will create approximately 935 acres of shallow water habitat; and the Naval Station Ingleside creates 5.5 acres. A net gain of approximately 235.7 acres of shallow water/bay bottom habitat will occur from mitigation and beneficial uses due to all projects reviewed.

As presented in Section 5.4.1.1, a net gain of 44 acres of wetland habitat is estimated. Approximately 595.1 acres of Gulf of Mexico ocean bottom are expected to be temporarily affected by the combined Packery Channel project (69.1 acres) and the CCSCCIP preferred alternative (526 acres). These temporary disturbances will be from the initial lowering of the channel bottom and resultant maintenance dredging, and beneficial use placement along beach shorelines. A small amount (7.1 acres) of Gulf bottom will be lost permanently to jetties for the Packery Channel project.

5.4.1.3 Terrestrial Habitat

Terrestrial vegetation present on any placement sites will be covered by deposition of the maintenance materials as a result of those reviewed projects requiring dredging activities. This vegetation consists mainly of opportunistic species that thrive on disturbed soils and are likely to return after the site has been dewatered. These species are not anticipated to make significant contributions as food or detritus sources. The following projects will cause a total impact of 996.2 acres to terrestrial areas: Packery Channel (42.2 acres), JFITC (45 acres), La Quinta Gateway Project (295 acres), and Naval Station Ingleside (614 acres). Approximately 819 acres of cropland potentially impacted by the La Quinta Gateway Project is not included as terrestrial habitat. Terrestrial vegetation found in the vicinity of the JFK Causeway will be destroyed during construction of the elevated bridge and causeway; however, the upland areas within the road ROW will continue to provide habitat for opportunistic species. Projects providing upland habitat include: 5 acres created for the Rincon Channel Federal Assumption of Maintenance, and a 120-acre upland site (BU Site E) west of the La Quinta Gateway Project for the CCSCCIP preferred alternative. For the Packery Channel project, dune mitigation of 1.5 acres of displaced dunes for restoring and revegetating has been proposed. A net loss of terrestrial habitat totals 877.2 acres among all of the reviewed projects.

5.4.1.4 Mammals

The general study area is not considered high quality mammal habitat; however, terrestrial species will be negatively affected by periodic placement of dredged material on upland disposal sites and construction of facilities and roads associated with the projects. Habitat which attracted them will be covered, resulting in death to any slow moving or non-motile species. Others will be displaced; however for the upland disposal sites after dewatering, the habitat will likely return. Upland placement sites are not intended to be managed for mammal habitat.

5.4.1.5 Reptiles and Amphibians

The general study area is not considered high quality reptile and amphibian habitat; however, land turtles, snakes, lizards, and others may be adversely affected by periodic placement of dredged material on upland placement sites or clearing of upland sites. Habitat which attracted them will be covered, resulting in death to nonmotile or slow-moving species remaining on the site during placement. After dewatering from a placement area, the habitat will likely return; however, placement sites are not expected to be managed for this purpose.

5.4.1.6 Threatened and Endangered Species

Refer to Section 4.5 in this FEIS for a discussion of potential impacts to threatened and endangered species from the CCSCCIP preferred alternative. No significant impacts to threatened or endangered species are anticipated as a result of the reviewed projects in the general study area, with the exception of Packery Channel. The Biological Opinion for impacts to endangered and threatened species relative to Packery Channel has been issued by FWS. Piping plover critical habitat will be affected by the dredging of Packery Channel. Approximately 1.5 acres of critical habitat will be negatively impacted by the channel and jetties. In addition, 20 acres of beach nourishment will be placed on foraging beachfront areas for piping plover, yet would be considered a temporary impact.

5.4.1.7 Benthic Habitat

Organisms present on open-bay bottom will be temporarily affected by the project due to excavation and placement of dredged materials. However, a 290.4-acre net gain will occur when considering beneficial uses creation and mitigation for bay bottom and shallow-water habitat, SAV, wetlands (salt marsh), and flats (see sections 5.4.1.1, 5.4.1.2, 5.4.1.10, and 5.4.1.11). Additional impacts associated with the loss of Gulf of Mexico ocean bottom will occur due to the opening of Packery Channel (69.1 acres: 7.1 acres permanent; 62 acres temporary) and the CCSCCIP preferred alternative (526 acres), a temporary impact. Dredging activity in association with these projects may temporarily reduce the quality of nearby benthic habitat from increased turbidity. Most organisms present in areas covered for open water placement sites will be permanently lost; however, recovery will occur after placement is completed. Recent studies in Corpus Christi Bay (Ray and Clarke, 1999) have indicated that recovery occurs at open-bay placement sites in less than 1 year. Opportunistic populations can overtake newly created benthic habitat increasing its value to foraging species.

Toxic materials may be present in roadway runoff, which will negatively affect the benthos in the immediate vicinity of the JFITC and the JFK Causeway. Piers constructed to support the causeway and bridge are expected to be colonized by animals such as barnacles, oysters, and limpets, providing habitat for crabs, shrimp, small fish, and other marine organisms. The creation of shallow-water unvegetated and vegetated habitat is expected to provide rich substrate for benthic populations to develop. Rock breakwaters associated with CCSCCIP BU sites and the jetties at Packery Channel are expected to be colonized by animals such as barnacles, oysters, and limpets, providing habitat for crabs, shrimp, small fish, and other marine organisms.

5.4.1.8 Plankton

Increased turbidity during dredging and placement will decrease light transmittance necessary for photosynthesis of phytoplankton. Increased turbidity may also negatively affect zooplankton by damaging their filtering mechanism and impeding respiration. However, these impacts are temporary and local.

Toxic materials released during dredging of the projects, construction of the JFITC or the JFK Causeway, or traffic accidents on the bridge may have an adverse effect on plankton populations. However, data are not available to provide a quantitative analysis of the potential problem.

5.4.1.9 Essential Fish Habitat

Section 305(b)(1)(A and B) of the Magnuson Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act, 16 U.S.C 1801 et seq.), as amended, requires that the Regional Fishery Management Councils submit, by October 11, 1998, amendments to their Fishery Management Plans that identify and describe EFH for species under management. The Act also requires identification of adverse impacts on EFH and the actions that should be considered to ensure that EFH is conserved and enhanced.

Based on direct impacts (868 acres) to submerged aquatic vegetation, salt marsh, shallow bay bottom habitat, and flats identified in the reviewed projects, the net gain from proposed mitigation and beneficial use areas amounts to approximately 290.4 acres, with the majority of this acreage proposed by shallow water habitat. Given the size of this bay system, and the net gains from the projects, EFH will not be adversely affected.

5.4.1.10 Submerged Aquatic Vegetation

Based on the results of the document reviews, SAV will experience an area-wide increase. Approximately 5 acres are to be negatively impacted by the CCSCCIP and mitigated at a 3:1 ratio and approximately 935 acres of potential SAV habitat will be created in the BU sites. Four projects account for approximately 12.9 acres of negative impacts to SAV in the general vicinity. These include La Quinta Gateway Project (2.9 acres), Packery Channel (5.4 acres), Naval Station Ingleside (1.1 acres), and Mine Warfare Center of Excellence (3.5 acres). Negative impacts to seagrass habitat by these projects will be mitigated with 50 acres proposed for restoration.

As presented in the CCBNEP studies by Pulich et al. (1997), the Laguna Madre system has seen many changes since the 1950s, primarily in response to salinity changes. A summary of studies identified in the CCBNEP (Pulich et al., 1997) provide seagrass data results. In the Upper Laguna Madre from 1967 to 1988, shoalgrass increased; but from 1988 to 1994, shoalgrass decreased up to 60 percent with manateegrass becoming established in the northern part. Decreases since 1990 in the Upper Laguna Madre have been attributable to brown tide which reduces water clarity. Between 1958 and 1994, there has been an indication of an expansion of shoalgrass and widgeongrass on the backside of Mustang Island (Pulich et al., 1997). According to Pulich et al. (1997), general trends have shown that seagrass dynamics are highly variable with localized changes.

5.4.1.11 Estuarine Sand Flats/Mud Flats/Algal Flats

For the purpose of this study, impacts resulting from the CCSCCIP preferred alternative to this habitat were included in the Essential Fish Habitat (Section 5.4.1.9). No negative impacts were found to estuarine sand flats/mud flats/algal flats due to the CCSCCIP preferred alternative. Of the projects reviewed, the Naval Station Ingleside project identifies potential impacts at the project site to 112 acres of low-quality sand flats, and Packery Channel construction impacts identifies 1.9 acres. No mitigation has been proposed for any of the projects reviewed for tidal flats.

5.4.1.12 Open-Water Habitat

The construction of Packery Channel will cause the loss of approximately 7.1 acres of open-water habitat for jetty construction. No additional impacts are due to the CCSCCIP preferred alternative, with the exception of an anticipated loss from the conversion of deep-bay open-water to shallow-water marsh habitat and emergent islands in the BU sites. The benefit of the BU sites outweighs the impact of the loss of open water due to the high productivity to be created in these areas.

5.4.1.13 Oyster Reef Habitat

No impacts will occur to oyster reef habitat from the CCSCCIP preferred alternative. Impacts to oyster reef habitat were not indicated by the reviewed projects.

5.4.1.14 Coastal Shore Areas/Beaches/Sand Dunes

No significant or noticeable impacts are expected from the CCSCCIP preferred alternative. Impacts to coastal shore areas/beaches/sand dunes from the reviewed projects include approximately 63.0 acres from Packery Channel and 0.7 mile of shoreline for the La Quinta Gateway project. However, these impacts from Packery Channel result from beach nourishment with placement of sands on eroding beach and in shallow Gulf waters along the beach. Dune relocation and revegetation of 5,670 cy (approximately 1.5 acres) of dunes has been proposed for the Packery Channel project.

5.4.2 Physical/Chemical Resources

Increases in both upland and submerged elevations from dredged material placement with the preferred alternative can be expected to change local circulation patterns.

5.4.2.1 Topography/Bathymetry

Projects impacting topography/bathymetry include Packery Channel (3.5 miles), JFK Causeway (0.9 mile), La Quinta Gateway Project (32 acres), and Naval Station Ingleside (8.4 miles). The CCSCCIP will impact 43 miles. Periodic placement of maintenance material on open-water placement areas will temporarily decrease water depth in those areas until currents and wave action erode the dredged material away. Surface elevation will increase due to replacement of open bay with created marshes as BU sites and with the building of structures for reviewed projects.

5.4.2.2 Noise

Noise impacts included in those projects associated with dredging will include operation and maintenance noise. This impact will be temporary, will move up and down the project area depending on the section being dredged, and is not expected to differ from current maintenance dredging for many of the projects.

5.4.2.3 Air Quality

Objectionable odors (mercaptan, hydrogen sulfide) may result from the dredging of maintenance sediments containing high concentrations of organic matter in those reviewed projects requiring dredging. Temporary and intermittent maintenance dredging activities would emit nitrogen oxides and carbon monoxide primarily. During operation, pollutants expected to be emitted include nitrogen oxides, carbon monoxide, particulates, sulfur dioxides, and hydrocarbons. No reviewed projects are anticipated to violate the NAAQS because these projects require State air permits and compliance with permits would result in no adverse cumulative impacts on air quality.

5.4.2.4 Water Quality

Contaminants originating from the Inner Harbor and contained in material displaced or dredged from the Inner Harbor to Station 1080+00 and in upper Corpus Christi Bay will be contained in UCPAs. Monitoring and management of the effluent from these sites will control the reintroduction of contaminants to the environment. All reviewed projects will comply with the requirements of NPDES during construction of the projects.

Although water quality in the general study area appears to be improving, dredging and placement operations are expected to temporarily degrade water quality in the project vicinity through increased turbidity and release of bound nutrients. This is true of all projects involving dredging and dredged material placement. No projects reviewed cited concerns with sediment contamination or nutrients, including the CCSCCIP preferred alternative.

Dredging and placement at proposed open water and upland placement areas may increase suspended solids, release contaminants and bound nutrients, and deplete oxygen. This impact is temporary and, except for turbidity, insignificant. If temporary degradation occurs, the study area should rapidly return to ambient conditions upon completion of dredging.

A slight impact to water quality may occur as a result of vehicular use of the JFITC and the elevated JFK Causeway. Stormwater runoff, which may contain oil and grease may also have minimal impacts to water quality.

5.4.2.5 Salinity

Existing salinity condition is anticipated to be maintained as a result of dredging and maintenance of the majority of projects reviewed. Possible changes in hydrodynamics from the proposed JFK Causeway and Packery Channel may cause localized changes and, therefore, will not change the salinity structure of the Upper Laguna Madre or Corpus Christi Bay, as a whole (Hicks et al., 1999).

5.4.2.6 Freshwater Inflows

No alteration to freshwater flow is anticipated from the preferred alternative or from any projects reviewed in this analysis.

5.4.2.7 Turbidity

Reviewed projects requiring dredging and open water placement of dredged material will produce increased turbidity during dredging and placement. Continued use of open water placement areas may provide a source of continuing turbidity due to erosion by currents and wave action. Turbidity will also often occur in the immediate vicinity of the cutterhead dredge near the point of open-water placement and from runoff from construction sites during highway projects. Turbidity from these sources is expected to return to concentrations below ambient soon after cessation of dredging.

5.4.2.8 Circulation/Tides

Temporary, minor changes in circulation in the vicinity of open water placement areas containing newly placed materials are expected upon construction dredging and with the maintenance dredging process. Circulation is expected to return to existing conditions when the majority of the material has eroded away. No changes in turnover and tides are expected as a result of dredging the reviewed projects. Hicks et al. (1999) predicts a small, localized effect in hydrodynamics as water is allowed to move through a 2,550-foot water opening in the proposed JFK Causeway, rather than the present exchange through Humble Channel and the GIWW only. Changes in circulation will occur with the opening of Packery Channel.

5.4.2.9 Sediment Quality

Potentially contaminated sediments from the Inner Harbor reach of the CCSCCIP will be placed in UCPAs. Monitoring and management of the effluent from these sites will control reintroduction of these contaminants to the environment. Decreased ship traffic resulting from the preferred alternative may decrease the potential for spills that may eventually contaminate sediments in the study area.

5.4.3 Cultural/Socioeconomic Resources

Cultural impacts are anticipated to be minimal as a result of the CCSCCIP preferred alternative. There is a low probability that unknown submerged archaeological sites, excluding shipwrecks, may be impacted.

Socioeconomic impacts relate mainly to an increase in population, an increase in demand for housing, and impacts to land use. These impacts would occur in Nueces and San Patricio Counties primarily in the following communities: Corpus Christi, Portland, Ingleside, Ingleside-by-the-Bay, and Aransas Pass. The population increase that would result from the projects evaluated would be approximately 29,000 (assuming complete build-out of all projects). This increase in population would provide the impetus for a local demand of approximately 11,450 housing units. One business would be relocated as a result of the construction of the Raising Kennedy Causeway project. No EJ or community cohesion impacts would result from any of the projects evaluated. Land use impacts include development of approximately 1,300 acres of vacant land in San Patricio County, expanded roadways and rail-lines on the north side of the Corpus Christi Bay and within the Inner Harbor area of Corpus Christi. The Packery Channel project would impact approximately 25 acres of currently vacant land, although approximately 20 of these acres would be converted to public parkland (including parking and other structures). Cumulative impacts related to an increase in visitor usage of parks and recreational areas was not evaluated, as these impacts were not addressed in any of the documentation prepared for any of the reviewed projects.

Socioeconomic benefits are grouped into benefits that would occur during project construction, and those that would occur after project construction is complete. The projects that were reviewed would provide an increase in annual employment of approximately 7,305 jobs (includes indirect and induced jobs), and wages for these jobs would be approximately $238 million annually. Total economic output within San Patricio and Nueces Counties would be approximately $597 million annually, and indirect business taxes for local and State government would be $15.9 million annually. After construction on all reviewed projects is complete, there would be an increase in annual employment of approximately 17,530 annual jobs, and wages for these jobs would be approximately $641.4 million annually. Total economic output within San Patricio and Nueces Counties would be approximately $795.1 million, and indirect business taxes for local and State government would be $25.5 million annually.

Secondary effects would occur as a result of the reviewed projects. Increased tourist and recreational usage of North Padre and Mustang islands is anticipated as a result of potential secondary development due to improved access resulting from the JFK Causeway. The Packery Channel Project would also increase tourist and recreational usage in the North Padre Island area. Economic development in this area is anticipated to result in increased commercial, and residential development on North Padre Island. Transportation access will be improved with new channel development projects and maintenance of existing channels. Transportation safety will be improved in all channel projects and hurricane evacuation for Padre Island will be improved due to the JFK Causeway project.

5.4.3.1 Oil and Gas Production on Submerged Lands

Current oil and gas pipelines are placed to accommodate existing channel dimensions. The majority of the reviewed project documents did not address oil and gas production; however, no change in oil and gas production is anticipated as a result of the projects evaluated for cumulative impact assessment.

5.4.3.2 Ship Accidents/Spills

A decrease in the number of vessels will occur with the CCSCCIP preferred alternative relative to the No-Action alternative and may occur due to the other channel improvement or maintenance projects reviewed, which may decrease potential for spills. The potential for accidental releases related to dredging activity will exist; however, spill prevention plans can minimize impacts. No additional impacts are anticipated.

5.4.3.3 Historic Resources

Historic and archeological resources are expected to be impacted by the CCSCCIP preferred alternative (see Section 4.7). None of the reviewed projects conflict with sites currently listed on the NRHP or are designated as SALs.

5.4.3.4 Recreation

The Corpus Christi Bay area is widely used by recreational fishermen and boaters. Turbidity associated with dredging and placement is anticipated to temporarily damage local fisheries in small portions of the general study area. Restricted areas are likely to be associated with the U.S. Navy projects (Naval Station Ingleside and Mine Warfare Center). Channel improvement projects like those reviewed provide greater access to and throughout the bay for recreational fishermen and boaters. Increased tourism would likely be a response to the opening of Packery Channel and the development of ancillary park facilities. Cumulative impacts associated with aquatic habitat are addressed in Sections 5.4.1.2, 5.4.1.7, and 5.4.1.9.

5.4.3.5 Commercial and Recreational Fisheries

Many commercially and recreationally important species of shrimp and finfish are common in the general study area, specifically, red drum, spotted sea trout, black drum, mullet, southern flounder, brown shrimp, and pink shrimp. These species may be adversely affected by degradation of open-bay bottom foraging habitat due to open-water placement, but recovery is speedy (Ray and Clarke, 1999). Refer to Section 4.2.1.2 in this FEIS for impacts to commercial and recreational fisheries with the CCSCCIP preferred alternative. Opening Packery Channel is expected to increase opportunities for recreational fisherman.

5.4.3.6 Public Health

No impacts to public health are expected from the reviewed projects.

5.4.3.7 Safety

The primary purpose of elevating the JFK Causeway to a minimum of 9 feet MSL is to enhance public safety, particularly during natural emergencies such as hurricanes. Safety impacts to other reviewed projects were not indicated except for the CCSCCIP preferred alternative, which would improve safety in the CCSC from channel widening and the addition of barge lanes.

5.4.3.8 Parks and Beaches

No impacts to parks and beaches are expected from the reviewed projects except the Packery Channel Project. Beach will be removed due to channel construction, and beach nourishment in two areas will temporarily prevent use by the public.

5.5 CONCLUSIONS

Cumulative impacts due to past, existing, and reasonably foreseeable future projects, along with the CCSCCIP preferred alternative, were found to produce a net positive cumulative impact in the CCSC area. Although some parameters would experience negative impacts, most of these impacts would be temporary and minor. Benefits realized through creation and protection of wetlands, seagrass, and marsh habitat by the preferred alternative and some other projects resulted in a net positive impact assessment.

6.0 COMPLIANCE WITH TEXAS COASTAL MANAGEMENT PROGRAM

Compliance with the Texas Coastal Management Program (CMP) is documented in Appendix E. The project was reviewed and found consistent by the Coastal Coordination Council.

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7.0 CONSISTENCY WITH OTHER STATE AND FEDERAL REGULATIONS

This FEIS has been prepared to satisfy the requirements of all applicable environmental laws and regulations and has been prepared using the CEQ's NEPA regulations (40 CFR Part 1500) and the USACE's regulation ER 200-2-2 (Environmental Quality: Policy and Procedures for Implementing NEPA, 33 CFR 230). The following sections present a summary of environmental laws, regulations, and coordination requirements applicable to this FEIS.

7.1 NATIONAL ENVIRONMENTAL POLICY ACT

This FEIS has been prepared in accordance with CEQ regulations in compliance with NEPA provisions. All impacts on terrestrial and aquatic resources have been identified, significant adverse impacts requiring mitigation have been identified, and mitigation has been proposed.

7.2 NATIONAL HISTORIC PRESERVATION ACT OF 1966

Compliance with the NHPA of 1966, as amended, requires identification of all NRHP-listed or NRHP-eligible properties in the project area and development of mitigation measures for those adversely affected in coordination with the SHPO and the Advisory Council on Historic Preservation (ACHP). As indicated in Section 4.7, this project will have no impacts on NRHP-listed properties or SALs. This FEIS has been coordinated with the Texas SHPO.

7.3 CLEAN WATER ACT

Section 404 of the Act applies to the preferred alternative and compliance will be achieved under Section 404(r). Section 404(r) provides an exemption from obtaining either State water quality certification or a 404 permit if specific requirements are met. These requirements include a discussion based on the Section 404(b)(1) Guidelines in the FEIS and submittal of that document to Congress before the proposed project is authorized. The FEIS contains the necessary evaluation (Appendix A) and will be submitted to Congress for authorization. The basis for concluding that 404(r) requirements have been met is the fact that all relevant sediment and water quality data for both new-work and maintenance material were reviewed by a team of State and Federal resource agencies (Contaminants Workgroup), including the TNRCC, and they found no cause for concern over water or sediment quality in any channel reach, except the Inner Harbor. New-work sediments were deemed suitable for use in constructing BU sites or placement in the open bay or upland confined PAs. Maintenance material will be handled according to the DMM/BU Plan. The Inner Harbor dredged material will be placed in fully confined upland PAs and the decant water returned to the Inner Harbor to avoid potential contamination of other areas.

7.4 ENDANGERED SPECIES ACT

Interagency consultation procedures under Section 7 of this act have been undertaken. A BA was prepared describing the study area, Federally listed endangered and threatened species likely to occur in the area (as provided by the FWS and NMFS), and potential impacts on these listed species (attached as Appendix C). The USACE has determined that no significant impacts to Federally listed species or designated Critical Habitat will occur as a result of the project addressed in this FEIS. Agency comments, including concurrence from FWS and the NMFS Biological Opinion, have been included as an attachment to this FEIS. The NMFS has guidelines to protect sea turtles when hopper dredges are being used. These guidelines will be followed.

7.5 FISH AND WILDLIFE COORDINATION ACT OF 1958

This act requires the FWS to prepare an official Fish and Wildlife Coordination Act Report (CAR). The Final CAR is included in this FEIS as part of the Appendix D, Coordination, and constitutes compliance with the act. All project alternatives, including the preferred alternative, have been extensively coordinated with the FWS and other State and Federal resource agencies, including an 8-month piping plover survey in the project area and FWS participation in the RACT and the Workgroups concerned with mitigation and beneficial uses.

7.6 FISHERY CONSERVATION AND MANAGEMENT ACT OF 1996

Congress enacted amendments to the Magnuson-Stevens Fishery Conservation and Management Act (PL 94-265) as amended in 1996 that established procedures for identifying Essential Fish Habitat (EFH) and required interagency coordination to further the conservation of Federally managed fisheries. Rules published by the National Marine Fisheries Service (50 CFR Sections 600.805 – 600.930) specify that any Federal agency that authorizes, funds or undertakes, or proposes to authorize, fund, or undertake an activity that could adversely affect EFH is subject to the consultation provisions of the above-mentioned act and identifies consultation requirements.

EFH consists of those habitats necessary for spawning, breeding, feeding, or growth to maturity of species managed by Regional Fishery Management Councils in a series of Fishery Management Plans. Sections 3.5.1.3 and 4.4.1.4 of the FEIS were prepared to address EFH in the project area and meet the requirements of the act.

7.7 COASTAL BARRIER IMPROVEMENT ACT OF 1990

This act is intended to protect fish and wildlife resources and habitat to prevent loss of human life and to preclude the expenditure of Federal funds that may induce development on coastal barrier islands and adjacent nearshore areas. Certain exceptions exist which allow for such expenditures. The preferred alternative is exempt from the prohibitions identified in the act.

7.8 MARINE PROTECTION, RESEARCH, AND SANCTUARIES ACT

This 1972 act requires a determination that dredged material placement in the ocean will not reasonably degrade or endanger human health, welfare, or amenities or the marine environment, ecological systems, or economic potentialities (shellfish beds, fisheries, or recreational areas). All construction material destined for the Gulf of Mexico has been evaluated using the CWA 404(b)(1) guidelines (Appendix A) and will be used beneficially, as determined by the RACT. Maintenance material proposed for placement at the existing Ocean Dredged Material Disposal Site designated by the EPA for maintenance material from the Corpus Christi Entrance Channel is subject to evaluation using the ocean dumping environmental criteria.

7.9 FEDERAL WATER PROJECT RECREATION ACT

This 1995 act requires consideration of opportunities for outdoor recreation and fish and wildlife enhancement in planning water resource projects. The beneficial uses included in the project for the construction material include uses requested by various recreational groups, environmental groups, and State and Federal regulatory agencies. All will benefit one or more of the items listed above.

7.10 EXECUTIVE ORDER 11988, FLOODPLAIN MANAGEMENT

This Executive Order (EO) directs Federal agencies to evaluate the potential effects of proposed actions on floodplains. Such actions should not be undertaken that directly or indirectly induce growth in the floodplain unless there is no practical alternative. The preferred alternative will not significantly affect the Corpus Christi Bay floodplain.

7.11 EXECUTIVE ORDER 11990, PROTECTION OF WETLANDS

This EO directs Federal agencies to avoid undertaking or assisting in new construction located in wetlands, unless no practical alternative is available. The preferred alternative has been analyzed for compliance with EO 11990. Erosion protection measures and beneficial uses should result in a net gain in wetland habitat.

7.12 TEXAS COASTAL MANAGEMENT PROGRAM

Section 6.0 and Appendix E address the compliance of the preferred alternative addressed in this FEIS with the TCMP, including a Consistency Agreement by the Coastal Coordination Council.

7.13 CEQ MEMORANDUM DATED 11 AUGUST 1980, PRIME OR UNIQUE FARMLANDS

There will be no impacts to prime and unique farmlands from the preferred alternative.

7.14 EXECUTIVE ORDER 12898, ENVIRONMENTAL JUSTICE

This EO directs Federal agencies to determine whether the preferred alternative will have a disproportionate adverse impact on minority or low-income population groups within the project area.

The preferred alternative has been analyzed for compliance with EO 12898. The preferred alternative will not significantly affect any low-income or minority population.

7.15 CLEAN AIR ACT OF 1972

This act is intended to protect and enhance the quality of the nation's air resources; to initiate and accelerate research and development to prevent and control air pollution; to provide technical and financial assistance for air pollution prevention and control programs; and to encourage and assist regional air pollution prevention and control programs. The preferred alternative is in compliance with this Act.

7.16 MARINE MAMMAL PROTECTION ACT OF 1972

This act, passed in 1972 and amended through 1997, is intended to conserve and protect marine mammals, establish a marine mammal commission, establish the International Dolphin Conservation Program, and establish a Marine Mammal Health and Stranding Response Program. The preferred alternative is in compliance with this Act.

8.0 PUBLIC INVOLVEMENT, REVIEW, AND CONSULTATION

Review and consultation of this document was performed by the USACE, PCCA, and RACT members.

8.1 PUBLIC INVOLVEMENT PROGRAM

The USACE and PCCA involved the public through outreach programs such as newsletters, public meetings, special interest group meetings, and other outreach throughout the history of this project. A proactive approach was taken to inform and involve the public, resource agencies, industry, local government, and other interested parties about the project and to identify any concerns from the aforementioned groups. Appendix D contains only a portion of the official record of communication with the public. The most pertinent documents were chosen to include in Appendix D.

In 1990, the U.S. Congress authorized the USACE to begin a reconnaissance study to investigate deepening the CCSC. Public involvement began during the reconnaissance phase on March 30, 1994, when the USACE held a public workshop to describe the study and solicit public input. In September 1994, the USACE completed the reconnaissance study. The study concluded that the benefits of channel improvements would be 2.5 times greater than the project cost. Therefore, the recommendation was made to proceed into the feasibility phase. Nine public meetings followed to update the public about the progression of the project and to solicit input. A series of newsletters was also sent to approximately 1,300 people or organizations in the area, including those who attended meetings or expressed an interest in the project or could potentially be interested in the project. In addition to the general public meetings, special-interest group meetings were also held. Other various forms of outreach utilized during this project included early regulatory agency coordination, RACT/Workgroup meetings, individual contacts, a toll-free 800 number, Spanish voice mailbox, web site posting, press releases, and comment forms.

8.2 REQUIRED COORDINATION

The Draft Feasibility Report and DEIS have been circulated to all known Federal, State, and local agencies. Interested organizations and individuals were sent notice of availability.

8.3 STATEMENT RECIPIENTS

The following list includes those who were sent a copy of these documents along with a request to review and provide comments on the documents:

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8.4 PUBLIC VIEWS AND RESPONSES

Public views and concerns expressed during this study have been considered during the preparation of this FEIS. The views and concerns were used to develop planning objectives, identify significant resources, evaluate impacts of various alternatives, identify potential beneficial uses, and identify a plan that is socially and environmentally acceptable. Important concerns expressed included the beneficial use of dredged material and recreational opportunities.

Development of alternatives is explained in the Feasibility Report. The recommended plan meets the expressed objectives, views, and concerns of the resource agencies and public. Comment letters on the DEIS, and responses to those comments, are included in Appendix D.

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9.0 LIST OF PREPARERS

The USACE Project Manager for the Corpus Christi Ship Channel – Channel Improvements Project EIS is Carl Anderson. PCCA Project Manager is David Krams.

PBS&J key personnel responsible for preparation of the EIS are listed below:

Topic/Area of Responsibility	Name/Title	Experience
U.S. Army Corps of Engineers, Galveston District		
Document Coordination & Review	Carolyn Murphy Environmental Section Chief	24 Years, Planning and Environmental Resources
Document Coordination & Review	Bob Heinly Project Engineer	11 Years, Civil Works Planning and Regulatory Branch
Document Coordination & Review	Terrell W. Roberts, Ph.D. Wildlife Biologist	18 Years, Environmental, Threatened, and Endangered Species Impact Analysis
Document Coordination & Review (Archaeological)	Janelle Stokes Archaeologist	21 Years, Cultural Resources Coordination, Archaeological Research and Surveys
Document Coordination & Review	John McManus Civil Engineer	29 Years, Civil Engineering
Document Coordination & Review	Dave McLintock Hazardous, Toxic, and Radioactive Waste, Water/ Air Quality	16 Years, Environmental Protection
Port of Corpus Christi Authority		
Document Coordination & Review	David Krams Senior Project Engineer/ Project Manager	18 Years, Engineering/Project Management
Document Coordination & Review	Paul Carangelo Environmental Project Manager	26 Years, Environmental Planning/ Project Management
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Project Manager	Martin Arhelger Vice President, Project Director	27 Years, Environmental Assessment and Impact Analysis
Assistant Project Manager, Document Review (Project Description, Alternatives Analysis)	Kari Jecker Ecologist	7 Years, Natural Resources Management and Impact Analysis
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Air Quality	Ruben Velasquez, P.E. Senior Engineer, Air Quality Specialist	19 Years, Air Quality Analysis
Vegetation; Endangered and Threatened Plant Species	Kathy Calnan Ecologist, Botanist	13 Years, Vegetation Analysis and Impacts
Hazardous Materials	Steve McVey Geologist, HAZMAT Specialist	8 Years, Environmental Geology
Historical/Cultural Resources – Terrestrial	Meg Cruse Archaeologist	14 Years, Archaeology
Land Use; Environmental Justice; Socioeconomics	Chris Moore Environmental Planner	6 Years, Urban and Environmental Planning
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Noise	Thomas Ademski Environmental Planner	3 Years, Environmental Planning and Noise Analysis
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Technical Support	Bob Bryant Lead Word Processor	13 Years, Word Processing

10.0 REFERENCES, ABBREVIATIONS, INDEX, AND GLOSSARY

10.1 REFERENCES

Alexander, F., E. Cousins, K. Evans, S.J. Johnson, V.W. McKinney, P. Peckenpaugh, B. Roberts, L.H. Sparks, E.M. Tubbs, H.W. Ward, E.D. Williams, M.P. Wise, and D. Woods. 1950. Padre Island by Writers' Round Table. The Naylor Company, San Antonio, Texas.

Alperin, L.M. 1977. Custodians of the Coast, History of the United States Army Corps of Engineers at Galveston. Galveston District, United States Army Corps of Engineers, Galveston.

American Ornithologist's Union (AOU). 1983. Committee on classification and nomenclature. Check-list of North American birds. 6th edition. American Ornithologists Union, Allen Press, Inc., Lawrence, Kansas.

———. 1998. Check-list of North American birds. 7th edition. Allen Press, Lawrence, Kansas. 829 pp.

Audubon Outdoor Club of Corpus Christi (AOCCC). 1994. Checklist of the birds within a 40-mile radius of Corpus Christi, Texas. 6th edition. Audubon Outdoor Club of Corpus Christi, Corpus Christi, Texas.

Babin, F. 2002. Personal communication with Chris Moore (PBS&J) and Fred Babin (Transportation Manager), Port of Corpus Christi. April 2, 2002.

Bailey, G.L. 1987. Archeological Bibliography of the Southern Coastal Corridor Region of Texas. Special Report 29. Office of the State Archeologist, Texas Historical Commission, Austin.

Barrera, T.A., Gamble, L.R., Jackson, G. Maurer, T. Robertson, S.M. and M.C. Lee. 1995. Contaminants assessment of the Corpus Christi Bay complex, Texas 1988-1989. U.S. Fish and Wildlife Service, Ecological Services, Corpus Christi, Texas, Region 2. September 1995. 61 pp. + appendices.

Bartlett, R.D. and P.P. Bartlett. 1999. A field guide to Texas reptiles and amphibians. Gulf Publishing Company, Houston, Texas.

Beasley, P.W. 1998. Texas Agricultural Experiment Station, Texas A&M University System, Port Aransas, Texas. Personal communication to F. Davis, EH&A, October 29.

Beaver, C. 2001. Center for Coastal Studies, Texas A&M University–Corpus Christi. Personal communication to S. Copeland, PBS&J, 24 September.

Black, S.L. 1989. South Texas Plains. In: From the Gulf to the Rio Grande: Human Adaptation in Central, South, and Lower Pecos, Texas. Arkansas Archeological Survey Research Series No. 33.

Black, S.L. and L. Highley. 1985. An Archaeological Survey of a Proposed Dredge Spoil Site in Nueces County, Texas. Center for Archaeological Research, The University of Texas at San Antonio. Archaeological Survey Report No. 148.

Blair, W.F. 1950. The Biotic Provinces of Texas. Tex. J. Sci. 2:93-117

Blumer, M. 1969. Oil pollution of the ocean. In: Oil on the sea, D.P. Hoult (Ed.). Plenum Publishing Co., New York. p. 5-13.

Board of Engineers. 1946. Chart of Aransas and Corpus Christi Bays, Report of Board of Engineers, July 9, 1846. La Retama Public Library. Corpus Christi.

Boren, J. 2001. Personal communication with Chris Moore of PBS&J and James Boren (Planner), City of Portland – Planning Department, Portland, Texas. August 14.

Brannon, J.M., R.H. Plumb, and I. Smith. 1978. Long-term release of contaminants from dredged material. DMRP. USAEWES. Technical Report D-78-49.

Breuer, J.P. 1962. An ecological survey of the lower Laguna Madre of Texas, 1953-1959. *Publications of Institute of Marine Sciences, University of Texas* 8: 153-183.

———. 1972. Ecological survey of the Brownsville Ship Channel, 1971-1972. Coastal Fisheries Project, TPWD. Mimeo.

Briggs, A.K. 1971. Archeological resources in the Texas coastal lowlands and littoral. Office of the State Archeologist Special Report 5. Texas Historical Commission, Austin.

Brown, C.L. and R. Clark. 1968. Observations on dredging and dissolved oxygen in a tidal waterway. Water Resour. Res. 4(6): 1381-1384.

Britton, J.C. And B. Morton. 1989. Shore ecology of the Gulf of Mexico. University of Texas Press, Austin, Texas, 387 pp.

Brown, L.F. Jr., J.L. Brewton, J.H. McGowen, T.J. Evans, W.L. Fisher, and C.G. Groat. 1976. Environmental geologic atlas of the Texas coastal zone: Corpus Christi area. Bureau of Economic Geology, University of Texas, Austin, Texas. 123 pp.

Buchman, Michael. 1999. National Oceanic and Atmospheric Administration (NOAA) Screening Quick Reference Tables. HAZMAT Report 99-1.

Burd, A.B. and K.H. Dunton (in press). Field verification of a light-driven model of biomass changes in the seagrass *Halodule wrightii*: Marine Ecology Progress Series.

Buskey, E.J., S. Stewart, J. Peterson, and C. Collumb. 1996. Current status and historical trends of Brown Tide and Red Tide phytoplankton blooms in the Corpus Christi Bay National Estuary Program Study Area. 1-173 pp. In T. E. Whitledge and J. W. Tunnell Jr. (eds.), Corpus Christi Bay National Estuary Program – Living Resources. Vol: CCBNEP-07. Texas Natural Resource Conservation Commission, Austin, Texas.

Calhoun, C.A. 1964. A polychrome vessel from the Texas Coastal Bend. Bulletin of the Texas Archeological Society 35:205-212.

Campbell, L. 1995. Endangered and threatened animals of Texas, their life history and management. Texas Parks and Wildlife, Resource Protection Division, Endangered Resources Branch. Austin, Texas. 130 pp.

Campbell, T.N. 1956. Archeological material from Five Islands in the Laguna Madre, Texas coast. Bulletin of the Texas Archeological Society, Volume 27.

———. 1958. Archeological remains from the Live Oak Point site, Aransas County. The Texas Journal of Science 10(4):423-442.

———. 1964. Appraisal of the Archeological Resources of Padre Island, Texas. Report submitted to the National Park Service by the Anthropology Department, The University of Texas at Austin.

Carangelo, P.D. 2001. Data Report and Assessment Concerning Potential Ballast Introduction into the Port of Corpus Christi, Texas. Data compilation, Screening, Determination of Potential Source and Volume of Ballast Water, and Comparison of Existing Project Future Conditions and Proposed Corpus Christi Ship Channel Improvement Project Future Conditions. In Draft.

Carlson, D.L. 1983. Archeological survey of the Hilltop Nature Area, Nueces County, Texas. Archeological Research Laboratory, Texas A&M University, College Station.

Carlson, D.L., D.G. Steele, and H.L. Bruno. 1982. Archeological Investigations at the Allison Site (41NU185), Nueces County, Texas. Reports of Investigations No. 1. Archeological Research Laboratory, Texas A&M University, College Station.

Carr, R.S., P.A. Montagna, and M.C. Kennicutt II. 1997. Sediment Quality Assessment of Storm Water Outfalls and Other Sites of Concern in the Corpus Christi Bay National Estuary Program Study Area. 167 pp.

Clarke, D. and T. Miller-Way. 1992. An environmental assessment of the effects of open-water disposal of maintenance dredged material on benthic resources in Mobile Bay, Alabama. Report number: Miscellaneous Paper D-92-1, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Collins, H.C. H.S. Douglas, and W.H. Hoffman. 1878. To accompany report on survey of Corpus Christi and Aransas Passes and Bays and their connections. Texas Historical Commission, Map File of the State Nautical Archaeologist. Austin.

Collins, J.T. 1990. Standard common and current scientific names for North American amphibians and reptiles. Third ed. Society for the Study of Amphibians and Reptiles, miscellaneous publications, Herpetological Circular No. 19. 41 pp.

Compagno, L.J.V. 1984. Sharks of the world. An annotated and illustrated catalogue of sharks species known to date. Part 1. Hexanchiformes to Lamniformes. FAO Fish Synop. 125:1-249.

Corbin, J.E. 1963. Archeological materials from the northern shore of Corpus Christi Bay, Texas. Bulletin of the Texas Archeological society 34:5-30.

Corpus Christi Bay National Estuary Program (CCBNEP). 1996a. Current status and trends of the estuarine living resources within the Corpus Christi Bay National Estuary Program study area. CCBNEP-06A. Volume 1. CCBNEP, Corpus Christi, Texas. 543 pp.

———. 1996b. Project summary for current status and historical trends of the estuarine living resources within the Corpus Christi Bay National Estuary Program study area. CCBNEP-06C. Volume 3. CCBNEP, Corpus Christi, Texas. 116 pp.

Corpus Christi Chamber of Commerce. 2000. Available on the internet: <http://www.portcityplaza.com/employment.html> Accessed on October 14, 2000.

———. 2002. Information on Corpus Christi's Labor Force. Available on the Internet at: http://www.corpuschristichamber.org/relocation_info/overview_contents.htm > Accessed on April 2, 2002.

Corpus Christi, City of. 2001a. City of Corpus Christi's Information and Services Directory. Available on the internet: <http://www.ci.corpus-christi.tx.us> Accessed on July 30, 2001.

———. 2001b. Description of Comprehensive Planning Program – City of Corpus Christi – Planning Department. Available on the internet: http://www.ci.corpus-christi.tx.us/services/planning/compln2.html.

Corpus Christi Regional Economic Development Corporation. 2002. Business Environment – Major Employers. Obtained from the Port of Corpus Christi via facsimile, on April 5, 2002.

Correll, D.S. and M.C. Johnston. 1970. Manual of the vascular plants of Texas. The University of Texas at Dallas, Richardson, Texas. 1881 pp.

Dankers, N. and D. R. Zuidema. 1995. The role of the mussel (*Mytilus edulis* L.) and mussel culture in the Dutch Waden Sea. Estuaries 18:71-80.

Davis, W.B. and D.J. Schmidly. 1994. The mammals of Texas. Texas Parks and Wildlife. Distributed by University of Texas Press. 338 pp. Austin.

De Yoe, H.R., D.A. Stockwell, R.R. Bidigare, M. Latasa, P.W. Johnson, P.E. Hargraves, and C.A Suttle. 1997. Description and characterization of the algal species *Aureoumbra lagunensis gen. et. sp. nov.* and referral of *Aureoumbra* and *Aureococcus* of the Pelagophyceae. J. Phycol. 33: 1042-1048.

Dixon, J.R. 1987. Amphibians and Reptiles of Texas. Texas A&M University Press. College Station, Texas. 434 pp.

———. 2000. Amphibians and reptiles of Texas. Second edition. Texas A&M University Press, College Station, Texas.

Dunn, G.E. and Miller, B.I. 1964. Atlantic hurricanes: Baton Rouge, Louisiana State University Press. 377 pp.

Dunstan, W. M., L. P. Atkinson and J. Netoli. 1975. Stimulation and inhibition of phytoplankton growth by low molecular weight hydrocarbons. Mar. Biol. 31:305-310.

Enright, J., R.L. Gearhart, C.L. Bond, and J. Watts. n.d. Marine Remote-Sensing Survey of Beneficial Use Areas and Diving Assessment of Nine Anomalies for Historic Properties, Corpus Christi Ship Channel Improvements and La Quinta Channel Improvements and Extension, Corpus Christi Bay, Texas (in press). Prepared for the U.S. Army Corps of Engineers, Galveston District. Austin, Texas.

Espey, Huston & Associates (EH&A). 1978. The biological effects of turbidity. Prepared for Board of Trustees, Galveston Wharves and Northville Industries Corporation. EH&A Doc No. 78187.

———. 1979. Final Environmental Assessment Report. Proposed multipurpose deepwater port and crude oil distribution system, Galveston, Texas. Prep. for Board of Trustees, Galveston Wharves and Northville Industries Corporation.

———. 1980. Dredging impact study. Prep. for Brownsville Navigation District. EH&A Doc. No. 80221.

———. 1981. Proposed deepwater channel and multipurpose terminal construction and operation near Brownsville, Texas. EH&A Document NO. 80490. Austin, Texas.

———. 1985. Corpus Christi Ship Channel, Texas, Biological Services. EH&A Document No. 85222: 55 pp + Appendices. Austin, Texas.

———. 1993. *Piping plover survey, Commodore's Cove, Unit II, Nueces County, Texas.* EH&A Document No. 930776. Austin.

———. 1995. Corpus Christi Entrance Channel Contaminant Assessment. EH&A Document No. 950619: 14 pp + Appendices. Austin, Texas.

Fields, R.C. 1984. An Archeological Survey of Two Alternate Well Pad Locations in the Padre Island National Seashore, Kenedy County, Texas. Prewitt and Associates Letter Report No. 259, Austin, Texas.

Fitzpatrick, W.S., J. Fitzpatrick, and T.N. Campbell. 1964. A Rockport Black-on-Gray Bessel from the Vicinity of Corpus Christi, Texas. Bulletin of the Texas Archeological Society 35:193-204.

Flemer, David A., W.L. Dovel, et al. 1968. Gross Physical and Biological Effects of Overboard Spoil Disposal in Upper Chesapeake Bay. J. Samit Eng. Div., Proc. Am., Soc. Civ. Engin. 94:683-706.

Fox, A.A. and T.R. Hester. 1976. An Archaeological Survey of Coleto Creek, Victoria and Goliad Counties, Texas. Archaeological Survey Report No. 18. Center for Archaeological Research, The University of Texas at San Antonio.

Freeman, M.D. 1990. Culture history of Europeans, Africans and their descendents. The Archeology and Bioarcheology of the Gulf Coastal Plain: Vol 2. Arkansas Archeological Survey Research Series No. 38. Fayetteville.

Fugro South, Inc. 2000. Field Exploration Services Corpus Christi Ship Channel and La Quinta Channel Proposed Extension Port of Corpus Christi Authority Corpus Christi, Texas. Prepared for the Port of Corpus Christi Authority. Report No. 1600-0129.

Gardner, K.M. 2001. Cultural affiliation overview of the Galveston District. Review Draft submitted to the U.S. Army Corps of Engineers, Galveston District. Prewitt and Associates, Inc. Austin.

Garrett, J.M. and D.G. Barker. 1987. A field guide to reptiles and amphibians of Texas. Texas Monthly Field Guide Series. Texas Monthly Press. Austin, Texas. 225 pp.

Gibson and Hester. 1982. An Archeological Survey of a Pelto Oil Company Well Drilling Site on North Padre Island, Kleberg County, Texas. A report by the Center for Archeological Research, The University of Texas at San Antonio.

Gill, R.E. Jr.; P. Canevari; and E.H. Iversen. 1998. Eskimo curlew (*Numenicus borealis*). In: The Birds of North America, no. 347 (A. Poole and F. Gill, editors). The Birds of North America, Inc., Philadelphia, PA.

Good, Carolyn. 1984. Letter report: Cultural resources assessment. Project area in Nueces County, Texas. COE permit 17078, Galveston.

Goodwyn, F. 1970. Behavior, life history and present status of the jaguarundi, *Felis yagouaroundi* (Lacepede), in South Texas. M.S. thesis, Texas A&I University, Kingsville, Texas. 63 pp.

Gould, F.W. 1975. Texas plants – a checklist and ecological summary. MP-585/Rev. Texas A&M University, Texas Agricultural Experiment Station, College Station, Texas. 121 pp.

Green, N. 1985. The Bald Eagle. In: A.M. Enos and R.L. DiSilvestro (editors), Audubon wildlife report 1985. Pp. 508-531. National Audubon Society, New York.

Gulf of Mexico Fishery Management Council. 1998. Generic Amendment for Addressing Essential Fish Habitat Requirements in the Following Fishery Management Plans of the Gulf of Mexico: Shrimp Fishery of the Gulf of Mexico, Red Drum Fishery of the Gulf of Mexico, Reef Fish Fishery of the Gulf of Mexico, Coastal Migratory Pelagic Resources (Mackerels) in the Gulf of Mexico and South Atlantic, Stone Crag Fishery of the Gulf of Mexico, Spiny Lobster in the Gulf of Mexico and South Atlantic, and Coral and Coral Reefs of the Gulf of Mexico. National Oceanic and Atmospheric Award No. NA87FC0003.

Gulf of Mexico Program. 2000. An Initial Characterization of nonindigenous aquatic species in the Gulf of Mexico Region. Nonindigenous Species Focus Team. September.

Guthrie, K. 1988. Texas Forgotten Ports: Mid Gulf Ports from corpus Christi to Matagorda Bay. Eakin Press. Austin, Texas.

Guzman, H.M. and R.W. Schreiber. 1987. Distribution and status of brown pelicans in Venezuela in 1983. Wilson Bull. 99(2):275-279.

Haig, S.M. and L.W. Oring. 1985. Distribution and status of the piping plover throughout the annual cycle. J. Field Ornithol. 56(4):334-345.

———. 1987. The piping plover. In: 1987 Audubon Wildlife Report. National Audubon Society, Academic Press, New York, pp. 508-519.

Hallbrook, K. 2001. Personal communication with Chris Moore of PBS&J and Kim Hallbrook (Assistant City Manager), City of Port Aransas, Texas. August 14.

Hall, E. R. 1981. The Mammals of North America. 2 vol. John Wiley & Sons, New York. 1180 pp.

Hall, G.D. 1987. A perspective on some prehistoric cemeteries in Texas: Loma Sandia in the regional setting. In Archaeological Investigations at the Loma Sandia Site (41LK28): A Prehistoric Cemetery and Campsite in Live Oak County, Texas (review draft), By A.J. Taylor and C.L. Highley. Texas Department of Transportation, Austin.

Hammer, Siler, George Associates (HSGA). 1997. Economic Impact Analysis – Packery Channel Project. Prepared for Nueces County, Texas. April.

Hatch, S.L., K.N. Gandhi, and L.E. Brown. 1990. Checklist of the vascular plants of Texas. TAES, Texas A&M University. College Station, Texas. 158 pp.

Headrick, P. 1993. The Archeology of 41NU11, The Kirchmeyer Site, Nueces County, Texas: Long Term Utilization of a Coastal Clay Dune. Studies in Archeology 15, Texas Archeological Research Laboratory, The University of Texas at Austin.

Heines and Williams. 2001. Corpus Christi and the Texas Coastal Bend – Insider's Guide. The Globe Pequot Press. Guilford, Connecticut.

Heinly, R.W. 1990. Seasonal occurrence and distribution of stranded sea turtles along the Texas and Southwest Louisiana coasts. Texas A&M University master thesis. December.

Henningson, B.F. 1977. Temporal effects of dredging and dredged material disposal of nekton in the offshore waters of Galveston, Texas, with notes on the natural history of the most abundant taxa. M.S. Thesis, Texas A&M Univ., College Station. 229 pp.

Henry, C. A. 1976. A study of offshore benthic communities in natural areas and in areas affected by dredging and dredged material disposal. M.S. thesis, Texas A&M Univ., College Station. 186 pp.

Hester, T. R. 1980. Digging Into South Texas Prehistory. Corona Publishing Company, San Antonio.

Hicks & Company Environmental/Archeological Consulting and Lockwood Andrews & Newman. (Hicks et al.) 1999. Environmental Assessment for Park Road 22 - JFK Causeway.

Highley, C.L, A. Gerstle, and T.R. Hester. 1977. An archaeological and historical assessment of the Tule Lake tract, Nueces County, Texas. Center for Archaeological Research, The University of Texas at San Antonio. Archaeological Survey Report 27 prepared for U.S. Army Engineer District, Galveston, Corps of Engineers in fulfillment of Purchase Order No. DACW64-767-M-0269.

Hildebrand, H. 1983. Random notes on sea turtles in the western Gulf of Mexico. In: D. Owens et al. (editors) Proc. Western Gulf of Mexico Sea Turtle Workshop, Texas A&M University, College Station, Texas. Pp. 34-40. TAMU-SG-84-105. 74 pp.

———. 1986. Personal communication to Derek Green, EH&A, January 16, 1986. Corpus Christi, Texas.

———. 1987. A reconnaissance of beaches and coastal waters from the border of Belize to the Mississippi River as habitats for marine turtles. Report prepared for National Marine Fisheries Service, Southeast Fisheries Center, Panama City Laboratory, Panama City, Florida. Purchase Order No. NA-84-CF-A-134. 63 pp.

Hirsch, N. D., L. H. DiSalvo, and R. Peddicord. 1978. Effects of dredging and disposal on aquatic organisms. U.S. Army Corps of Engineers, Waterways Eper. Sta. Tech. Rep. DS-78-5.

Hoese H.D. and R.H. Moore. 1998. The Fishes of the Gulf of Mexico Texas, Louisiana, and Adjacent Waters. Texas A&M University Press, College Station, Texas. 422 pp.

Hopkins, T.S. 1972. The effects of physical alteration on water quality in Mulatto Bayou, Excambia Bay. Quarterly Journal Florida Academy of Sciences 35(1): 2 (Abstr.).

Hosea, Diane. 2002. City Hall, city secretary. Personal communication with K. Martel, PBS&J. January 18, 2002.

Howard, M., M.D. Freeman, E. Morley, L. McNatt, C.G. Ward and C. Beceiro. 1997. Archeological Survey and History of Mustang Island State Park, Nueces County, Texas. Texas Parks and Wildlife, Cultural Resources Program, Austin.

Hoyt, S.D. 1990a. Remote sensing survey, diver verification and cultural resource assessment Port Mansfield entrance channel and vicinity, Willacy County, Texas. Espey, Huston & Associates Document No. 890518, Austin, Texas.

Hoyt, S.D. 1990b. National Register Assessment of the *SS Mary*, Port Aransas, Nueces County, Texas. Prepared for the U.S. Army Corps of Engineers, Galveston District (EH&A Document No. 900311). Austin, Texas.

Hoyt, S.D. and J. Stokes. 2001. Agency coordination meeting between U.S. Army Corps of Engineers, Texas Historical Commission and PBS&J. September 27, 2001.

Ingleside Chamber of Commerce. 2002. Major Employers. Available on the Internet at: <http://www.inglesidetxchamber.org/demographics2.htm#employment> Accessed on April 2, 2002.

James, S.R. Jr. and C.E. Pearson. 1991. Magnetometer survey and ground truthing anomalies, Corpus Christi Ship Channel, Aransas and Nueces Counties, Texas. Coastal Environments, Inc., Texas Antiquities Permit No. 1008. Baton Rouge, Louisiana. Submitted to the U.S. Army Corps of Engineers, Galveston District.

Jones, C., R.S. Hoffmann, D.W. Rice, M.D. Engstrom, R.D. Bradley, D.J. Schmidly, C.A. Jones, and R.J. Baker. 1997. Revised checklist of North American mammals north of Mexico, 1997. Occ. Papers, Museum of Texas Tech University, Number 173. 19 pp.

Jones, R.A. and G.F. Lee. 1978. Evaluation of the elutriate test as a method of predicting contaminant release during open-water disposal of dredged sediments and environmental impact of open-water dredged material disposal. Technical Report D-78-45, U.S. Army Waterways Experiment Station, Vicksburg, Miss. 217 pp.

Jones, F.B. 1977. Flora of the Texas Coastal Bend. Mission Press, Corpus Christi, Texas.

Kral, Robert. 1983. A report on some rare, threatened, or endangered forest-related vascular plants of the south. Vol. II. Technical publication R8-TP2, U.S. Department of Agriculture, Forest Service, Southern Region.

Kuehne, C.M. 1973. Hurricane Junction: A History of Port Aransas. St. Mary's University, San Antonio.

LaRue, J. 2001. Personal communication with Chris Moore of PBS&J and John LaRue (Executive Director), Port of Corpus Christi, Corpus Christi, Texas. August 14.

Lee, G.F. 1976. Dredged material research problems and progress. *Environmental Science & Technology* 10:334.

Lee Wilson & Associates, Inc. (LW&A). 1998a. Characterization of dredged material, Laguna Madre, Texas. LW&A Document No. EP556014. Santa Fe, New Mexico.

Marroquin, Rosaura. 2002. Ingleside Volunteer Fire Department, administrative assistant. Personal communication with K. Martel, PBS&J. January 18, 2002.

Martin, G.D. and W.H. Potter. (ND). Preliminary Archaeological Survey of a Portion of the Texas Coast. Privately printed, ca 1931. Copy on file at the Texas Archeological Research Laboratory, J.J. Pickle Research Campus, The University of Texas at Austin.

Matsumoto, J., B. Austin, C. Paternostro, and G. Powell. 2001. Tidal elevation and salinity changes due the Corpus Christi Ship Channel Improvement Project: Preferred Plan. Texas Water Development Board, Austin, Texas.

Maurer, D., R.T. Keck, J.C. Tinsman, W. A. Leathem, C. Wethe, C. Lord, and T.M. Church. 1986. Vertical migration and mortality of marine benthos in dredged material: a synthesis. International revue gestam Hydrobiologia 71:49-63.

May, E.B. 1973. Environmental effects of hydraulic dredging in estuaries. Alabama Marine Resources Bulletin 9:1-85.

McDonald, K.L. and D.S. Dibble. 1973. An archeological and historical resource inventory of a site in San Patricio County, Texas. Research Report No. 33, Texas Archeological Survey, The University of Texas at Austin.

McGowen, J.H. and R.A. Morton. 1979. Sediment distribution, bathymetry, faults and salt diapirs, submerged lands of Texas. Bureau of Economic Geology, The University of Texas at Austin. 31 pp.

McHugh, J.L. 1967. Estuarine nekton. Pages 581-620 in Lauff, G. H. (ed.), Estuaries. Amer. Assoc. Advanc. of Sci. Publication No. 83. Washington, D. C.

Mercado-Allinger, P.A and R.A. Ricklis. 1996. Regional Preservation Plan for Archeological Sites, Southern Coastal Corridor Archeological Region, Central & Southern Planning Region In Archeology in the Central and Southern Planning Region, Texas: A Planning Document. Office of the State Archeologist, Special Report 35 and the Department of Antiquities Protection, Cultural Resource Management Report 7. Austin.

Michaels, K. 2001. Personal communication with Chris Moore of PBS&J and Kari Michaels, Tri-County EMS, San Patricio County, Texas. September 7, 2001.

Miles, D.W. 1950. The life histories of the spotted seatrout (*Cynoscion nebulosus*) and redfish (*Sciaenops ocellatus*). Texas Game, Fish and Oyster Comm., Marine Lab. Ann. Rpt. (1949-1950): 66-103.

Mitchell, M.R. 1999. Bald eagle nest survey and management. Performance Report, Federal Aid Grant No. W-125-R-6, Project No. 30. Texas Parks and Wildlife, Austin, Texas. 31 August 1999.

Montagna, P.A., S.A. Holt, K.H. Dunton. 1998. Characterization of Anthropogenic and Natural Disturbance on Vegetated and Unvegetated Bay Bottom Habitats in the Corpus Christi Bay National Estuary Program Study Area. Final Project Report, Corpus Christi Bay National Estuary Program, Corpus Christi, Texas.

Moore, P.G. 1977. Inorganic particulate suspensions in the sea and their effects on marine animals. Ann. Rev. Oceanogr. Mar. Biol. 15:225-363.

Moore, S.F. and R.L. Dwyer. 1974. Effects of oil on marine organisms: A critical assessment of published data. Water Res. 8:819-827.

Mortimer, J.A. 1982. Feeding ecology of sea turtles. In: K. Bjorndal (editor), Biology and Conservation of Sea Turtles. Pp. 103-109. Smithsonian Institution Press, Washington, D.C. 583 pp.

Morton, J.W. 1977. Ecological effects of dredging and dredge spoil disposal: a literature review. Technical Papers U.S. Fish and Wildlife Ser. #94.

Mounger, M.A. 1959. Mission Espiritu Santo of coastal Texas: an example of historic site archaeology. M.A. Thesis, the University of Texas at Austin.

Murphy, Carolyn. 2001. Personal communication with James E. Bruseth. 9 May.

Musick, J.A., S. Branstetter, and J.A. Colvocoresses. 1993. Trends in shark abundance from 1974-1991 for the Chesapeake Bight region of the U.S. mid-Atlantic coast. Pp. 1-18. In: Conversation Biology of Elasmobranchs (Branstetter, S. ed.). NOAA Tech. Rep. NMFS 115.

National Fish and Wildlife Laboratory (NFWL). 1980. Selected vertebrate endangered species of the seacoast of the United States – Brown Pelican Eastern and California subspecies. U.S. Fish and Wildlife Service, Biological Services Program, Washington, D.C. FWS/OBS-80/01.40. 16 pp.

National Marine Fisheries Service and U.S. Fish and Wildlife Service (NMFS and FWS). 1991a. Recovery plan for U.S. population of loggerhead turtle. National Marine Fisheries Service, Washington, D.C. 64 pp.

———. 1991b. Recovery plan for U.S. population of Atlantic green turtle. National Marine Fisheries Service, Washington, D.C. 52 pp.

———. 1992. Recovery plan for leatherback turtles in the U.S. Caribbean, Atlantic, and Gulf of Mexico. National Marine Fisheries Service, Washington, D.C. 65 pp.

National Marine Fisheries Service (NMFS). 2000. Leatherback sea turtle (*Dermochelys coriacea*) endangered species. Available on the internet: <http://www.nmfs.noaa.govt/prot-res/species/turtles/leatherback.html>

———. 2001. Available on the internet: <http://www.nmfs.noaa.gov/prot_res/PR3/ candidates/ candidate.html>

Natural Resources Conservation Services (NRCS). 1992. Land Use Estimates by county for Texas. Natural Resources Inventory Division. Available on the internet: <http://www.nhq.usda.gov/ NRI/get_data.html>

Nature Serve: an online encyclopedia of life [web application]. 2000. Version 1.0. Arlington (VA): Association for Biodiversity Information. Available on the internet: <http://www.natureserve.org/> Accessed: October 16, 2000.

———. 2000a. Comprehensive report species *Charadrius montanus*.

———. 2000b. Comprehensive report species *Trichecus manatus*.

New World Research (NWR). 1981a. Cultural Resources Survey of Proposed Seismic Test Lines in the Vicinity of the Port Mansfield Channel, Padre Island, Texas. New World Research Report of Investigations, No. 54.

———. 1981b. Cultural Resources Survey of Twelve Proposed Seismic Lines within the Padre Island National Seashore, Kenedy County, Texas. New World Research Report of Investigations, No. 55.

Newcomb, W.W. Jr. 1993. Indians of Texas. University of Texas Press. Austin.

Nueces County. 2001. Texas and Nueces County History, Dates, & Addresses. Available on the internet: <http://www.rootsweb.com/~txcbgs/history.htm/> Accessed on July 30, 2001.

Nueces County Tax Office. 2001. Taxing Jurisdictions in Nueces County. Available on the internet: <http://www.co.nueces.tx.us/taxoffice/taxjurisdictions.asp/> Accessed August 2, 2001.

Oberholser, H.C. 1974. The Bird Life of Texas. 2 vol. University of Texas Press, Austin, Texas. 1,069 pp.

Odum, H.T. and R.F. Wilson. 1962. Further studies on reaeration and metabolism of Texas Bays, 1958-1960. Publ. Inst. Mar. Sci., Univ. of Tex. (8):23-25.

O'Shea, T.J., and M.E. Ludlow. 1992. Florida manatee (*Trichechus manatus tatirostris*). Pp. 190-200 in S.R. Humphrey (editor). Rare and endangered biota of Florida. Volume 1: Mammals. University Press of Florida, Gainesville, Florida.

Pacific International Engineering (PIE). 2001a. Corpus Christi Channel Improvement Project Shoreline Erosion Study. Prepared for Port of Corpus Christi Authority. Corpus Christi, Texas.

———. 2001b. Gulf of Mexico Shoreline Impact Study: Corpus Christi Ship Channel, Channel Improvement Project, Port of Corpus Christi Authority. Prepared for the Port of Corpus Christi Authority. Corpus Christi, Texas.

Patterson, P.E. and M.M. Ford. 1974. Oso Creek Flood Control Project Area, Nueces County, Texas: A Report on the Archeological and Historical Resources. Research Report No. 35. Texas Archeological Survey, The University of Texas at Austin.

Payne, B. 2001. Personal communication with Chris Moore of PBS&J and Bob Payne (Senior Planner), City of Corpus Christi Planning and Development Department – Comprehensive Planning Division, Corpus Christi, Texas. August 3.

PBS&J. 1999. Supplemental Environmental Impact Statement. Maintenance Dredging of the GIWW Laguna Madre, Texas. September.

———. 2001. Final report, piping plover and snowy plover survey, Corpus Christi Ship Channel project, Nueces County, Texas, September 2000 - April 2001. PBS&J document no. 010163. July 2001.

Pearce, J.B. 1972. Biological survey of submerged refuse. Mar. Pollution Bull. 3(10): 157-158.

Pearson, C.E. and S.R. James Jr. 1996. Diving Assessment for Target Number 1, Located at Port Ingleside, Gulf Intracoastal Waterway, Corpus Christi Bay, Nueces County, Texas. Coastal Environments, Inc., Baton Rouge. Submitted to the Galveston District, U.S. Army Corps of Engineers.

Pearson, C.E. and J.J. Simmons III. 1995. Underwater Archaeology of the Wreck of the Steamship *Mary* (41NU252) and Assessment of Seven Anomalies, Corpus Christi Entrance Channel, Nueces County, Texas. Coastal Environments, Inc., Baton Rouge. Submitted to the U.S. Army Corps of Engineers, Galveston District.

Pearson, C.E. and T. Wells. 1995. Magnetometer Survey of the Gulf Intracoastal Waterway (GIWW), Corpus Christi Bay to Point Penascal, Nueces, Kleberg, and Kenedy Counties, Texas. Coastal Environments, Inc., Baton Rouge. Submitted to the Galveston District, U.S. Army Corps of Engineers.

Pearson, J.C. 1929. Natural history and conservation of the redfish and other commercial sciaenids on the Texas coast. Bull. U.S. Bur. of Fisheries, 44:129-214.

Peddicord, R.K. 1979. Impacts of open-water dredged material. In: Proceedings of Eleventh Dredging Seminar. Pp. 24-48. College Station, TX/TAMU Center for Dredging Studies, TAMU_SG-80-103.

Perret, W.S., J.E. Weaver, R.C. Williams, F.L. Johanson, T.D. McIlwain, R.C., Raulerson, and W.M. Tatum. 1980. Fishery profiles of red drum and spotted seatrout. Gulf States Mar. Fish. Comm., Ocean Springs, MS. No. 6, 60 p.

Poole, J.M. 1985. Status report on *Anthericum chandleri*. Greenm. and Thomps. Texas Natural Heritage Program. 4 Dec. Austin, Texas.

Poole, J.M. and D.H. Riskind. 1987. Endangered, threatened, or protected native plants of Texas. Texas Parks and Wildlife, Austin, Texas.

Poole, J.M., J. Singhurst, D. Hurlburt-Price, and W.R. Carr. 2000. A list of rare plants of Texas. Austin, Texas.

Portland Chamber of Commerce. 2002. Portland Profile. Available on the Internet at: <http://www.portlandtx.org> Accessed on April 2, 2002.

Port of Corpus Christi Authority (PCCA). 1999. La Quinta Baseline Environmental Assessment. Final Draft Report. July 1999.

———. 2001a. The History of the Port of Corpus Christi: 1926 – 2001. Available on the Internet: <http://www.portofcorpuschristi.com/splash.html> Accessed on July 30, 2001.

———. 2001b. La Quinta Trade Gateway Preliminary Master Plan. Available on the Internet: <http://www.portofcorpuschristi.com/La QuintaTradeGateway.html > Accessed on August 25, 2001.

———. 2002. General Information. Available on the Internet at: <http://www.portofcorpuschristi.com/GeneralInformation.html> Accessed on April 2, 2002.

Prewitt, E.R. (Editor). 1984. Archeological and historical Investigations in the proposed Baker's Port project and vicinity, southern Live Oak Peninsula, San Patricio County, Texas. Prewitt and Associates Report of Investigations 25.

Prewitt, E.R. 1981. Cultural Chronology in Central Texas. Bulletin of the Texas Archeological Society 52:65- 89.

Pulich, W.M. Jr. 1998. Seagrass conservation plan for Texas. Resource Protection Division, Texas Parks and Wildlife, Austin, Texas.

Pulich W.M., Jr., C. Blair, and W.A. White. 1997. Current status and historical trends of seagrass in the Corpus Christi Bay National Estuary Program Study Area. Report CCBNEP-20. Corpus Christi Bay National Estuary Program, National Resources Center, TAMU-CC, Corpus Christi, Texas. 131 pp.

Pulich, W.M. Jr.; T. Amos, L. Turnbull, S. Holt, and J. Wilds, compilers. 1985. Birds of Mustang Island. Texas Parks and Wildlife, Resources Management Section. Austin, Texas. PWD Brochure 4000-432. June 1985.

Quammen, M.L. and C.P. Onuf. 1993. Laguna Madre: seagrass changes continue decades after salinity reduction. *Estuaries* 16, 303-311.

Rappole, J.H. and G.W. Blacklock. 1985. Birds of the Texas Coastal Bend, abundance and distribution. Texas A&M University Press. College Station, Texas. 126 pp.

Ray, G. and D. Clarke. 1999. Environmental Assessment of Open-Water Disposal of Maintenance Dredged Material in Corpus Christi Bay, Texas. Coastal Ecology Branch, Environmental Laboratory, U.S. Army Corps of Engineers, Waterway Experiment Station Final Report. January.

Rhoads, D.C., P.L. McCall and J.Y. Yingst. 1978. Disturbance and production on the estuarine seafloor. American Scientist 66:577-586.

Ricklis, R.A. 1986. Archaeological investigations at the McKinzie Site (41NU221), description and contextual interpretations. Unpublished Mater's thesis, Department of Anthropology, The University of Texas at Austin.

———. 1988. Archeological investigations at the McKinzie site (41NU221), Nueces County, Texas: description and contextual interpretations. Bulletin of the Texas Archeological Society 58 (for 1987): 1-76.

———. 1990. A Historical Cultural Ecology of the Karankawan Indians of the central Texas Coast: A Case Study in the Roots of Adaptive Change. Ph.D. dissertation, The University of Texas at Austin.

———. 1992. Aboriginal Karankawan adaptation and Colonial Period acculturation: Archeological and Ethnohistorical Evidence. Bulletin of the Texas Archeological Society 63:211-243.

———. 1993. A model of environmental and human adaptive change on the central Texas coast: geoarchaelogical investigations at White's Point, Nueces Bay, and surrounding area. Coastal Archaeological Studies, Inc., Corpus Christi.

———. 1995. Prehistoric occupation on the central and lower Texas coast: A regional overview. Bulletin of the Texas Archeological Society 66:265-300.

———. 1999. Archaeological Survey of Port of Corpus Christi Tracts 1 and 2, North Shore of Corpus Christi Bay, San Patricio County, Texas. TAS, Inc., and Coastal Archaeological Research, Inc.

Ricklis, R.A. and K.A. Cox. 1991. Toward a chronology of adaptive change during the Archaic of the Texas Coastal Bend area. La Tierra 18(2):13-31.

Ritchie, D.W. 1970. Fish. In: Gross physical and biological effects of overboard spoil disposal in upper Chesapeake Bay. L. E. Cronin (Ed.). Univ. Md., Nat. Res. Inst., Spec. Rpt. No. 3.

Robinson, L., P. Campbell, and L. Butler. 1998. Trends in Texas commercial fishery landings, 1972-1997. Management Data Series No. 158. Texas Parks and Wildlife, Coastal Fisheries Division. Austin, Texas.

San Patricio County Appraisal District. 2001. Texas Property Taxes. Available on the Internet: <http://www.sanpatriciocad.org/> Accessed on August 2, 2001.

Sather, J.H. and R.D. Smith. 1984. An overview of major wetland functions and values. Prepared for Western Energy and Land Use Team Division of Biological Services Research and Development, U.S. Fish and Wildlife Service. FWS/OBS 84/18. 68 pp.

Sayles, E.B. 1953. An Archaeological Survey of Texas. Medallion Papers 17 (XVII). Gila Pueblo, Globe, Arizona.

Schmidly, J.D. 1991. The Bats of Texas. Texas A&M University Press, College Station, Texas. 188 pp.

Schmidt, J.S., and S.D. Hoyt. 1995. Mapping of the *Utina* (41NU264), Corpus Christi Entrance Channel, Nueces County, Texas. Prepared for Galveston District, Army Corps of Engineers. Texas Antiquities Permit No. 1457. Espey, Huston & Associates, Inc. Document No. 941204.

Schubel, J.R., H.H. Carter, R.E. Wilson, W.M. Wise, M.G. Heaton, and M.G. Gross. 1978. Field Investigations of the Nature Degree, and Extent of Turbidity Generated by Open-Water Pipeline Disposal Operations. U.S. Army Engineer Waterways Experiment Station Technical Report D-78-30.

Science Applications, Inc. 1984. Characterization of the benthic environment at four existing and proposed dredged material disposal sites along the South Texas coast during October-November 1983. Draft final report. U.S. Environmental Protection Agency, Criteria and Standards Branch, Washington, D.C. 158 pp.

Scurlock, J.D., W.M. Lynn, and R.T. Ray. 1974. An assessment of the Archeological Resources of Padre Island National Seashore, Texas. Office of the State Archeologist Special Report 11, Austin.

Shafer, H.J. and C.L. Bond. 1983. An Archeological Review of the Central Texas Coast in Bulletin of the Texas. Texas Archeological Society 54 (1985 for 1983).

Shaver, D.J. 1984. The surf zone fish fauna of the Padre Island National Seashore. M.S. thesis, Texas A&I University, Kingsville, Texas. 231 pp.

———. 2000. Padre Island National Seashore, field station leader. Personal communication to Derek Green, PBS&J, 20 November 2000.

Shepsis, V.J. 2001. Corpus Christi Ship Channel Improvement Project Shoreline Erosion Study. Prepared for the Port of Corpus Christi Authority by Pacific International Engineering, Austin, Texas.

Sherk, J.A., Jr. 1971. The effects of suspended and deposited sediments on estuarine organisms. Natural Resources Institute of the Univ. of Maryland. Chesapeake Biological Lab. February 1971.

Shiner, Moseley and Associates, Inc. (SMA). 1987. Draft environmental assessment on reopening of Packery Channel for Fish Trackers Inc./Reopen Packery Channel Association, Corpus Christi, Texas.

———. 2001. Environmental assessment for the proposed Joe Fulton International Trade Corridor from IH 37 to US 181, Nueces County, Texas. July.

Simmons, E.G. and J.P. Brewer. 1962. A study of redfish (*Sciaenops ocellatus Linnaeus*) and black drum (*Pogonias cromis Linnaeus*). Pub. Of Inst. Mar. Sci., Univ. Texas. 8:184-211

Smithsonian Environmental Research Center (SERC). 1998. National Ballast Water Information Clearinghouse. Available on the internet: <http://invasions.si.edu/ballast.htm>

Snow, C. 1981. Southern Bald Eagle (*Haliaeetus leucocephalus leucocephalus*) and Northern Bald Eagle (*Haliaeetus leucocephalus alascanus*). Habitat management series for endangered species, Report No. 5. Bureau of Land Management, Denver, Colorado. T-N-171. 58 pp.

Southwest Parks and Monuments Association (SPMA). 1990. A checklist of the birds of Padre Island National Seashore. Southwest Parks and Monuments Association, Tucson, Arizona. 4M/SPMA/ 1990.

Southwest Research Institute (SWRI). 1980. Biological Services, Corpus Christi Ship Channel, Texas. Prepared for USACE, Galveston District.

Stern, E.M. and W.B. Stickle. 1978. Effects of turbidity and suspended material in aquatic environments. Literature Review. Tech. Rep. D-78-21. USCE, Waterways Experiment Station, Vicksburg.

Stickney, R.R. 1972. Effects of intracoastal waterway dredging on ichthyofauna and benthic macroinvertebrates. Skidaway Inst. Oceanogr., Savannah, Ga.

Stockwell, D.A. 1993. Studies on conditions conductive to the development and maintenance of a persistence brown tide in the Laguna Madre, Texas. Page 18 in Whitledge, T. E. and W. M. Pulich Jr. (eds.), Report Brown Tide Symposium Workshop, 15-16 July, 1991, UTMSI. Port Aransas, Texas.

Stokes, J. and S.D. Hoyt. 2000. Personal communication with J. Enright of PBS&J. 2 November.

Stutzenbaker, C.D. 1999. Aquatic and Wetland Plants of the Western Gulf Coast. Texas Parks and Wildlife, Wildlife Division. Austin, Texas. 465 pp.

Suhm, D.A., A.D. Krieger, and E.B. Jelks. 1954. An introductory handbook of Texas archeology. Bulletin of the Texas Archeological Society 25.

Teeter, A. 2000. Erosion and circulation of dredged material in Laguna Madre, Texas (in prep.).

Tennant, A. 1984. The snakes of Texas. Texas Monthly Press, Austin, Texas. 561 pp.

Tereco Corporation. 1981. Corpus Christi Ship Channel: Biological Services Inner Basin to La Quinta Junction. Final Report to the U.S. Army Corps of Engineers, Galveston District, Galveston, TX.

———. 1982a. Corpus Christi Ship Channel: Biological Services La Quinta Junction to Main Turning Basin. Final Report to the U.S. Army Corps of Engineers, Galveston District, Galveston, TX.

———. 1982b. Corpus Christi Ship Channel: Biological Services Main Turning Basin to Viola Turning Basin (New Work). Final Report to the U.S. Army Corps of Engineers, Galveston District, Galveston, TX.

———. 1982c. Corpus Christi Ship Channel: Biological Services Channel to La Quinta. Final Report to the U.S. Army Corps of Engineers, Galveston District, Galveston, TX.

Tewes, M. and D. Everett. 1987. Status and distribution of the endangered ocelot and jaguarundi in Texas. In: S.D. Miller and D.D. Everett (eds.), Cats of the world: biology, conservation, and management. Pp. 147-158. National Wildlife Federation, Washington, D.C. 501 pp.

Texas Biological and Conservation Data System (TXBCD). 1999. Special species list for Nueces and Kleberg counties. Texas Parks and Wildlife. Austin, Texas.

Texas Coastal Management Program (TCMP). 1996. Texas Coastal Management Program, Final Environmental Impact Statement, August 1996. Texas General Land Office. Austin, Texas.

Texas Comptroller of Public Accounts. 2001a. Local Sales and Use Tax Information. Available on the Internet: http://www.cpa.state.tx.us/taxinfo/salestax.html#localtax > Accessed on August 2, 2001.

———. 2001b. Local Sales and Use Tax Information. Available on the Internet: <http://www.cpa.state.tx.us/taxinfo/proptax/riremedy01/remedy1.html#1> Accessed on August 2, 2001.

Texas Department of Transportation (TxDOT). 1999. Air Quality Guidelines. Prepared by Environmental Affairs Division. Austin, Texas.

Texas Emergency Services. 2001. Texas Emergency Services website. Available on the Internet: http://hometown.aol.com/adamj8484/auspub.htm > Accessed on September 6, 2001.

Texas General Land Office (GLO). 2000. Texas Coastal Oil Spill Planning and Response. CD. September 2000.

Texas General Land Office and U.S. Fish and Wildlife Service (GLO & FWS). 1998. The Mollie Beattie Habitat Community, Nueces County, Texas.

Texas Natural Resource Conservation Commission (TNRCC). 1998. Texas Clean Air Strategy. TNRCC New Texas Clean Air Strategy Page. Available on the internet: <http://www.tnrcc.state.tx.us>

———. 2000. Proposed Texas Surface Water Quality Standards, Chapter 307, Rule Amendment.

Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened and watch lists of Texas plants. Pub. 9, Third Revision. August, 1993. Austin, Texas.

———. 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication No. 10. Austin, Texas. 22 pp.

Texas Ornithological Society (TOS). 1995. Checklist of the birds of Texas, 3rd Edition. 166 pp.

Texas Parks and Wildlife Department (TPWD). 1999. Great Nature Wildlife Trails. Available on the Internet at: <http://www.tpwd.state.tx.us/birdingtrails/> Accessed on April 5, 2002.

———. 2000. Nature; endangered and threatened species; leatherback sea turtle (*Dermochelys coriacea*). Available on the internet: <http://www.tpwd.state.tx.us/nature/endang/animals/lethback.html>

———. 2001. Great Texas Wildlife Trails. Available on the internet: <http://www.tpwd.state.tx.us/birdingtrails/>

———. Texas Parks and Wildlife Department (TPWD). 2001. Trends in Commercial Fishery Landings, 1972 – 1999. Management Data Series, No. 194. TPWD, Coastal Fisheries Division.

Texas Parks and Wildlife Biological Conservation Data System (TXBCD). 2001. Data files and information on USGS topographic maps. 11 September.

Texas State Data Center (TSDC). 2000. Total population estimates for Texas counties and places for January 1, 2000. May.

Texas Workforce Commission (TWC). 1980-1999. Civilian labor force estimates for Texas Counties. Monthly publications from 1980-1999.

Texas Workforce Commission (TWC). 2001. Civilian labor force estimates for Texas Counties. Monthly publications from 1980 – 1999.

Thomas, P.M. and C.S. Weed. 1980a. A Cultural Resources Survey of Houston Pipe Line Company's 12" Proposed Pipeline Padre Island, Texas. New World Research, Report of Investigations #30.

———. 1980b. Cultural Resources Survey of the Proposed Transcontinental Gas Pipeline Corporation's 24" North Padre Island Pipeline, Texas. New World Research Report of Investigations, No. 38.

Thompson, J.R. 1973. Ecological effects of offshore dredging and beach nourishment: A review. USCE, Coastal Engin. Res. Center, Miscellaneous Paper No. 1-73.

Tilden, J.W. and A.C. Smith. 1986. A field guide to western butterflies. The Peterson Field Guide Series. Houghton Mifflin Company, Boston. 370 pp.

Tunnell, J.W., Q.R. Dokken, E.H. Smith, and K. Withers. 1996. Current Status and Historical Trends of the Estuarine Living Resources within the Corpus Christi Bay National Estuary Program Study Area B Vol. 1 of 4. Texas Natural Resource Conservation Commission, Austin, Texas. CCBNEP-06A. 543 pp.

Turner, B.L. 1983. Status report of *Ambrosia cheiranthifolia* Gray. Prepared for U.S. Fish and Wildlife Service.

Turner, R.E. 1977. Intertidal vegetation and commercial yields of Penaeid shrimp. Trans. of Am. Fisheries Society. 106(5):411-416.

Tyler, R. 1996. The New Handbook of Texas, Vol. 4 and Vol. 5. The Texas State Historical Association. Austin.

U.S. Army Engineer District. 1979. Corpus Christi Ship Channel, Texas (45-Foot Project). Prepared for the U.S. Army Corps of Engineers, Galveston District, Texas.

U.S. Army Corps of Engineers (USACE), reported in Hoyt 1990. 1880. Annual Report, Chief of Engineers, Improvement of Rivers and Harbors: House Ex. Doc. 1, pt. 2, 46th Cong., 3d Sess., v.2, pt 2, App N-8.

———, reported in Hoyt 1990. 1910. Annual Report of the Chief of Engineers. House Ex. Doc. 61st Congress, 2d Session, pt. I, pgs 552-553.

———, reported in Hoyt 1990. 1879. Annual Report of the Chief of Engineers. House Ex. Doc. 1, pt. 2, 46th Congress, 2d Session, Vol. II, pt. I, App K, pgs 928-939.

———, reported in Hoyt 1990. 1922. Annual Report of the Chief of Engineers. "Letter from the Chief of Engineers, Reports on Preliminary Examination and Survey of the Coast of Texas in the Vicinity of Aransas Pass, Port Aransas, Rockport, and Corpus Christi." On file with the Texas Antiquities Committee, Austin, Texas.

U.S. Army Corps of Engineers (USACE). 1910. Channel from Aransas Pass Harbor through Turtle Cove to Corpus Christi, Texas: House Do. 678, 61st Cong., 2d Sess., v. 29.

———. 1922. Reported in Alperin, 1977

———. 1994. Corpus Christi Ship Channel, Texas, 50-foot Project Reconnaissance Report, September. Galveston District, Southwestern Division.

———. (Waterways Experiment Station) 1998. Use of Sediment Quality Guidelines (SQGs) in Dredged Material Management. Dredging Research Technical Note EEDP-04-29.

———. 1999a. Packery Channel, Texas, Supplement to the Project Study Plan, Preliminary Alternatives Analysis. September, 1999.

———. 1999b. Project Study Plan Packery Channel, Texas, Feasibility Study Phase, Version 3. August 1999.

———. 2000. Navigation Data Center (NDC), AAPA Advisory, January 24 (Accessed 11/6/2000 at: www.wrsc.usace.army.mil/ndc/wcporton.htm).

———. 2002. Navigation Data Center (NDC), Publications and U.S. Waterway Data CD, Volume 8. Port Series Report No. 25 – Corpus Christi, Texas.

———. 2003. Final Environmental Impact Statement, North Padre Island Storm Damage Reduction and Environmental Restoration Project, Galveston, Texas. Document No. 000349. PBS&J, Austin, Texas. March.

U.S. Army Corps of Engineers-Galveston District (USACE) and The Port of Corpus Christi Authority. 1999a. Consistency Determination for Corpus Christi Ship Channel for the Texas Coastal Coordination Council. USACE-Galveston District, Galveston, Texas. July 10.

———. 1999b. Consistency Determination for La Quinta Channel for the Texas Coastal Coordination Council. USACE-Galveston District, Galveston, Texas. July 10.

U.S. Bureau of the Census (USBOC). 1980. 1980 Census of Population. General social and economic characteristics. Texas, Section 1.

———. 1990. 1990 Census of Population. Summary Population and Housing Characteristics. Available on the internet: <http://venus.census.gov/cdrom/lookup>

———. 2001. Census 2000 Summary File 1 (SF1) – 100 Percent Data. Available on the internet: <http://factfinder.census.gov/servlet/BasicFactsServlet/>

U.S. Coast Guard (USCG). 2000. Ballast Water Brochure. Available on the internet: <http://www.uscg.mil/hq/g-m/mso/mso4/ bwbrochure.html>

U.S. Coast Survey. 1869. Corpus Christi Pass Texas. Texas Historical Commission, Map File of the State Nautical Archaeologist, Austin.

U.S. Environmental Protection Agency (EPA). 1974. Information on levels of environmental noise requisite to protect public health and welfare with an adequate margin of safety. Office of Noise Abatement and Control.

———. 1978. Protective Noise Levels.: Condensed Version of EPA Levels Document. Office of Noise Abatement and Control.

———. 1986. *Quality Criteria for Water, 1986.* EPA 440/5-86-0001, as revised.

———. 1987. Draft Environmental Impact Statement. United States Navy Gulf Coast Strategic Homeporting, Corpus Christi/Ingleside, Texas. Ocean Dredged Material Disposal Site Designation. EPA 906/11-87-006. Region VI.

———. 1988. Final Environmental Impact Statement. United States Navy Gulf Coast Strategic Homeporting, Corpus Christi/Ingleside, Texas. Ocean Dredged Material Disposal Site Designation. EPA 906/06-88-001. Region VI.

———. 2002a. U.S. EPA Air Data. Monitor Values Report. Available on the internet: <http://www.epa.gov/air/data/monvals.html> February 2002.

———. 2002b. U.S. EPA Air Data. Monitor Values Report. Available on the internet: <http://www.epa.gov/air/data/nettier.html> February 2002.

U.S. Environmental Protection Agency/U.S. Army Corps of Engineers. 1991. *Evaluation of Dredged Material Proposed for Ocean Disposal, Testing Manual.* EPA-503/8-91/001. 205 pp + Appendices.

———. 1998. *Evaluation of Dredged Material Proposed for Discharge in Waters of the U.S., Testing Manual, Inland Testing Manual.* EPA-823-B-96-004. 169 pp + Appendices.

U.S. Fish and Wildlife Service (FWS), Department of the Interior. 1995. Threatened and endangered species of Texas. FWS Texas State Office, Austin, Texas.

———. 1997. Federally and State Endangered Slender rush-pea *Hoffmannseggia tenella* information sheet. PWD LF W3000-019N. Austin, Texas.

———. 2000. Federally listed as threatened and endangered species of Texas. County by county list. March 28.

———. 2001. Texas colonial waterbird database. Available on the Internet: <http://texascoastal program.fws.gov>

United States Navy. 1987. Environmental impact statement - United States Navy Gulf Coast strategic homeporting. Appendix I, Corpus Christi, Texas.

———. 2000. June 30. Available on the internet: <http://www.nsi.navy.mil/nsi_home.htm> Accessed on November 7, 2000.

Valdez, F. Jr. 1982. An Archeological Survey of a Proposed Drilling Site Located South of Baffin Bay on Padre Island National Seashore, Kenedy County, Texas. A report by the Center for Archeological Research, The University of Texas at San Antonio.

Villareal, T.A. and K. Dunton. 2000. UT-MSI, personal communication to Kathy Calnan, PBS&J; brown tide trends.

Villareal, T. 2000. Personal Profile and Publications. Available on the internet: <http://www.utmsi. utexas.edu/staff/villareal/> Accessed May 2001.

Villarreal, J. 2001. Personal communication with Chris Moore of PBS&J and Judy Villarreal (Addressing Agent), Nueces County Public Works Corpus Christi, Texas. September 7, 2001.

Wakeman, T.H. 1974. Release of trace constituents form sediments resuspended during dredging operations. In: American Chemical Society Conference, Atlantic City, NJ/COE San Francisco.

Ward, G.H. 1997. Processes and Trends of Circulation Within the Corpus Christi Bay National Estuary Program Study Area. Publication CCBNEP-21, November 1997.

Ward, G.H. and N.E. Armstrong. 1997. Current Status and Historical Trends of Ambient Water, Sediment, Fish, and Shellfish Tissue Quality in the Corpus Christi Bay National Estuary Program Study Area. Publication CCBNEP-13. March 1997.

Warren, J.E. 1985. An Archaeological Survey of a Proposed Drilling Pad Location on Padre Island National Seashore in Kenedy County, Texas. Submitted to Continental Shelf Associates Inc., Galveston, Texas by the Center for Archaeological Research, The University of Texas at San Antonio.

———. 1987. A Cultural Resources Survey at Packery Point Development, Nueces County, Texas. J.E. Warren Report 114. George West, Texas.

Warren, T.A., L.M. Green, and K. W. Spillar. 1994. Trends in finfish landings of sport-boat anglers in Texas marine waters May 1974-May 1992. Management Data Series No. 109. Texas Parks and Wildlife, Coastal Fisheries Division. Austin, Texas.

Warshaw, S. 1975. Water quality segment report for Segment No. 2491, Laguna Madre. Report No. WQS-14. Texas Water Quality Board, Surveillance section, Field Operations Division. Austin, Texas.

Webb, W.P. (Editor). 1952. The Handbook of Texas, Vol. I and II. The Texas State Historical Association, Austin.

Weddle, Robert S. 1991. *The French Thorn: Rival Explorers in the Spanish Sea, 1682-1762.* Texas A&M University Press, College Station, Texas.

Werler, J.E. and J.R. Dixon. 2000. Texas snakes identification, distribution, and natural history. University of Texas Press, Austin, Texas.

White, W.A., T.A. Trembly, J. Hinson, D. Moulton, W. Pulich, E.H. Smith, and K.V. Jenkins. 1998. Current status and historical trends of selected estuarine and coastal habitats in the Corpus Christi national estuary program study area. Prepared for the Corpus Christi National Estuary Program, Corpus Christi, Texas. 161 pp.

Windom, H.L. 1972. Environmental aspects of dredging in estuaries. J. Water. Har. and Coas. Eng. Div. ASCE, 98(WW4): 475-487.

Wright, Thomas D. 1978. Aquatic dredged material disposal impacts. U.S. Army Eng. Water Experiment Station Environmental Laboratory, Vicksburg, Miss. Technical Report DS-78-1.

Zonick, C. and M. Ryan. 1996. The ecology and conservation of piping plover (*Charadrius melodus*) wintering along the Texas Gulf Coast. 1995. Annual Report. Dept. of Fisheries and Wildlife, University of Missouri.

10.2 LIST OF ABBREVIATIONS

ADP	Area Development Plan
AIC	Agency Information Consultants
AOU	American Ornithologists' Union
AST	aboveground storage tank
AWOIS	Automated Wreck and Obstruction Information System
BA	Biological Assessment
BEG	U.S. Bureau of Economic Development
BNSF	Burlington Northern Santa Fe Railway
BU	Beneficial Use
BUW	Beneficial Uses Workgroup
CAR	Center for Archaeological Research
CAW	Cumulative Assessment Workgroup
CBBF	Coastal Bend Bays Foundation
CBD	central business district
CCBNEP	Corpus Christi Bay National Estuary Program (now the Coastal Bend Bays & Estuaries Program (CBBEP)
CCRCS	Corpus Christi Rincon Canal System
CCSC	Corpus Christi Ship Channel
CCSCCIP	Corpus Christi Ship Channel – Channel Improvements Project
CCTR	Corpus Christi Terminal Railroad
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act (1980)
CERCLIS	EPA's Comprehensive Environmental Response, Compensation, and Liability Information System
CFR	Code of Federal Regulations
CIP	Capital Improvement Program
CLF	civilian labor force
CORRACT	RCRIS Corrective Action Database
CW	Contaminants Workgroup
dBA	A-weighted decibel
DEIS	Draft Environmental Impact Statement
DoD	Department of Defense
EA	Environmental Assessment
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
EJ	Environmental Justice

EO	Executive Order
EPA	U.S. Environmental Protection Agency
ERDC	U.S. Army Engineer Research and Development Center
ERL	Effects Range Low
ERNS	Emergency Response Notification System
ESA	Endangered Species Act (1973)
ETJ	extra-territorial jurisdiction
FEIS	Final Environmental Impact Statement
FEMA	Federal Emergency Management Agency
FINDS	Facility Index System
FMP	Fisheries Management Plan
FR	Federal Register *or* Feasibility Report
FS	Feasibility Study
FWS	U.S. Fish and Wildlife Service
GIWW	Gulf (of Mexico) Intracoastal Waterway
GLO	Texas General Land Office
GMFMC	Gulf of Mexico Fishery Management Council
HSMW	Hydrodynamic and Salinity Modeling Workgroup
HTRW	Hazardous, Toxic, Radioactive Waste
IH	Interstate Highway
ISO	Insurance Services Office, Inc.
JFITC	Joe Fulton International Trade Corridor
JFK	John F. Kennedy (Causeway)
L_{dn}	day-night sound level
LPUST	leaking petroleum underground storage tank
LQG	large quantity generator
mcy	million cubic yards
mg/kg	milligrams per kilogram
mg/l	milligrams per liter
MLT	mean low tide
mph	miles per hour
MSF	Magnetic Silencing Facility
MSFCMA	Magnuson-Stevens Fishery Conservation and Management Act
MSL	mean sea level
MW	Mitigation Workgroup
NAAQS	National Ambient Air Quality Standards
NGVD	National Geodetic Vertical Datum
NEPA	National Environmental Policy Act

NFRAP	No Further Remedial Action Planned
NIS	Non-Indigenous Invasive Species
NISA	National Invasive Species Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NPS	National Parks Service
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NWI	National Wetlands Inventory
NWPCP	National Wetlands Priority Conservation Plan
NWR	National Wildlife Refuge
OAQPS	(EPA) Office of Air Quality Planning and Standards
PA	dredged material placement area
PAH	polycyclic aromatic hydrocarbons
PCB	polychlorinated biphenyl
PCCA	Port of Corpus Christi Authority
PCE	perchloroethane
PM	particulate matter
ppb	parts per billion
ppt	parts per thousand
RACT	Regulatory Agency Coordination Team
RCRA	Response Conservation and Recovery Act
RCRA-GEN	RCRA Generators Sites
RCRIS	EPA's Resource Conservation and Recovery Information System
RIA	Regional Implementation Agreement
RIP	Rincon Industrial Park
SAL	State Archeological Landmark
SAV	submerged aquatic vegetation
SEW	Shoreline Erosion Workgroup
SH	State Highway
SHPO	State Historical Preservation Officer
SOC	Species of Concern
SQG	Sediment Quality Guidelines
SQT	Sediment Quality Triad
SWL	Solid Waste Landfill
TAAS	Texas Agricultural Statistics Service

TARL	Texas Archeological Research Laboratory
TCMP	Texas Coastal Management Program
TDH	Texas Department of Health
TDWR	Texas Department of Water Resources
THC	Texas Historical Commission
TMDL	total maximum daily load
TNRCC	Texas Natural Resource Conservation Commission
TOC	total organic carbon
TOES	Texas Organization for Endangered Species
TOS	Texas Ornithological Society
TPH	total petroleum hydrocarbons
TPWD	Texas Parks and Wildlife Department
TSD	Treatment, Storage or Disposal (TSD) database
TSDC	Texas State Data Center
TWC	Texas Workforce Commission
TWDB	Texas Water Development Board
TWQS	Texas Surface Water Quality Standards
TXBCD	Texas Biological and Conservation Data System
TxDOT	Texas Department of Transportation
μg/kg	micrograms per kilogram
μg/l	micrograms per liter
UPRR	Union Pacific Railroad
U.S.	United States
UCPA	Upland Confined Placement Area
USACE	U.S. Army Corps of Engineers
USBEA	U.S. Bureau of Economic Analysis
USBOC	U.S. Bureau of Census
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
UST	underground storage tank
VFD	volunteer fire department
VOC	volatile organic compound

10.3 INDEX

10.4 GLOSSARY

The following definitions are for the convenience of those reading this Environmental Impact Statement and do not replace definitions in State, Federal, or local laws, regulations and ordinances.

benthos – Aquatic bottom dwelling organisms which include worms, leeches, snails, flatworms, burrowing mayflies, clams.

bioaccumulation – The accumulation of contaminants in the tissues of organisms through any route, including respiration, ingestion, or direct contact with contaminated water, sediment, or dredged material.

biomass – The mass of living material in a given area or volume of habitat.

brackish water – A mixture of fresh and salt water.

coastal zone – Coastal waters and adjacent lands that exert a measurable influence on the uses of the sea and its ecology.

contaminant – A chemical or biological substance in a form that can be incorporated into, onto, or be ingested by and that harms aquatic organisms, consumers of aquatic organisms, or users of the aquatic environment.

crustacean – A group of aquatic animals characterized by jointed legs and a hard shell which is shed periodically, e.g., shrimp, crabs, crayfish, isopods, and amphipods.

dredged material – Material excavated from waters of the United States or ocean waters. The term dredged material refers to material which has been dredged from a water body, while the term sediment refers to material in a water body prior to the dredging process.

effluent – A discharge of pollutants into the environment, partially or completely treated or in its natural state. Generally used in regard to discharges into waters.

EIS – Environmental impact statement. A document prepared on the environmental impact of actions significantly affecting the quality of the human environment and used as a tool for decision-making.

family household – A household maintained by a householder who is in a family.

floodplain – The flat, low-lying portion of a stream valley subject to periodic inundation.

groundwater – The supply of freshwater under the earth's surface in an aquifer or soil that forms the natural reservoir for man's use.

group quarters – Noninstitutional living arrangements for groups not living in conventional housing units or groups living in housing units containing ten or more unrelated people

habitat – The specific area or environment in which a particular type of plant or animal lives. An organism's habitat provides all of the basic requirements for the maintenance of life. Typical coastal habitats include beaches, marshes, rocky shores, bottom sediments, mudflats, and the water itself.

infauna – Animals which live within the sediment of the sea bottom.

isopod – A small, flattened crustacean belonging to the order Isopoda.

lagoon – A shallow body of seawater generally isolated from the ocean by a barrier island. Also the body of water enclosed within an atoll, or the water within a reverse estuary.

larva (pl. **larvae**) – An embryo that differs markedly in appearance from its parents and becomes self-sustaining before assuming the physical characteristics of its parents.

lead – A heavy metal that may be hazardous to human health if breathed or ingested.

mercury – A heavy metal, highly toxic of breathed or ingested. Mercury is residual in the environment, showing biological accumulation in all aquatic organisms, especially fish and shellfish. Chronic exposure to airborne mercury can have serious effects on the central nervous system.

non-family household – A household maintained by a householder who is not in a family.

open-water disposal – Placement of dredged material in rivers, lakes, estuaries, or oceans via pipeline or surface release from hopper dredges or barges.

organism – Any living human, plant, or animal.

particulate matter – very fine solid or liquid particles in the air or in an emission, including dust, fog, fumes, mist, smoke, and spray, etc.

PCB – Polychlorinated biphenyls, a group of organic compounds used in the manufacture of plastics. In the environment, PCBs exhibit many of the same characteristics as DDT and may, therefore, be confused with that pesticide. PCBs are highly toxic to aquatic life, they persist in the environment for long periods of time and are biologically accumulative.

"permitted" – Used by TNRCC personnel to mean 1) required to have a permit from the TNRCC or 2) having received such a permit through a process that includes a written application and a formal review by the agency.

phytoplankton – Plantlike, usually single-celled members (generally microscopic) of the plankton community.

plankton – Drifting or weakly swimming organisms suspended in water. Their horizontal position is to a large extent dependent on the mass flow of water rather than on their own swimming efforts.

runoff – The portion of rainfall, melted snow, or irrigation water that flows across ground surface and eventually is returned to streams. Runoff can pick up pollutants from the air or the land and carry them to receiving waters.

sediment – The layer of soil, sand, and minerals at the bottom of surface water that absorbs contaminants.

shoalgrass – Seagrass species (*Halodule beaudettei*); submerged perennial, restricted to shallow, saline coastal bays.

Superfund – The common name used for the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).

surface water – Water on the earth's surface exposed to the atmosphere as rivers, lakes, streams, and oceans.

TNRCC – Texas Natural Resource Conservation Commission. On September 1, 1993, the Texas Air Control Board, Texas Water Commission, and parts of the Texas Department of Health merged and became the TNRCC.

toxic pollutant – Pollutants, or combinations of pollutants, including disease-causing agents, that after discharge and upon exposure, ingestion, inhalation, or assimilation into any organism, either directly from the environment or indirectly by ingestion through food chains, will, on the basis of information available to the Administrator of the U.S. Environmental Protection Agency, cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions, or physical deformations in such organisms or their offspring.

TPDES – Texas Pollutant Discharge Elimination System. The major program for regulating municipal and industrial wastewater discharges through the permitting of wastewater treatment facilities. In 1998, TNRCC took over the administration of this program in Texas, formerly the NPDES, administered by the U.S. EPA.

turbidity – An optical measure of the amount of material suspended in the water. Increasing the turbidity of the water decreases the amount of light that penetrates the water column. High levels of turbidity may be harmful to aquatic life.

wetlands – Areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support and that, under normal circumstances, do support a prevalence of vegetation typically adapted for life in saturated-soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas (40 CFR Part 230), especially areas preserved for wildlife, zooplankton (planktonic animals that supply food for fish).

VOC – Volatile organic compounds. Secondary petrochemicals, including light alcohols, acetone, trichloroethylene, perchloroethylene, dichloroethylene, benzene, vinyl chloride, toluene, and methylene chloride, which are used as solvents, degreasers, paint thinners, and fuels. Because of their volatile nature, they readily evaporate into the air, increasing the potential exposure to humans. Due to their low water solubility, environmental persistence and widespread industrial use, they are commonly found in soil and groundwater.

zooplankton – Animal members of the plankton community.

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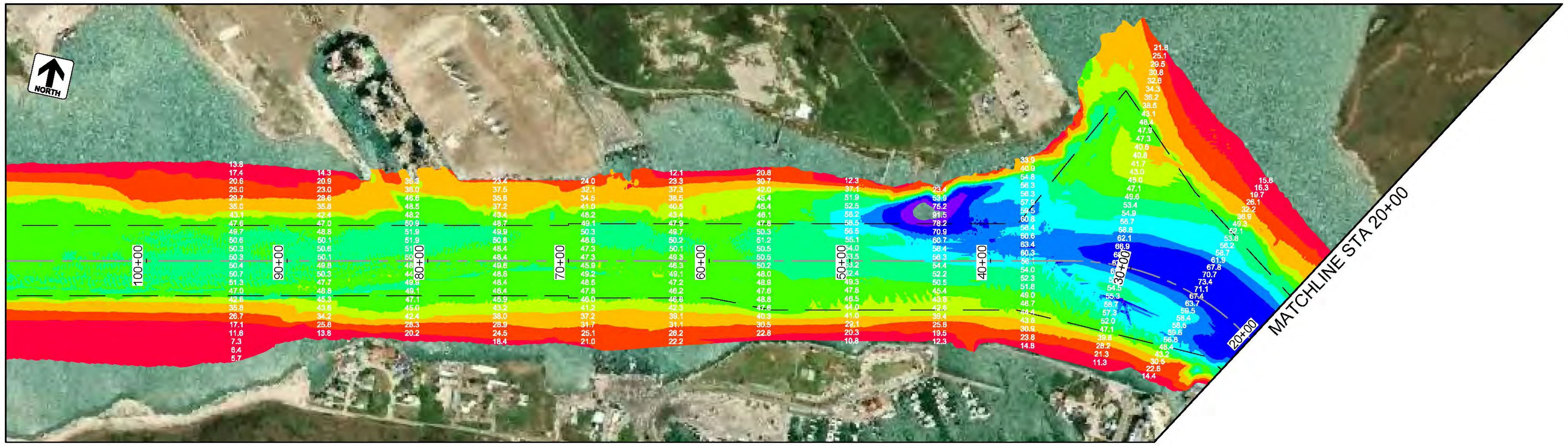
Appendix B

Fugro Geotech (Channel Bathymetry, Cross Sections, and Geotechnical Boring Logs)

CHANNEL BATHYMETRY



Elevations Table

Number	Minimum Elevation	Maximum Elevation	Color
1	−20.000	0.000	🟥
2	−30.000	−20.000	🟧
3	−40.000	−30.000	🟧
4	−45.000	−40.000	🟨
5	−50.000	−45.000	🟩
6	−55.000	−50.000	🟩
7	−60.000	−55.000	🟦
8	−65.000	−60.000	🟦
9	−75.000	−65.000	🟦
10	−85.000	−75.000	🟪

SCALE:
0 250' 500' 1,000'

PCCA PROJ. #18−038A

GENERAL NOTES:

1. BATHYMETRY DATA SHOWN IS COMPRISED OF USACE SINGLE BEAM DATED JUNE 2018 AND TERRASOND MULTIBEAM DATED SEPTEMBER 2018.
2. SOUNDINGS AND ELEVATIONS SHOWN REPRESENT CONDITIONS AT THE TIME SURVEYED.
3. SOUNDINGS AND ELEVATIONS ARE IN FEET AND TENTHS AND ARE REFERENCED TO MEAN LOWER LOW WATER (MLLW) DATUM.
4. HORIZONTAL COORDINATES ARE REFERENCED TO U.S. STATE PLANE TEXAS SOUTH 4205, NAD83.
5. AERIAL IMAGERY OBTAINED FROM ESRI WORLD IMAGERY AND IS DATED 2018.

NO.	DATE	REVISION

PORT CORPUS CHRISTI

PORT OF CORPUS CHRISTI AUTHORITY

CORPUS CHRISTI SHIP CHANNEL
DEEPENING PROJECT

Permit # SWE 2019−00067

SCALE: 1" = 500'
DWN. BY: JS

CHANNEL BATHYMETRY
MAP 1

DATE: 3/7/2019
DWG. NO.

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Elevations Table

Number	Minimum Elevation	Maximum Elevation	Color
1	-20.000	0.000	🟥
2	-30.000	-20.000	🟧
3	-40.000	-30.000	🟧
4	-45.000	-40.000	🟨
5	-50.000	-45.000	🟩
6	-55.000	-50.000	🟩
7	-60.000	-55.000	🟦
8	-65.000	-60.000	🟦
9	-75.000	-65.000	🟦
10	-85.000	-75.000	🟪

GENERAL NOTES:

1. BATHYMETRY DATA SHOWN IS COMPRISED OF USACE SINGLE BEAM DATED JUNE 2018 AND TERRASOND MULTIBEAM DATED SEPTEMBER 2018.
2. SOUNDINGS AND ELEVATIONS SHOWN REPRESENT CONDITIONS AT THE TIME SURVEYED.
3. SOUNDINGS AND ELEVATIONS ARE IN FEET AND TENTHS AND ARE REFERENCED TO MEAN LOWER LOW WATER (MLLW) DATUM.
4. HORIZONTAL COORDINATES ARE REFERENCED TO U.S. STATE PLANE TEXAS SOUTH 4205, NAD83.
5. AERIAL IMAGERY OBTAINED FROM ESRI WORLD IMAGERY AND IS DATED 2018.

NO.	DATE	REVISION

SCALE:
0 250' 500' 1,000'
PCCA PROJ. #18-038A

PORT CORPUS CHRISTI

PORT OF CORPUS CHRISTI AUTHORITY

CORPUS CHRISTI SHIP CHANNEL
DEEPENING PROJECT

Permit # SWE 2019-00067

SCALE: 1" = 500'
DWN. BY: JS
CHANNEL BATHYMETRY
MAP 2
DATE: 3/7/2019
DWG. NO. 18-031A-####

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Elevations Table

Number	Minimum Elevation	Maximum Elevation	Color
1	-20.000	0.000	🟥
2	-30.000	-20.000	🟧
3	-40.000	-30.000	🟨
4	-45.000	-40.000	🟩
5	-50.000	-45.000	🟩
6	-55.000	-50.000	🟩
7	-60.000	-55.000	🟦
8	-65.000	-60.000	🟦
9	-75.000	-65.000	🟦
10	-85.000	-75.000	🟪

SCALE:
0 250' 500' 1,000'

PCCA PROJ. #18-038A

GENERAL NOTES:

1. BATHYMETRY DATA SHOWN IS COMPRISED OF USACE SINGLE BEAM DATED JUNE 2018 AND TERRASOND MULTIBEAM DATED SEPTEMBER 2018.
2. SOUNDINGS AND ELEVATIONS SHOWN REPRESENT CONDITIONS AT THE TIME SURVEYED.
3. SOUNDINGS AND ELEVATIONS ARE IN FEET AND TENTHS AND ARE REFERENCED TO MEAN LOWER LOW WATER (MLLW) DATUM.
4. HORIZONTAL COORDINATES ARE REFERENCED TO U.S. STATE PLANE TEXAS SOUTH 4205, NAD83.
5. AERIAL IMAGERY OBTAINED FROM ESRI WORLD IMAGERY AND IS DATED 2018.

NO.	DATE	REVISION

PORT CORPUS CHRISTI

PORT OF CORPUS CHRISTI AUTHORITY

CORPUS CHRISTI SHIP CHANNEL
DEEPENING PROJECT

Permit # SWE 2019-00067

SCALE: 1" = 500'
DWN. BY: JS

CHANNEL BATHYMETRY
MAP 3

DATE: 3/7/2019
DWG. NO. 18-031A-####

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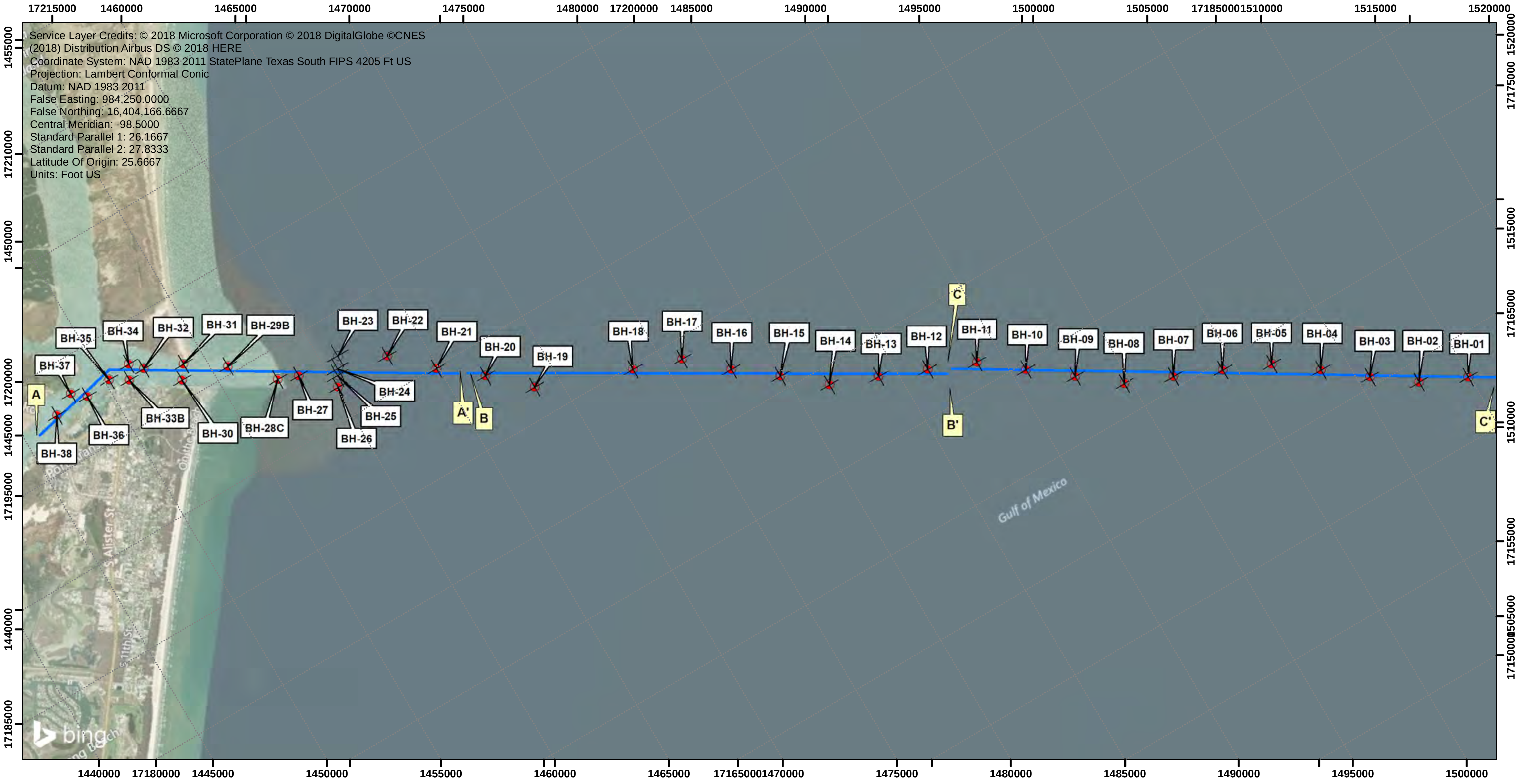
CROSS SECTIONS



Service Layer Credits: © 2018 Microsoft Corporation © 2018 DigitalGlobe ©CNES (2018) Distribution Airbus DS © 2018 HERE
Coordinate System: NAD 1983 2011 StatePlane Texas South FIPS 4205 Ft US
Projection: Lambert Conformal Conic
Datum: NAD 1983 2011
False Easting: 984,250.0000
False Northing: 16,404,166.6667
Central Meridian: -98.5000
Standard Parallel 1: 26.1667
Standard Parallel 2: 27.8333
Latitude Of Origin: 25.6667
Units: Foot US

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LEGEND

GEOTECHNICAL BORING

⊕ COMPLETED

⊕ CANCELLED

— CROSS-SECTION LINES

NOTES:

1. Boring locations are approximate.
2. As-built coordinates of exploration locations surveyed by Fugro Starfix Positioning System.

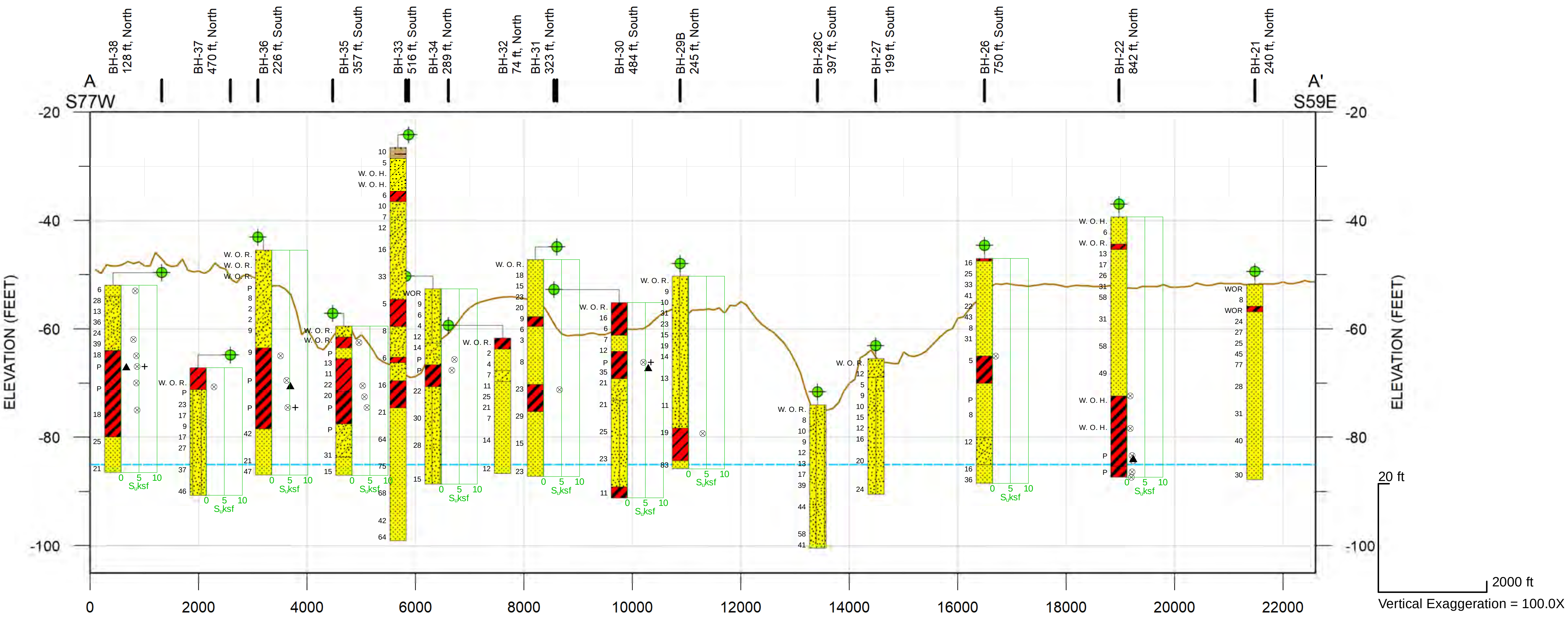
N E S W

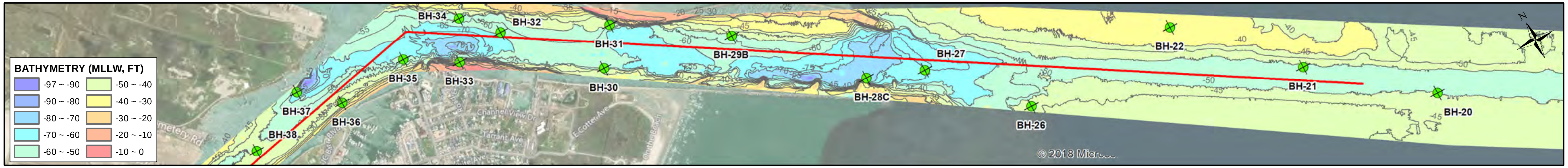
0 2,500 5,000 10,000
Feet

PLAN OF BORINGS

PCCA CORPUS CHRISTI CHANNEL DEEPENING PROJECT
AECOM
CORPUS CHRISTI, TEXAS

PLATE 2





LEGEND

- ▨ Fill
- 🟥 Lean CLAY (CL)
- ▨ Fat CLAY (CH)
- 🟨 Poorly-Graded SAND (SP)
- ▨ Clayey SAND (SC)
- ▨ Silty SAND (SM)
- — Bathymetry (MLLW, ft)
- - - Minimum Boring Termination Depth (85 ft, MLLW)

UNDRAINED SHEAR STRENGTH (S_u)

- ▲ Unconsolidated Undrained Triaxial
- ⊕ Torvane
- ⊗ Pocket Penetrometer
- + Soil Strength Exceeds Instrument's Maximum Measurable Strength.

TUBE AND SPT SAMPLES

P	Push thin-walled 3" tube.
20	Number of blows to produce 12" of penetration after the initial 6" of seating.
86/11"	Number of blows required to produce the indicated penetration after an initial 6" seating.
Ref/3"	50 blows produced the indicated penetration during the initial 6" interval.
W.O.H.	Weight of Hammer

NOTES:

1. As-built coordinates of exploration locations provided by Fugro Starfix Positioning System.
2. Stratigraphic contacts are approximate, and interpreted from borings. Conditions vary both along and perpendicular to the section line. The lateral extent of the top soil is not known based on the limited borings.
3. Boring data are projected onto the cross section line, therefore, stratigraphic contacts may not correspond to the descriptions (lithology, shear strength, etc.) on the logs.
4. Material descriptions are generalized. Materials may vary within the stratigraphic unit and include layers of material that differ from the general description. Refer to boring logs for detailed descriptions of the materials encountered at the exploration location.
5. See Plate 2 for location of explorations and cross section lines.

SUBSURFACE PROFILE (A-A')

PCCA CORPUS CHRISTI CHANNEL DEEPENING PROJECT
AECOM
CORPUS CHRISTI, TEXAS

PLATE 3

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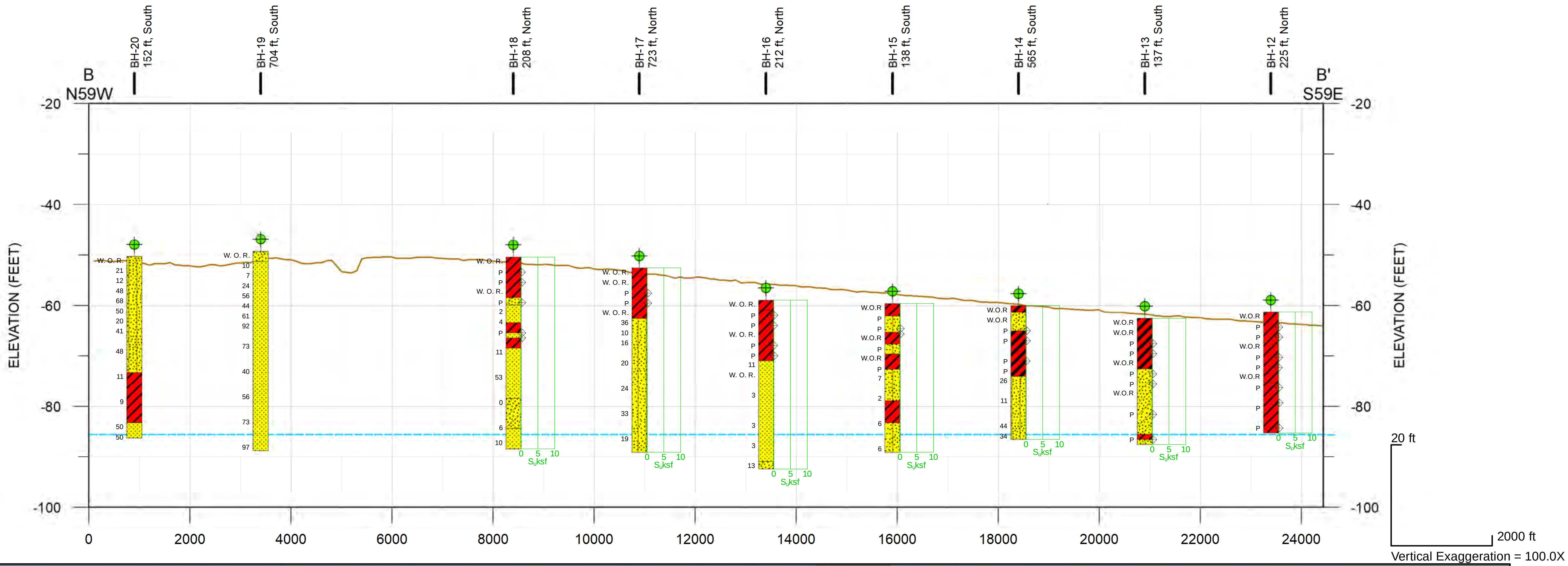

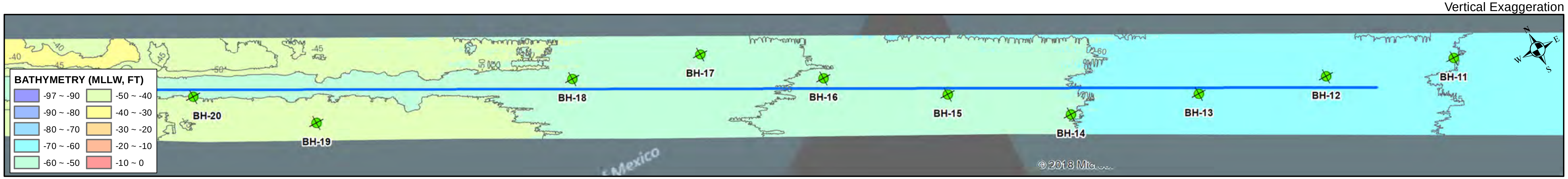

LEGEND

- 🟥 Lean CLAY (CL)
- 🟥 Fat CLAY (CH)
- 🟨 Poorly-Graded SAND (SP)
- 🟨 Clayey SAND (SC)
- 🟨 Silty SAND (SM)
- ― Bathymetry (MLLW, ft)
- - - Minimum Boring Termination Depth (85 ft, MLLW)

UNDRAINED SHEAR STRENGTH (S_u)

- ▲ Unconsolidated Undrained Triaxial
- ⊕ Torvane
- ⊗ Pocket Penetrometer
- \+ Soil Strength Exceeds Instrument's Maximum Measurable Strength.

TUBE AND SPT SAMPLES

P	Push thin-walled 3" tube.
20	Number of blows to produce 12" of penetration after the initial 6" of seating.
86/11"	Number of blows required to produce the indicated penetration after an initial 6" seating.
Ref/3"	50 blows produced the indicated penetration during the initial 6" interval.
W.O.H.	Weight of Hammer

NOTES:

1. As-built coordinates of exploration locations provided by Fugro Starfix Positioning System.
2. Stratigraphic contacts are approximate, and interpreted from borings. Conditions vary both along and perpendicular to the section line. The lateral extent of the top soil is not known based on the limited borings.
3. Boring data are projected onto the cross section line, therefore, stratigraphic contacts may not correspond to the descriptions (lithology, shear strength, etc.) on the logs.
4. Material descriptions are generalized. Materials may vary within the stratigraphic unit and include layers of material that differ from the general description. Refer to boring logs for detailed descriptions of the materials encountered at the exploration location.
5. See Plate 2 for location of explorations and cross section lines.

SUBSURFACE PROFILE (B-B')
PCCA CORPUS CHRISTI CHANNEL DEEPENING PROJECT
AECOM
CORPUS CHRISTI, TEXAS

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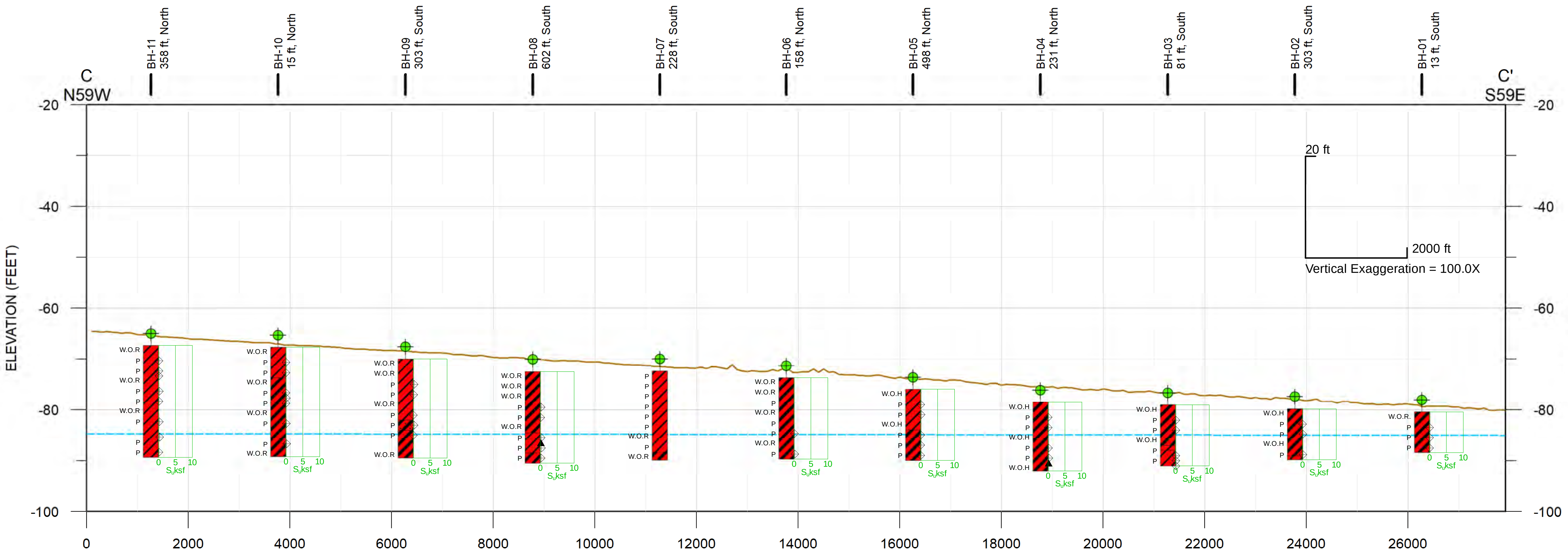

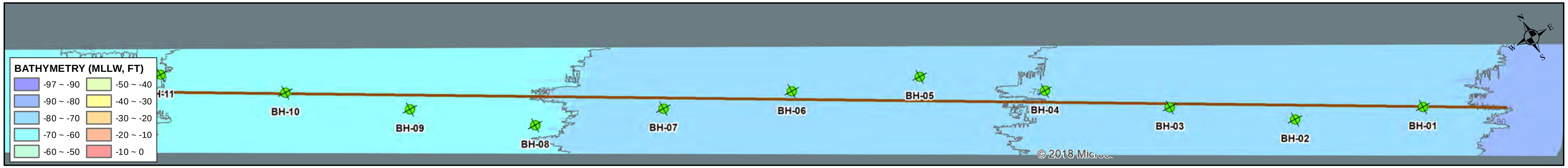

LEGEND

- ▨ Lean CLAY (CL)
- ▨ Fat CLAY (CH)
- ▨ Sandy Fat CLAY (CH)
- — Bathymetry (MLLW, ft)
- --- Minimum Boring Termination Depth (85 ft, MLLW)

UNDRAINED SHEAR STRENGTH (S_u)

- ▲ Unconsolidated Undrained Triaxial
- ◇ Torvane
- ⊗ Pocket Penetrometer
- \+ Soil Strength Exceeds Instrument's Maximum Measurable Strength.

TUBE AND SPT SAMPLES

P	Push thin-walled 3" tube.
20	Number of blows to produce 12" of penetration after the initial 6" of seating.
86/11"	Number of blows required to produce the indicated penetration after an initial 6" seating.
Ref/3"	50 blows produced the indicated penetration during the initial 6" interval.
W.O.H.	Weight of Hammer

NOTES:

1. As-built coordinates of exploration locations provided by Fugro Starfix Positioning System.
2. Stratigraphic contacts are approximate, and interpreted from borings. Conditions vary both along and perpendicular to the section line. The lateral extent of the top soil is not known based on the limited borings.
3. Boring data are projected onto the cross section line, therefore, stratigraphic contacts may not correspond to the descriptions (lithology, shear strength, etc.) on the logs.
4. Material descriptions are generalized. Materials may vary within the stratigraphic unit and include layers of material that differ from the general description. Refer to boring logs for detailed descriptions of the materials encountered at the exploration location.
5. See Plate 2 for location of explorations and cross section lines.

SUBSURFACE PROFILE (C-C')
PCCA CORPUS CHRISTI CHANNEL DEEPENING PROJECT
AECOM
CORPUS CHRISTI, TEXAS

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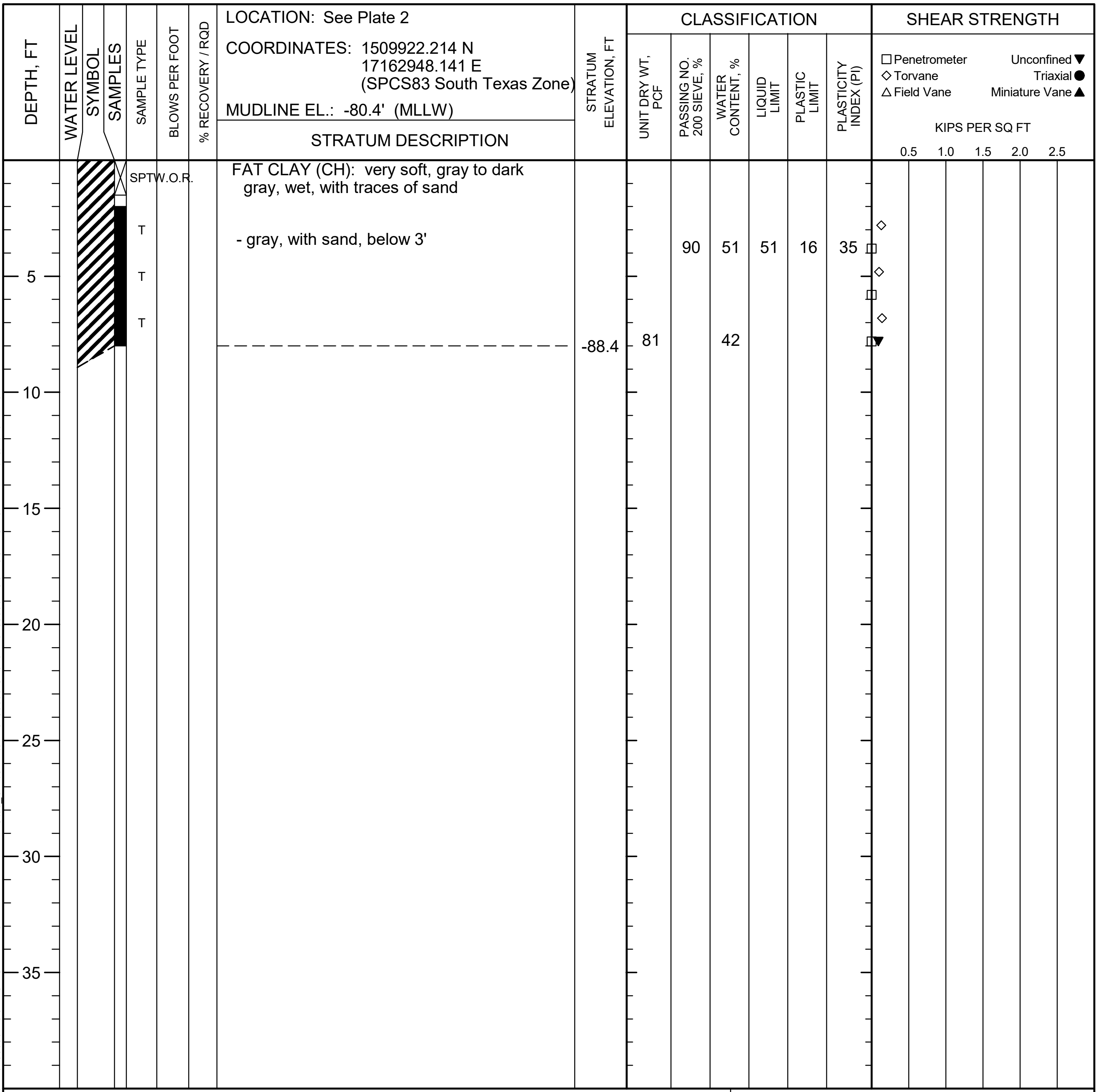
BORING LOGS



LOCATION: See Plate 2

COORDINATES: 1509922.214 N
17162948.141 E
(SPCS83 South Texas Zone)

MUDLINE EL.: -80.4' (MLLW)

SAMPLE TYPE	BLOWS PER FOOT	STRATUM DESCRIPTION	STRATUM ELEVATION, FT	UNIT DRY WT, PCF	PASSING NO. 200 SIEVE, %	WATER CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX (PI)
SPT	W.O.R.	FAT CLAY (CH): very soft, gray to dark gray, wet, with traces of sand							
T									
		- gray, with sand, below 3'			90	51	51	16	35
T									
T									
			-88.4	81		42			

NOTES:
Depth to Mudline (ft) = 92.0
Depth to Water (ft) = 10.5
Water Depth (ft) = 81.5
Record Date&Time: 8/1/2018 5:30

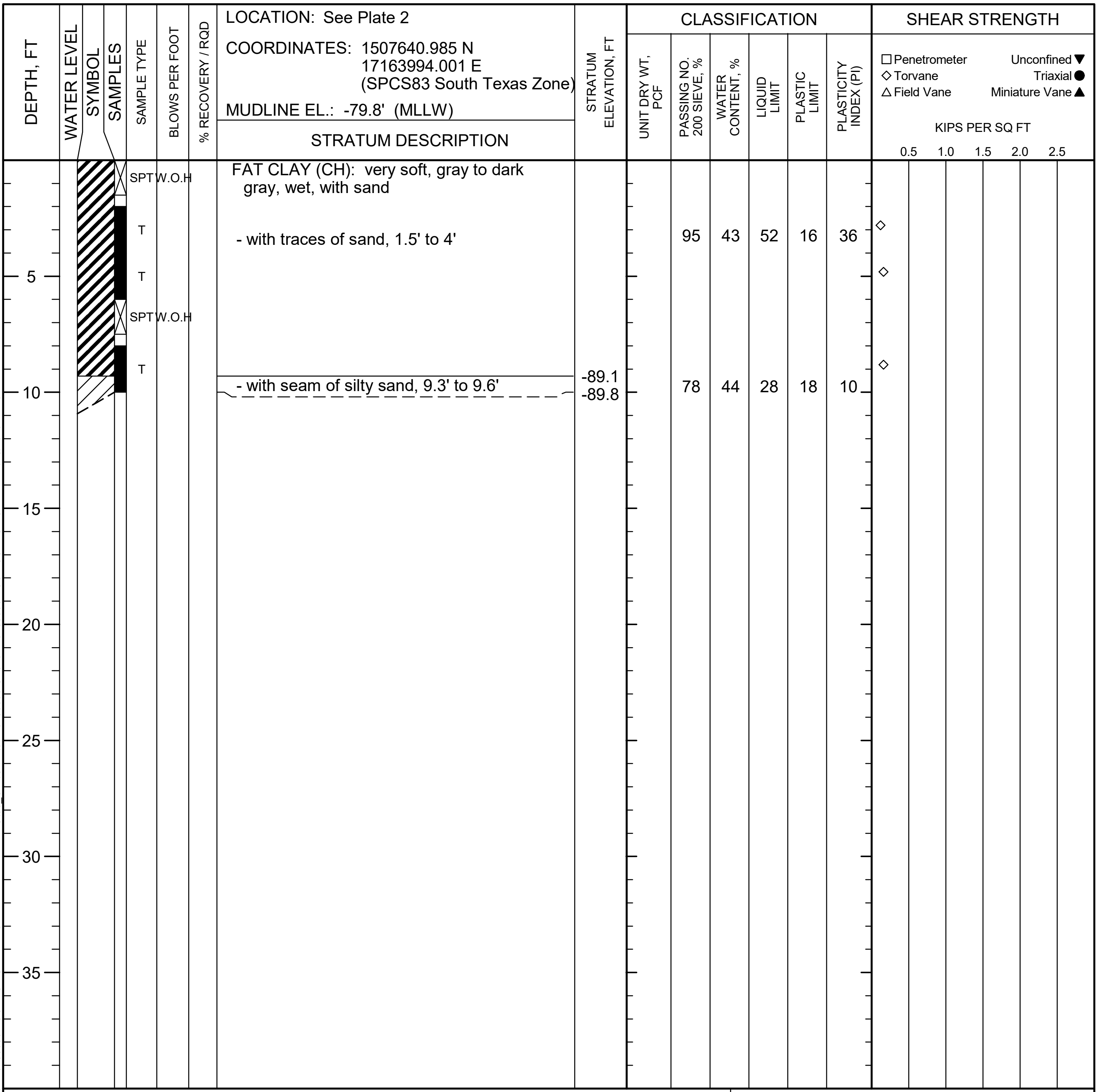
DATE: August 1, 2018
TOTAL DEPTH: 8'
CAVED DEPTH: Not Applicable
DRY AUGER: Not Applicable
WET ROTARY: 0' to 8'
BACKFILL: NONE
HAMMER TYPE: Automatic Trip
LOGGER: J. Soto/A. Bull

LOG OF BORING NO. BH-01
SHIP CHANNEL DEEPENING PROJECT
PORT OF CORPUS CHRISTI AUTHORITY
CORPUS CHRISTI, TEXAS

LOCATION: See Plate 2

COORDINATES: 1507640.985 N
17163994.001 E
(SPCS83 South Texas Zone)

MUDLINE EL.: -79.8' (MLLW)

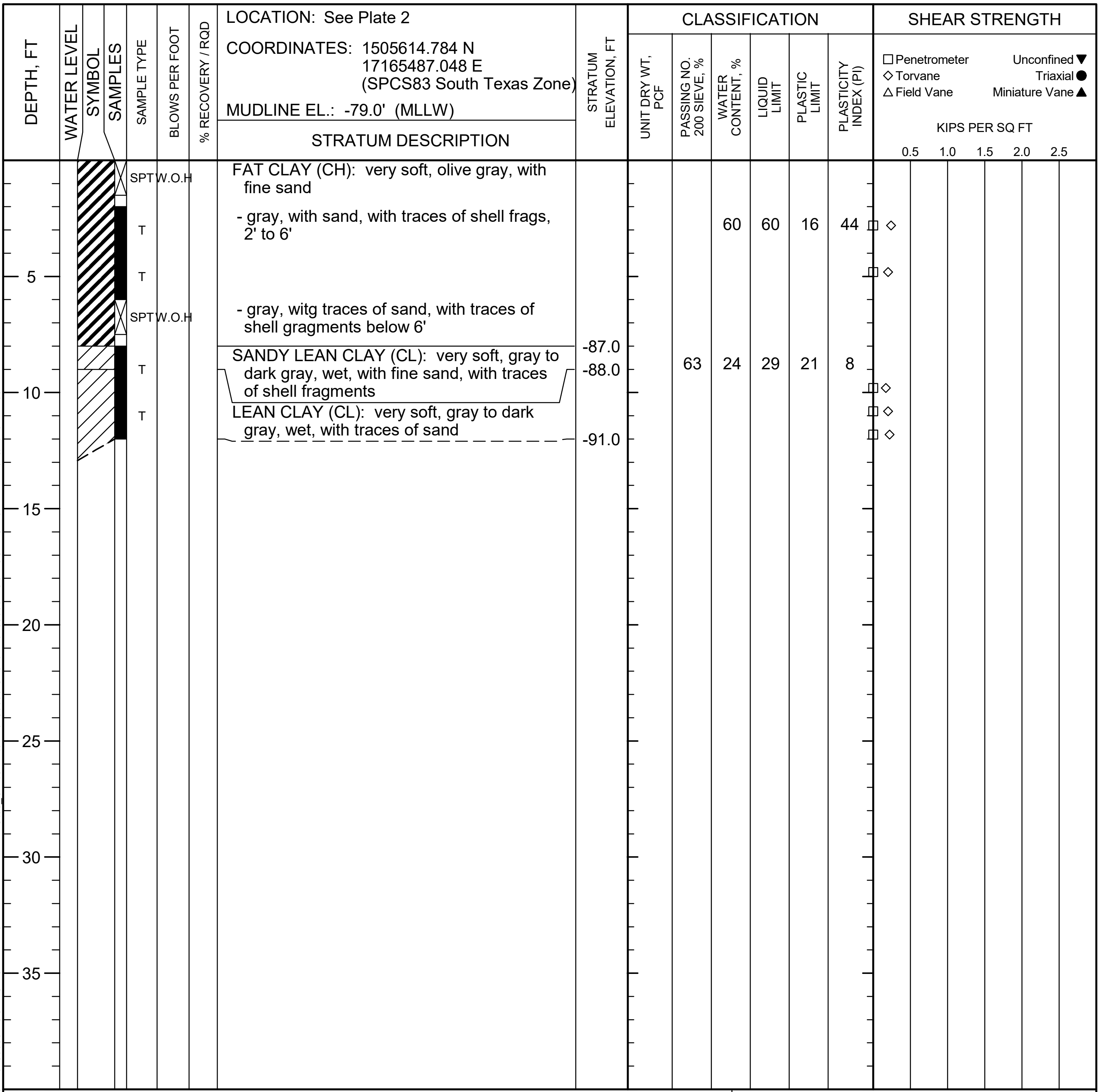


SAMPLE TYPE	BLOWS PER FOOT	% RECOVERY / RQD	STRATUM DESCRIPTION	STRATUM ELEVATION, FT	UNIT DRY WT, PCF	PASSING NO. 200 SIEVE, %	WATER CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX (PI)
SPT	W.O.H		FAT CLAY (CH): very soft, gray to dark gray, wet, with sand							
T			- with traces of sand, 1.5' to 4'			95	43	52	16	36
T										
SPT	W.O.H									
T				-89.1						
			- with seam of silty sand, 9.3' to 9.6'	-89.8		78	44	28	18	10

NOTES:
Depth to Mudline (ft) = 90.1
Depth to Water (ft) = 10.2
Water Depth (ft) = 79.9
Record Date&Time: 8/1/2018 1:00

DATE: August 1, 2018
TOTAL DEPTH: 10'
CAVED DEPTH: Not Applicable
DRY AUGER: Not Applicable
WET ROTARY: 0' to 10'
BACKFILL: NONE
HAMMER TYPE: Automatic Trip
LOGGER: J. Soto

LOG OF BORING NO. BH-02
SHIP CHANNEL DEEPENING PROJECT
PORT OF CORPUS CHRISTI AUTHORITY
CORPUS CHRISTI, TEXAS



LOCATION: See Plate 2

COORDINATES: 1505614.784 N
17165487.048 E
(SPCS83 South Texas Zone)

MUDLINE EL.: -79.0' (MLLW)

SAMPLE TYPE	BLOWS PER FOOT	% RECOVERY / RQD	STRATUM DESCRIPTION	STRATUM ELEVATION, FT	UNIT DRY WT, PCF	PASSING NO. 200 SIEVE, %	WATER CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX (PI)
SPT	W.O.H		FAT CLAY (CH): very soft, olive gray, with fine sand							
T			- gray, with sand, with traces of shell frags, 2' to 6'				60	60	16	44
T										
SPT	W.O.H		- gray, witg traces of sand, with traces of shell gragments below 6'							
			SANDY LEAN CLAY (CL): very soft, gray to dark gray, wet, with fine sand, with traces of shell fragments	-87.0						
T				-88.0		63	24	29	21	8
T			LEAN CLAY (CL): very soft, gray to dark gray, wet, with traces of sand							
				-91.0						

NOTES:

Depth to Mudline (ft) = 97.0
Depth to Water (ft) = 17.2
Water Depth (ft) = 79.8
Record Date&Time: 7/31/2018 20:30

DATE: July 31, 2018
TOTAL DEPTH: 12'
CAVED DEPTH: Not Applicable
DRY AUGER: Not Applicable
WET ROTARY: 0' to 12'
BACKFILL: NONE
HAMMER TYPE: Automatic Trip
LOGGER: A. Bull/J. Soto

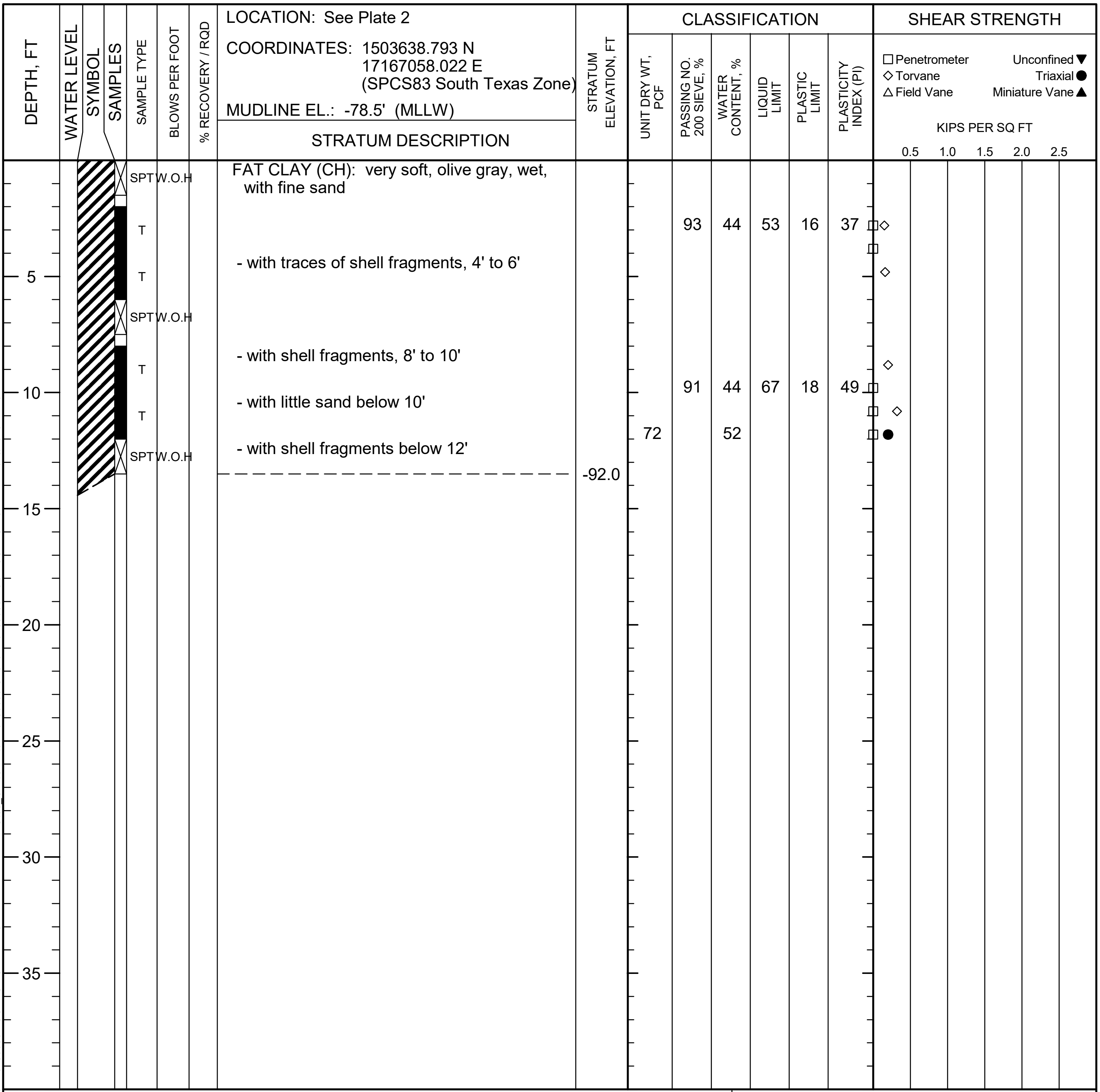
LOG OF BORING NO. BH-03

SHIP CHANNEL DEEPENING PROJECT
PORT OF CORPUS CHRISTI AUTHORITY
CORPUS CHRISTI, TEXAS

LOCATION: See Plate 2

COORDINATES: 1503638.793 N
17167058.022 E
(SPCS83 South Texas Zone)

MUDLINE EL.: -78.5' (MLLW)



FAT CLAY (CH): very soft, olive gray, wet, with fine sand

- with traces of shell fragments, 4' to 6'
- with shell fragments, 8' to 10'
- with little sand below 10'
- with shell fragments below 12'

UNIT DRY WT, PCF	PASSING NO. 200 SIEVE, %	WATER CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX (PI)
	93	44	53	16	37
	91	44	67	18	49
72		52			

NOTES:
Depth to Mudline (ft) = 89.5
Depth to Water (ft) = 10.3
Water Depth (ft) = 79.2
Record Date&Time: 7/31/2018 12:45

DATE: July 31, 2018
TOTAL DEPTH: 13.5'
CAVED DEPTH: Not Applicable
DRY AUGER: Not Applicable
WET ROTARY: 0' to 13.5'
BACKFILL: NONE
HAMMER TYPE: Automatic Trip
LOGGER: A. Bull

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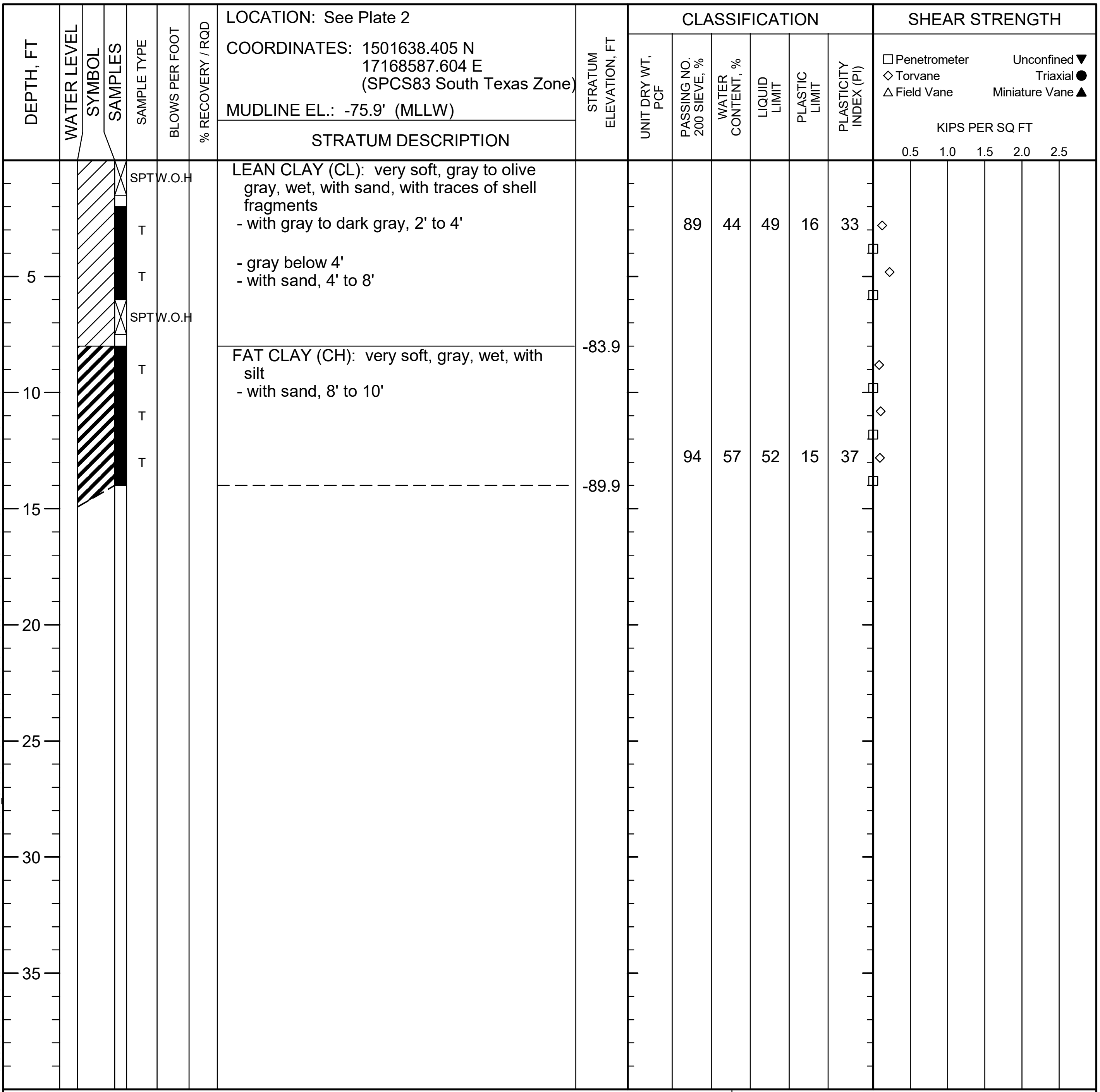
LOG OF BORING NO. BH-04
SHIP CHANNEL DEEPENING PROJECT
PORT OF CORPUS CHRISTI AUTHORITY
CORPUS CHRISTI, TEXAS



LOCATION: See Plate 2

COORDINATES: 1501638.405 N
17168587.604 E
(SPCS83 South Texas Zone)

MUDLINE EL.: -75.9' (MLLW)

DEPTH, FT	SAMPLE TYPE	BLOWS PER FOOT	STRATUM DESCRIPTION	STRATUM ELEVATION, FT	PASSING NO. 200 SIEVE, %	WATER CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX (PI)
0	SPT	W.O.H	LEAN CLAY (CL): very soft, gray to olive gray, wet, with sand, with traces of shell fragments - with gray to dark gray, 2' to 4'						
	T				89	44	49	16	33
5	T		- gray below 4' - with sand, 4' to 8'						
	SPT	W.O.H							
	T		FAT CLAY (CH): very soft, gray, wet, with silt - with sand, 8' to 10'	-83.9					
10	T								
	T				94	57	52	15	37
14				-89.9					

NOTES:
Depth to Mudline (ft) = 88.0
Depth to Water (ft) = 11.4
Water Depth (ft) = 76.6
Record Date&Time: 7/31/2018 9:15

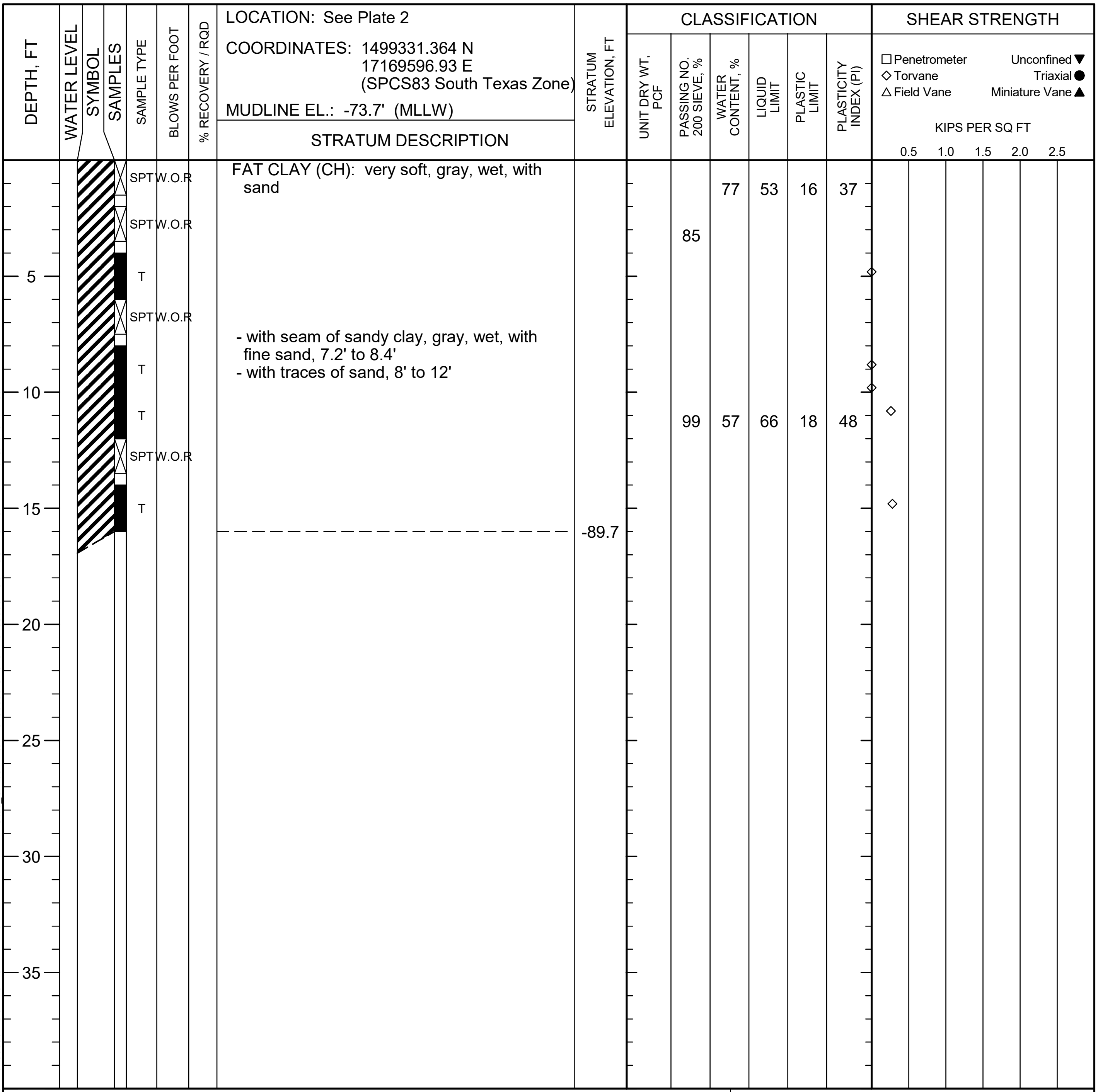
DATE: July 31, 2018
TOTAL DEPTH: 14'
CAVED DEPTH: Not Applicable
DRY AUGER: Not Applicable
WET ROTARY: 0' to 14'
BACKFILL: NONE
HAMMER TYPE: Automatic Trip
LOGGER: J. Soto/A. Bull

LOG OF BORING NO. BH-05
SHIP CHANNEL DEEPENING PROJECT
PORT OF CORPUS CHRISTI AUTHORITY
CORPUS CHRISTI, TEXAS

LOCATION: See Plate 2

COORDINATES: 1499331.364 N
17169596.93 E
(SPCS83 South Texas Zone)

MUDLINE EL.: -73.7' (MLLW)



Sample Type	Blows per Foot	Passing No. 200 Sieve, %	Water Content, %	Liquid Limit	Plastic Limit	Plasticity Index (PI)
SPT	W.O.R		77	53	16	37
SPT	W.O.R	85				
T						
SPT	W.O.R					
T						
T		99	57	66	18	48
SPT	W.O.R					
T						

FAT CLAY (CH): very soft, gray, wet, with sand

- with seam of sandy clay, gray, wet, with fine sand, 7.2' to 8.4'
- with traces of sand, 8' to 12'

NOTES:

Depth to Mudline (ft) = 84.0
Depth to Water (ft) = 10.0
Water Depth (ft) = 74.0
Record Date&Time: 7/30/2018 19:31

DATE: July 30, 2018
TOTAL DEPTH: 16'
CAVED DEPTH: Not Applicable
DRY AUGER: Not Applicable
WET ROTARY: 0' to 16'
BACKFILL: NONE
HAMMER TYPE: Automatic Trip
LOGGER: J. Soto

LOG OF BORING NO. BH-06

SHIP CHANNEL DEEPENING PROJECT
PORT OF CORPUS CHRISTI AUTHORITY
CORPUS CHRISTI, TEXAS

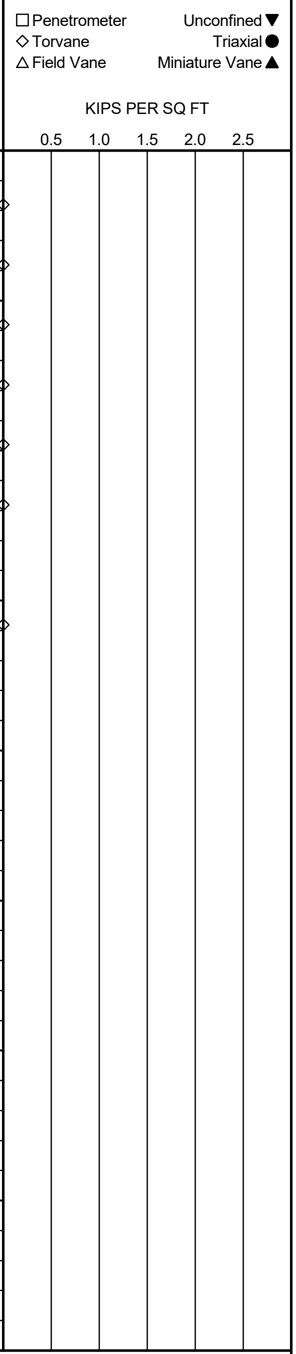
LOCATION: See Plate 2

COORDINATES: 1496999.926 N
17170564.864 E
(SPCS83 South Texas Zone)

MUDLINE EL.: -72.3' (MLLW)

DEPTH, FT	WATER LEVEL	SYMBOL	SAMPLES	SAMPLE TYPE	BLOWS PER FOOT	% RECOVERY / RQD	STRATUM DESCRIPTION	STRATUM ELEVATION, FT	UNIT DRY WT, PCF	PASSING NO. 200 SIEVE, %	WATER CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX (PI)
							LEAN CLAY (CL): very soft, gray							
				T										
				T										
5				T						90	51	48	16	32
				T			- with fine sand, with traces of shell fragments, 6' to 8'							
				T										
10							- with clay, below 10'							
				T										
				SPT	W.O.R									
15				T										
				SPT	W.O.R		FAT CLAY (CH): very soft, gray, with silt	-88.3						
								-89.8		85	54	62	18	44
20														
25														
30														
35														

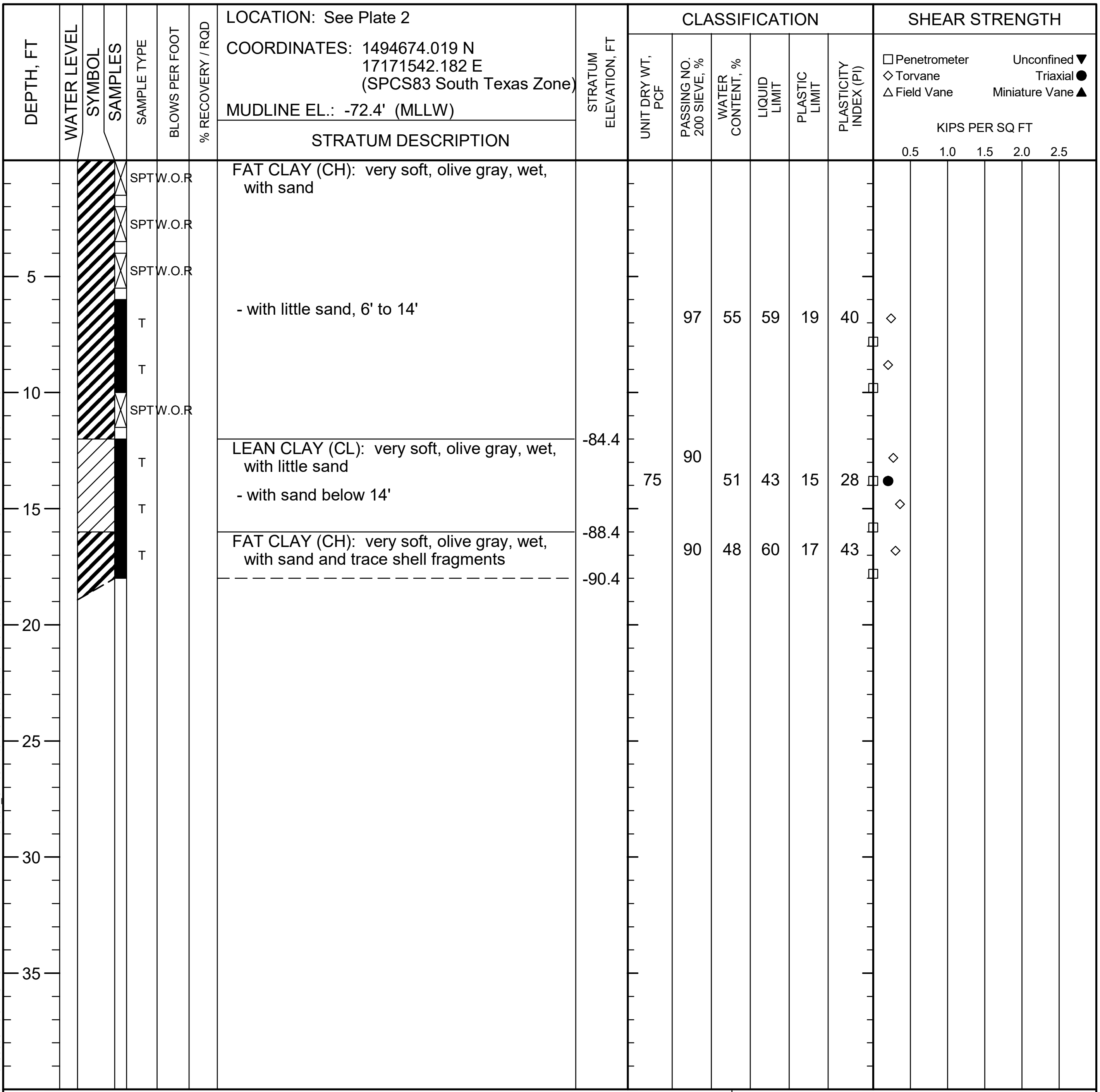
SHEAR STRENGTH



NOTES:
Depth to Mudline (ft) = 84.4
Depth to Water (ft) = 11.2
Water Depth (ft) = 73.2
Record Date&Time: 7/30/2018 10:30

DATE: July 30, 2018
TOTAL DEPTH: 17.5'
CAVED DEPTH: Not Applicable
DRY AUGER: Not Applicable
WET ROTARY: 0' to 18'
BACKFILL: NONE
HAMMER TYPE: Automatic Trip
LOGGER: A. Bull

LOG OF BORING NO. BH-07
SHIP CHANNEL DEEPENING PROJECT
PORT OF CORPUS CHRISTI AUTHORITY
CORPUS CHRISTI, TEXAS



LOCATION: See Plate 2

COORDINATES: 1494674.019 N
17171542.182 E
(SPCS83 South Texas Zone)

MUDLINE EL.: -72.4' (MLLW)

Sample Type	Blows per Foot
SPT	W.O.R
SPT	W.O.R
SPT	W.O.R
T	
T	
SPT	W.O.R
T	
T	
T	

STRATUM DESCRIPTION	STRATUM ELEVATION, FT
FAT CLAY (CH): very soft, olive gray, wet, with sand - with little sand, 6' to 14'	
LEAN CLAY (CL): very soft, olive gray, wet, with little sand - with sand below 14'	-84.4
FAT CLAY (CH): very soft, olive gray, wet, with sand and trace shell fragments	-88.4
	-90.4

UNIT DRY WT, PCF	PASSING NO. 200 SIEVE, %	WATER CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX (PI)
	97	55	59	19	40
	90				
75		51	43	15	28
	90	48	60	17	43

NOTES:
Depth to Mudline (ft) = 85.6
Depth to Water (ft) = 12.1
Water Depth (ft) = 73.5
Record Date&Time: 8/1/2018 11:00

DATE: August 1, 2018
TOTAL DEPTH: 18'
CAVED DEPTH: Not Applicable
DRY AUGER: Not Applicable
WET ROTARY: 0' to 18'
BACKFILL: NONE
HAMMER TYPE: Automatic Trip
LOGGER: A. Bull

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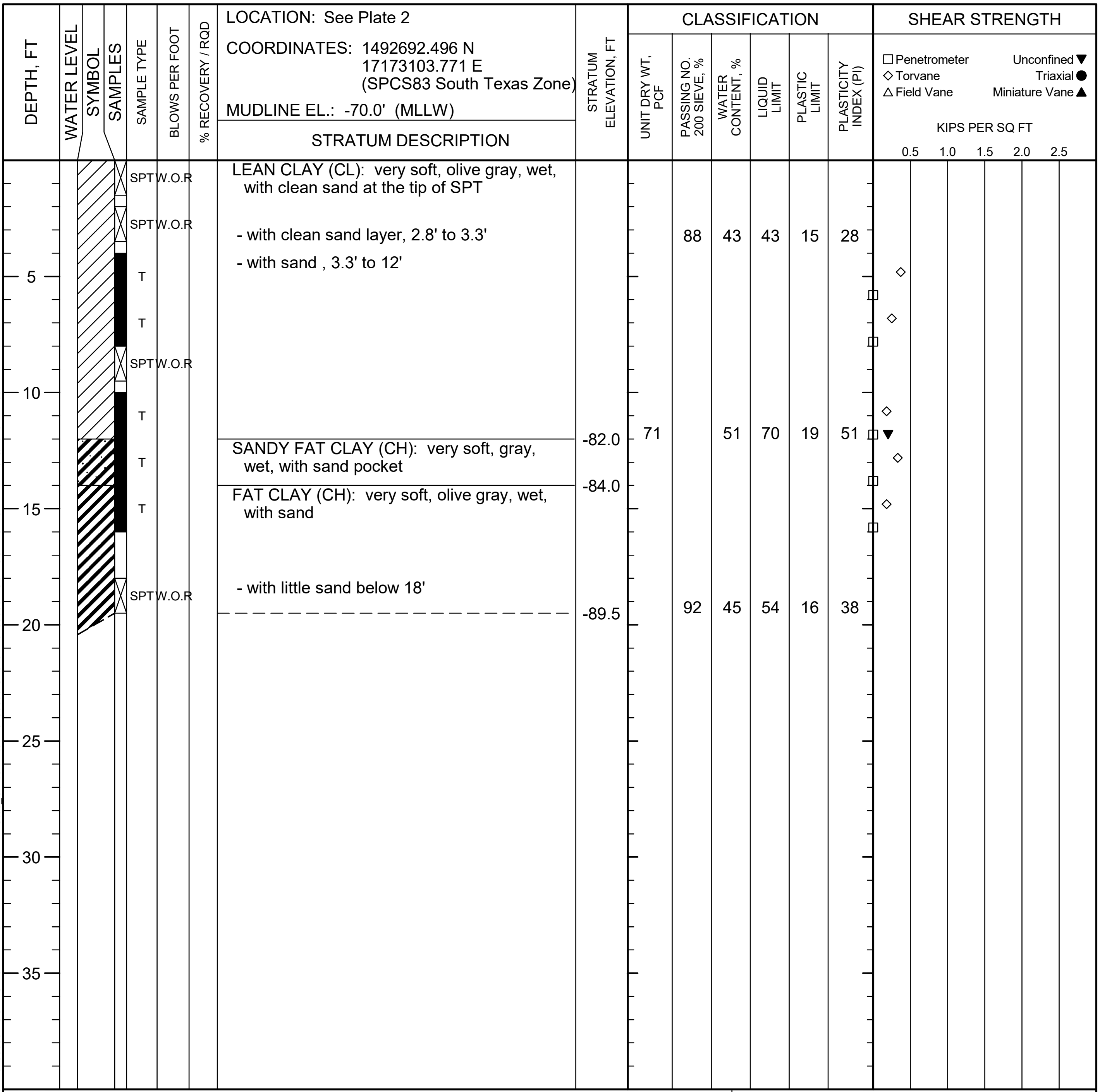
LOG OF BORING NO. BH-08
SHIP CHANNEL DEEPENING PROJECT
PORT OF CORPUS CHRISTI AUTHORITY
CORPUS CHRISTI, TEXAS

LOCATION: See Plate 2

COORDINATES: 1492692.496 N
17173103.771 E
(SPCS83 South Texas Zone)

MUDLINE EL.: -70.0' (MLLW)



Depth, ft	Sample Type	Blows per Foot
0.5	SPT	W.O.R
2.5	SPT	W.O.R
5	T	
7	T	
9	SPT	W.O.R
11	T	
13	T	
15	T	
18.5	SPT	W.O.R

Stratum Description	Stratum Elevation, ft
LEAN CLAY (CL): very soft, olive gray, wet, with clean sand at the tip of SPT - with clean sand layer, 2.8' to 3.3' - with sand , 3.3' to 12'	-82.0
SANDY FAT CLAY (CH): very soft, gray, wet, with sand pocket	-84.0
FAT CLAY (CH): very soft, olive gray, wet, with sand - with little sand below 18'	-89.5

Depth, ft	Unit Dry Wt, PCF	Passing No. 200 Sieve, %	Water Content, %	Liquid Limit	Plastic Limit	Plasticity Index (PI)
3		88	43	43	15	28
12	71		51	70	19	51
19.5		92	45	54	16	38

NOTES:

Depth to Mudline (ft) = 82.8
Depth to Water (ft) = 11.5
Water Depth (ft) = 71.3
Record Date&Time: 8/1/2018 14:45

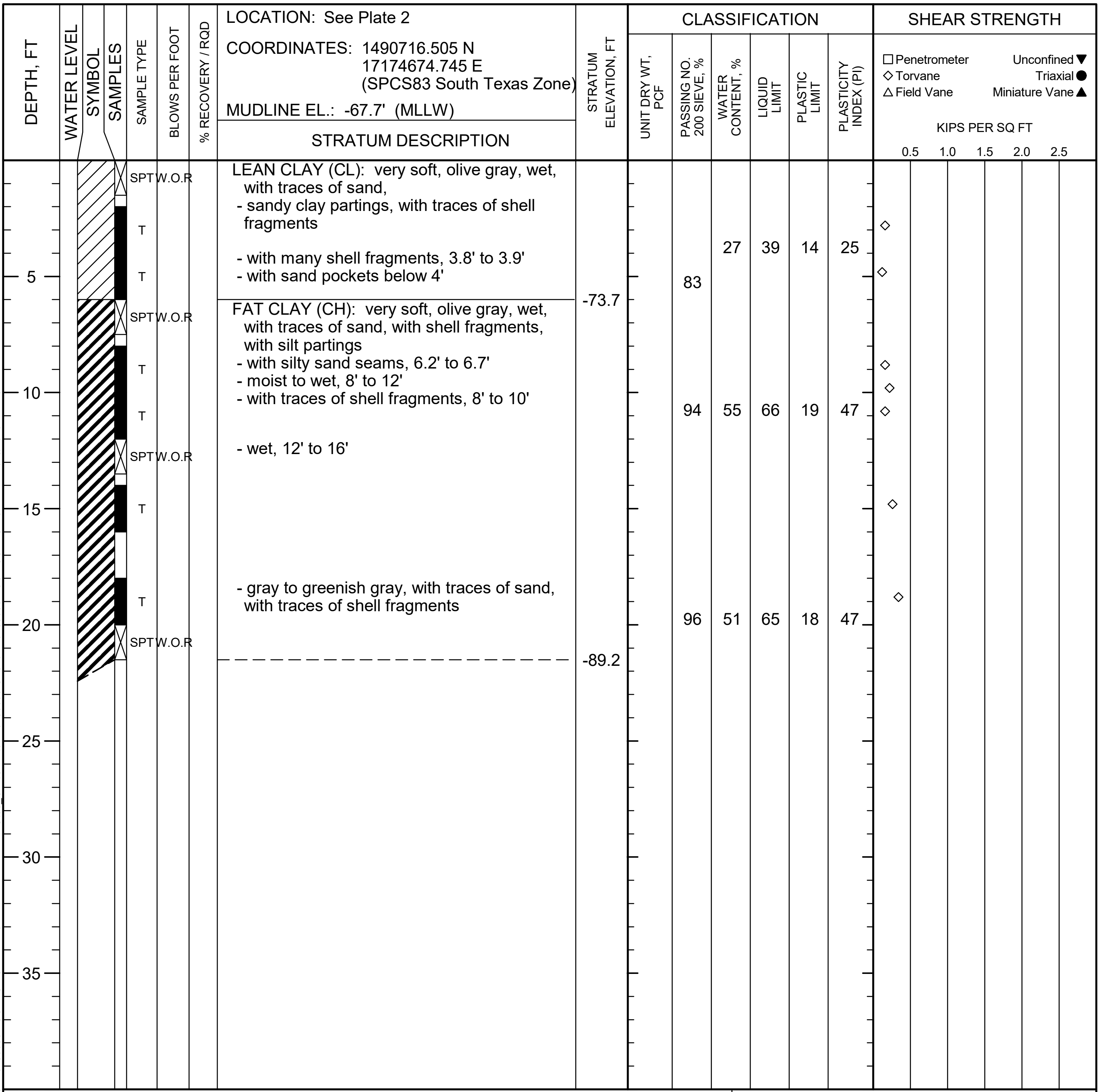
DATE: August 1, 2018
TOTAL DEPTH: 19.5'
CAVED DEPTH: Not Applicable
DRY AUGER: Not Applicable
WET ROTARY: 0' to 19.5'
BACKFILL: NONE
HAMMER TYPE: Automatic Trip
LOGGER: A. Bull

LOG OF BORING NO. BH-09
SHIP CHANNEL DEEPENING PROJECT
PORT OF CORPUS CHRISTI AUTHORITY
CORPUS CHRISTI, TEXAS

LOCATION: See Plate 2

COORDINATES: 1490716.505 N
17174674.745 E
(SPCS83 South Texas Zone)

MUDLINE EL.: -67.7' (MLLW)



STRATUM DESCRIPTION	STRATUM ELEVATION, FT
LEAN CLAY (CL): very soft, olive gray, wet, with traces of sand, - sandy clay partings, with traces of shell fragments - with many shell fragments, 3.8' to 3.9' - with sand pockets below 4'	-73.7
FAT CLAY (CH): very soft, olive gray, wet, with traces of sand, with shell fragments, with silt partings - with silty sand seams, 6.2' to 6.7' - moist to wet, 8' to 12' - with traces of shell fragments, 8' to 10' - wet, 12' to 16' - gray to greenish gray, with traces of sand, with traces of shell fragments	-89.2

CLASSIFICATION

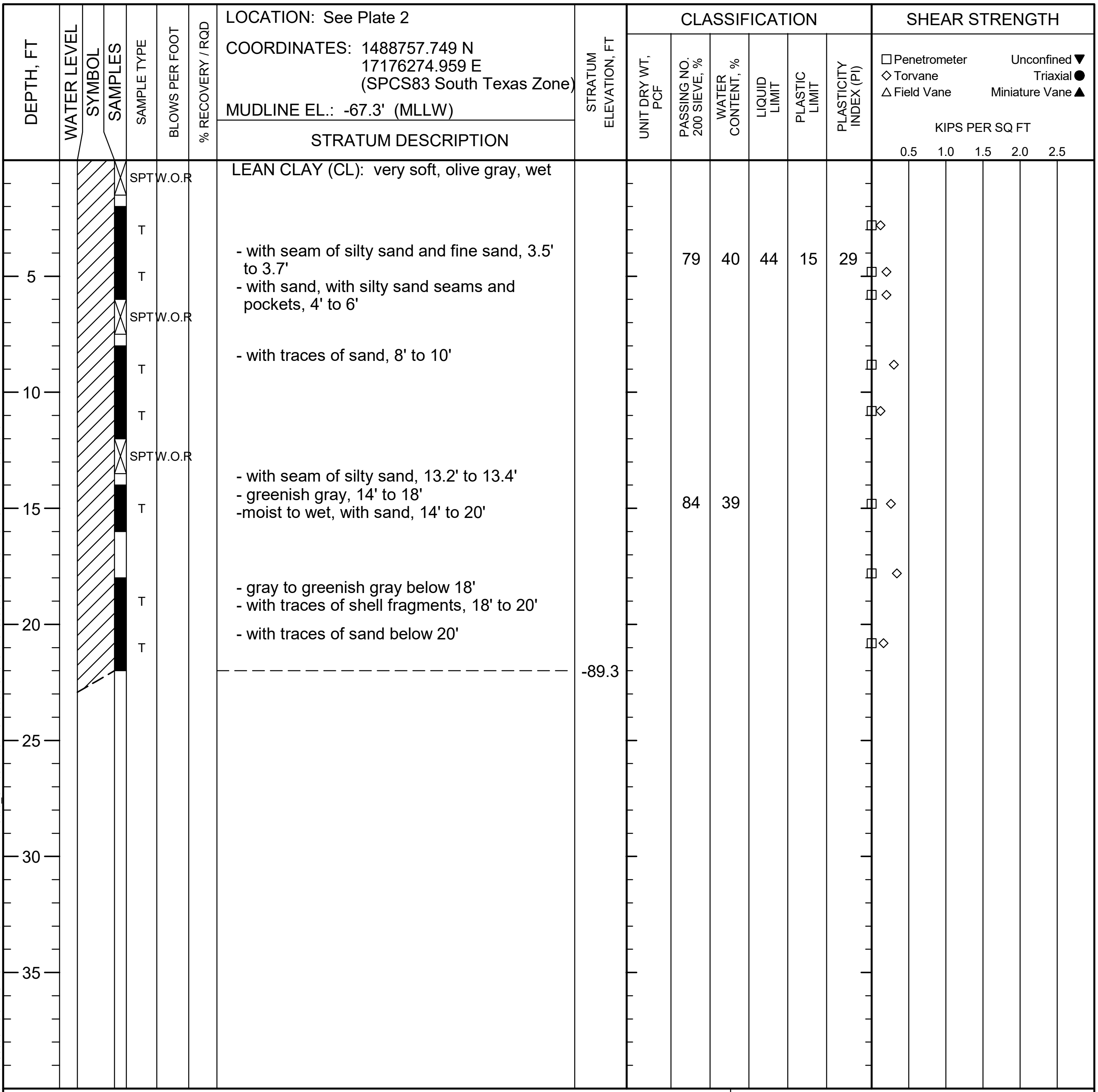
UNIT DRY WT, PCF	PASSING NO. 200 SIEVE, %	WATER CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX (PI)
		27	39	14	25
	83				
	94	55	66	19	47
	96	51	65	18	47

NOTES:
Depth to Mudline (ft) = 79.7
Depth to Water (ft) = 10.8
Water Depth (ft) = 68.9
Record Date&Time: 8/1/2018 20:55

DATE: August 1, 2018
TOTAL DEPTH: 21.5'
CAVED DEPTH: Not Applicable
DRY AUGER: Not Applicable
WET ROTARY: 0' to 21.5'
BACKFILL: NONE
HAMMER TYPE: Automatic Trip
LOGGER: J. Soto

LOG OF BORING NO. BH-10
SHIP CHANNEL DEEPENING PROJECT
PORT OF CORPUS CHRISTI AUTHORITY
CORPUS CHRISTI, TEXAS

PLATE C-10



LOCATION: See Plate 2

COORDINATES: 1488757.749 N
17176274.959 E
(SPCS83 South Texas Zone)

MUDLINE EL.: -67.3' (MLLW)

STRATUM DESCRIPTION

LEAN CLAY (CL): very soft, olive gray, wet

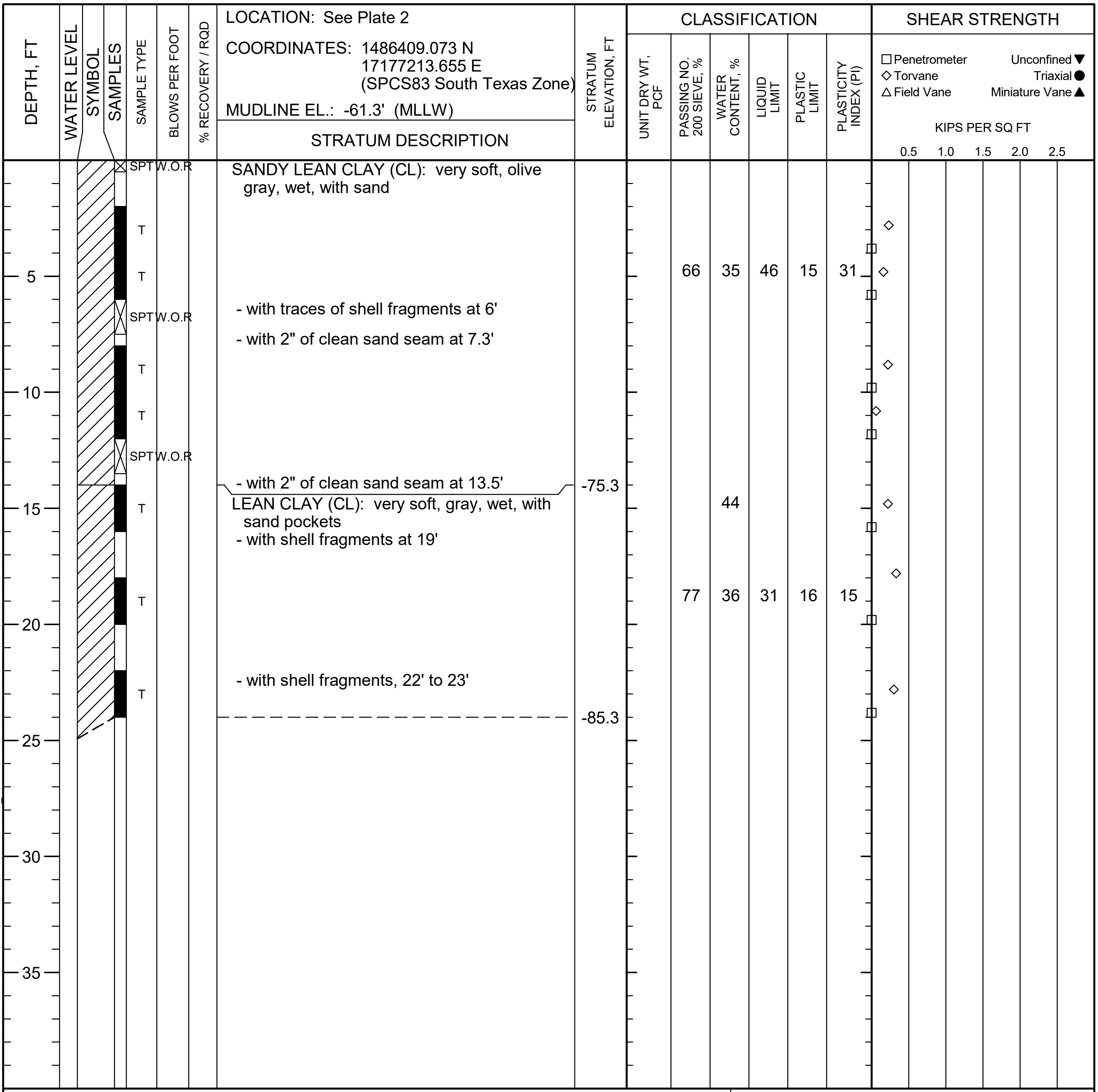
- with seam of silty sand and fine sand, 3.5' to 3.7'
- with sand, with silty sand seams and pockets, 4' to 6'
- with traces of sand, 8' to 10'
- with seam of silty sand, 13.2' to 13.4'
- greenish gray, 14' to 18'
-moist to wet, with sand, 14' to 20'
- gray to greenish gray below 18'
- with traces of shell fragments, 18' to 20'
- with traces of sand below 20'

UNIT DRY WT, PCF	PASSING NO. 200 SIEVE, %	WATER CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX (PI)
	79	40	44	15	29
	84	39			

NOTES:
Depth to Mudline (ft) = 79.8
Depth to Water (ft) = 11.6
Water Depth (ft) = 68.2
Record Date&Time: 8/2/2018 1:35

DATE: August 2, 2018
TOTAL DEPTH: 22'
CAVED DEPTH: Not Applicable
DRY AUGER: Not Applicable
WET ROTARY: 0' to 22'
BACKFILL: NONE
HAMMER TYPE: Automatic Trip
LOGGER: J. Soto

LOG OF BORING NO. BH-11
SHIP CHANNEL DEEPENING PROJECT
PORT OF CORPUS CHRISTI AUTHORITY
CORPUS CHRISTI, TEXAS



LOCATION: See Plate 2

COORDINATES: 1486409.073 N
17177213.655 E
(SPCS83 South Texas Zone)

MUDLINE EL.: -61.3' (MLLW)

STRATUM DESCRIPTION	STRATUM ELEVATION, FT
SANDY LEAN CLAY (CL): very soft, olive gray, wet, with sand - with traces of shell fragments at 6' - with 2" of clean sand seam at 7.3' - with 2" of clean sand seam at 13.5'	-75.3
LEAN CLAY (CL): very soft, gray, wet, with sand pockets - with shell fragments at 19' - with shell fragments, 22' to 23'	-85.3

DEPTH, FT	UNIT DRY WT, PCF	PASSING NO. 200 SIEVE, %	WATER CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX (PI)
5		66	35	46	15	31
15			44			
19		77	36	31	16	15

NOTES:
Depth to Mudline (ft) = 70.25
Depth to Water (ft) = 7.5
Water Depth (ft) = 62.75
Record Date&Time: 8/2/2018 7:45

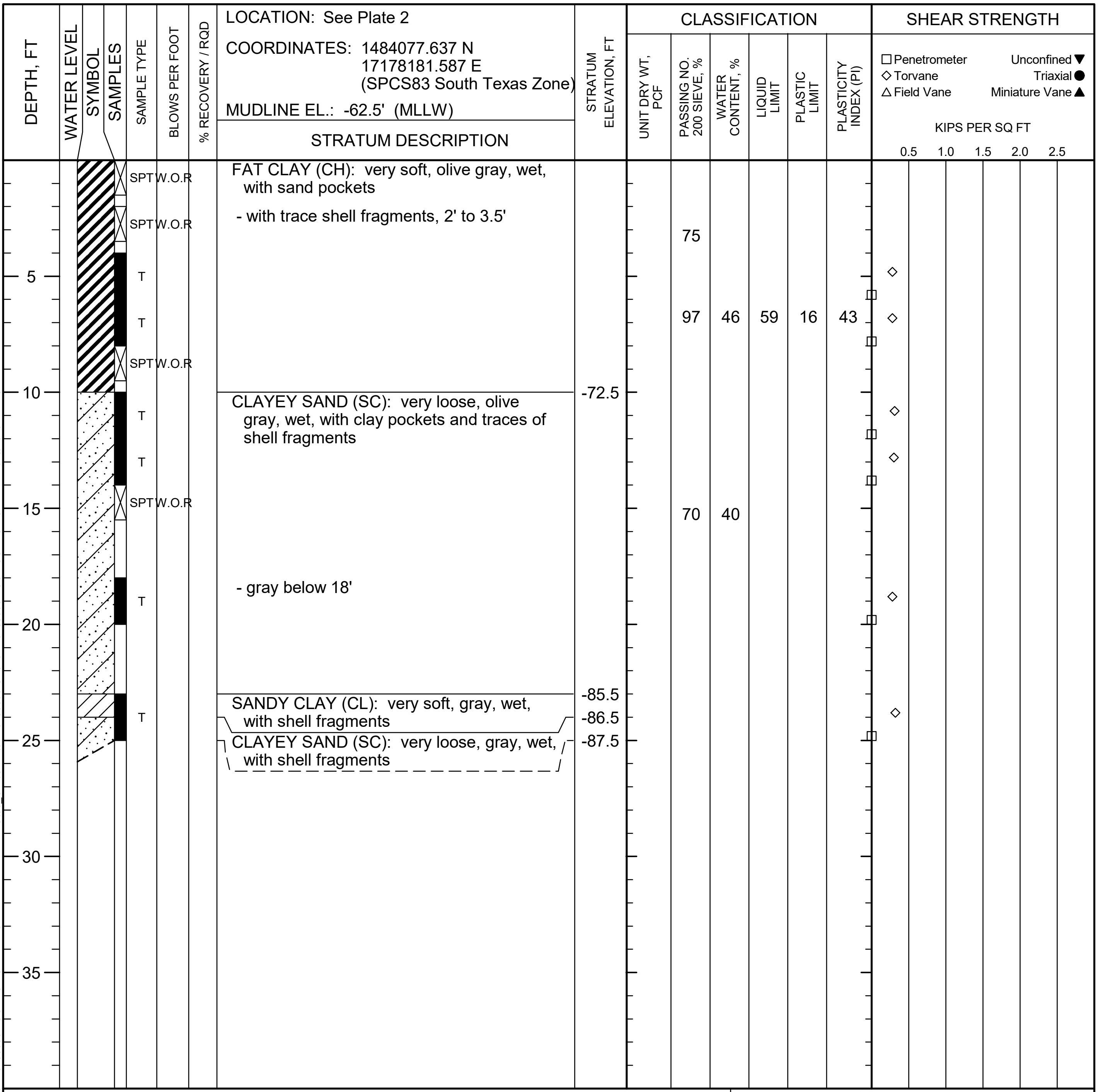
DATE: August 2, 2018
TOTAL DEPTH: 24'
CAVED DEPTH: Not Applicable
DRY AUGER: Not Applicable
WET ROTARY: 0' to 24'
BACKFILL: NONE
HAMMER TYPE: Automatic Trip
LOGGER: A. Bull

LOG OF BORING NO. BH-12
SHIP CHANNEL DEEPENING PROJECT
PORT OF CORPUS CHRISTI AUTHORITY
CORPUS CHRISTI, TEXAS

LOCATION: See Plate 2

COORDINATES: 1484077.637 N
17178181.587 E
(SPCS83 South Texas Zone)

MUDLINE EL.: -62.5' (MLLW)



Sample Type	Blows per Foot	Stratum Description	Stratum Elevation, ft	Passing No. 200 Sieve, %	Water Content, %	Liquid Limit	Plastic Limit	Plasticity Index (PI)
SPT	W.O.R	FAT CLAY (CH): very soft, olive gray, wet, with sand pockets						
SPT	W.O.R	- with trace shell fragments, 2' to 3.5'		75				
T								
T				97	46	59	16	43
SPT	W.O.R							
T		CLAYEY SAND (SC): very loose, olive gray, wet, with clay pockets and traces of shell fragments	-72.5					
T								
SPT	W.O.R			70	40			
T		- gray below 18'						
T		SANDY CLAY (CL): very soft, gray, wet, with shell fragments	-85.5					
		CLAYEY SAND (SC): very loose, gray, wet, with shell fragments	-86.5					
			-87.5					

NOTES:
Depth to Mudline (ft) = 74.2
Depth to Water (ft) = 10.5
Water Depth (ft) = 63.7
Record Date&Time: 8/2/2018 13:00

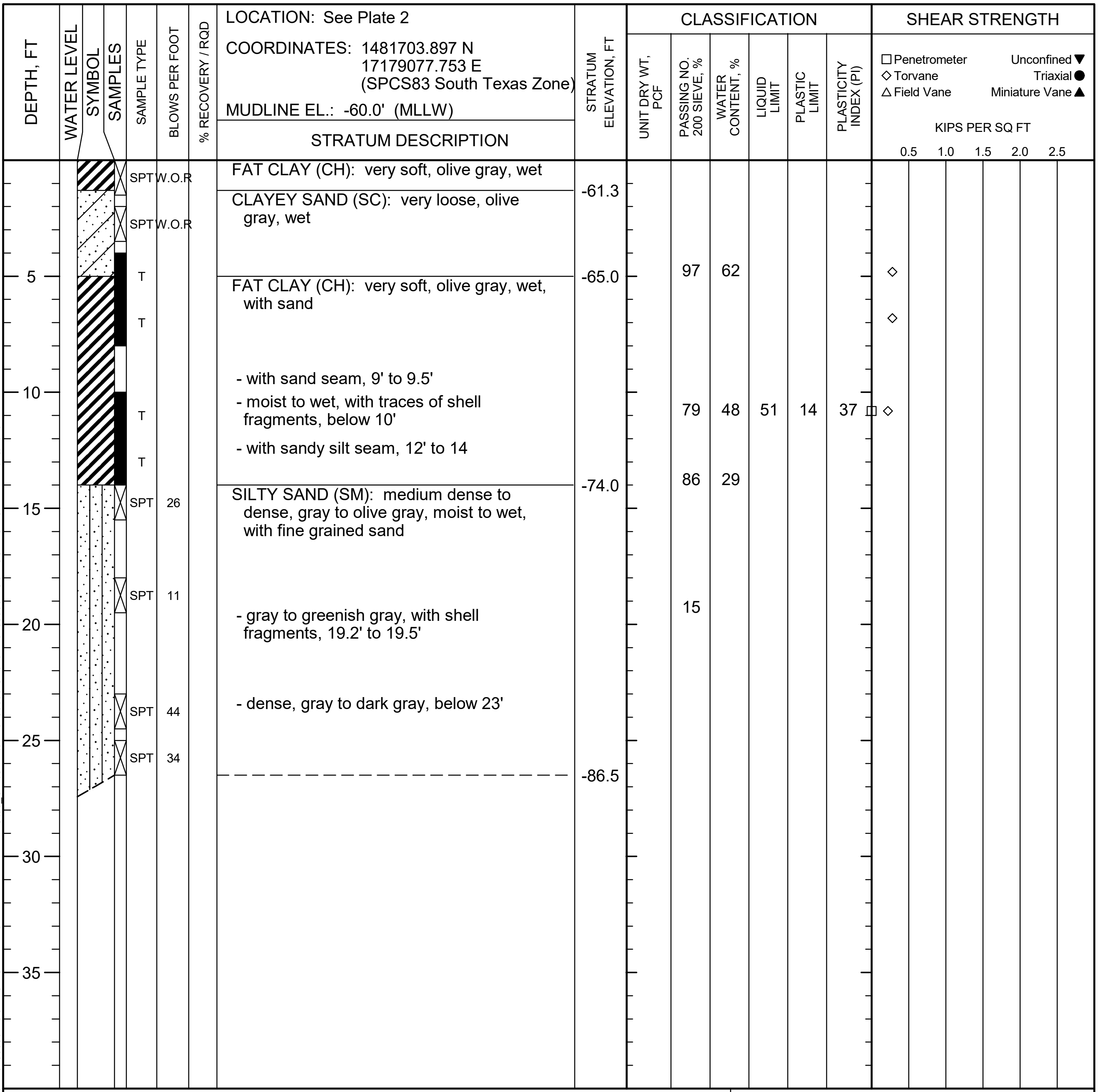
DATE: August 2, 2018
TOTAL DEPTH: 25'
CAVED DEPTH: Not Applicable
DRY AUGER: Not Applicable
WET ROTARY: 0' to 25'
BACKFILL: NONE
HAMMER TYPE: Automatic Trip
LOGGER: A. Bull

LOG OF BORING NO. BH-13
SHIP CHANNEL DEEPENING PROJECT
PORT OF CORPUS CHRISTI AUTHORITY
CORPUS CHRISTI, TEXAS

LOCATION: See Plate 2

COORDINATES: 1481703.897 N
17179077.753 E
(SPCS83 South Texas Zone)

MUDLINE EL.: -60.0' (MLLW)



STRATUM DESCRIPTION	STRATUM ELEVATION, FT
FAT CLAY (CH): very soft, olive gray, wet	-61.3
CLAYEY SAND (SC): very loose, olive gray, wet	-65.0
FAT CLAY (CH): very soft, olive gray, wet, with sand - with sand seam, 9' to 9.5' - moist to wet, with traces of shell fragments, below 10' - with sandy silt seam, 12' to 14	-74.0
SILTY SAND (SM): medium dense to dense, gray to olive gray, moist to wet, with fine grained sand - gray to greenish gray, with shell fragments, 19.2' to 19.5' - dense, gray to dark gray, below 23'	-86.5

SAMPLE TYPE	BLOWS PER FOOT
SPT	W.O.R
SPT	W.O.R
T	
T	
T	
T	
SPT	26
SPT	11
SPT	44
SPT	34

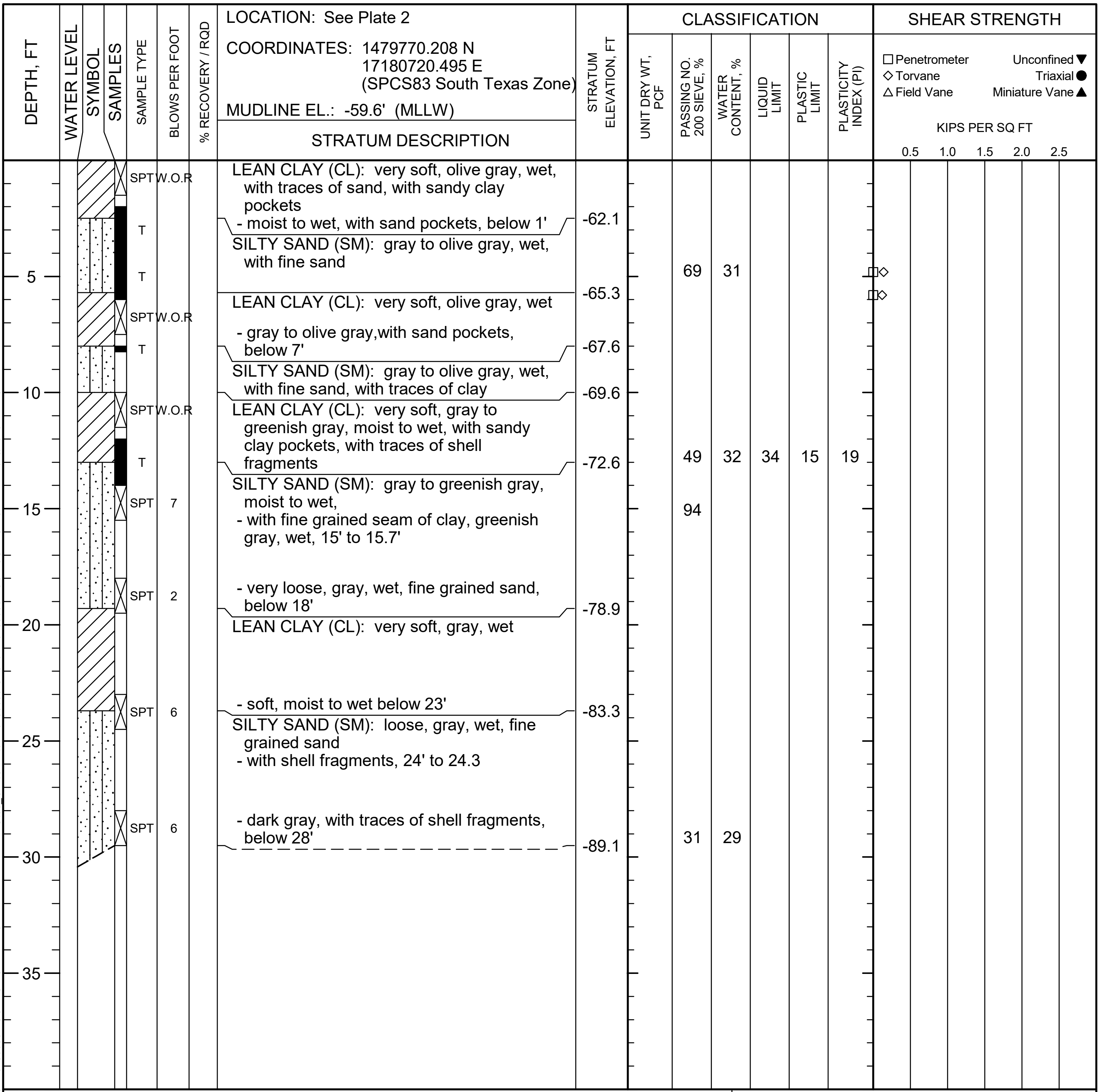
DEPTH, FT	UNIT DRY WT, PCF	PASSING NO. 200 SIEVE, %	WATER CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX (PI)
5		97	62			
10.7		79	48	51	14	37
13.7		86	29			
19.3		15				

NOTES:

Depth to Mudline (ft) = 71.2
Depth to Water (ft) = 9.8
Water Depth (ft) = 61.4
Record Date&Time: 8/2/2018 18:30

DATE: August 2, 2018
TOTAL DEPTH: 26.5'
CAVED DEPTH: Not Applicable
DRY AUGER: Not Applicable
WET ROTARY: 0' to 26.5'
BACKFILL: NONE
HAMMER TYPE: Automatic Trip
LOGGER: A. Bull/J. Soto

LOG OF BORING NO. BH-14
SHIP CHANNEL DEEPENING PROJECT
PORT OF CORPUS CHRISTI AUTHORITY
CORPUS CHRISTI, TEXAS



LOCATION: See Plate 2

COORDINATES: 1479770.208 N
17180720.495 E
(SPCS83 South Texas Zone)

MUDLINE EL.: -59.6' (MLLW)

SAMPLE TYPE	BLOWS PER FOOT	STRATUM DESCRIPTION	STRATUM ELEVATION, FT	UNIT DRY WT, PCF	PASSING NO. 200 SIEVE, %	WATER CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX (PI)
SPT	W.O.R	LEAN CLAY (CL): very soft, olive gray, wet, with traces of sand, with sandy clay pockets - moist to wet, with sand pockets, below 1'	-62.1						
T T		SILTY SAND (SM): gray to olive gray, wet, with fine sand	-65.3		69	31			
SPT T	W.O.R	LEAN CLAY (CL): very soft, olive gray, wet - gray to olive gray,with sand pockets, below 7'	-67.6						
		SILTY SAND (SM): gray to olive gray, wet, with fine sand, with traces of clay	-69.6						
SPT T	W.O.R	LEAN CLAY (CL): very soft, gray to greenish gray, moist to wet, with sandy clay pockets, with traces of shell fragments	-72.6		49	32	34	15	19
SPT SPT	7 2	SILTY SAND (SM): gray to greenish gray, moist to wet, - with fine grained seam of clay, greenish gray, wet, 15' to 15.7' - very loose, gray, wet, fine grained sand, below 18'	-78.9		94				
SPT	6	LEAN CLAY (CL): very soft, gray, wet - soft, moist to wet below 23'	-83.3						
SPT	6	SILTY SAND (SM): loose, gray, wet, fine grained sand - with shell fragments, 24' to 24.3 - dark gray, with traces of shell fragments, below 28'	-89.1		31	29			

NOTES:
Depth to Mudline (ft) = 71.1
Depth to Water (ft) = 10.2
Water Depth (ft) = 60.9
Record Date&Time: 8/2/2018 23:15

DATE: August 3, 2018
TOTAL DEPTH: 29.5'
CAVED DEPTH: Not Applicable
DRY AUGER: Not Applicable
WET ROTARY: 0' to 29.5
BACKFILL: NONE
HAMMER TYPE: Automatic Trip
LOGGER: J. Soto

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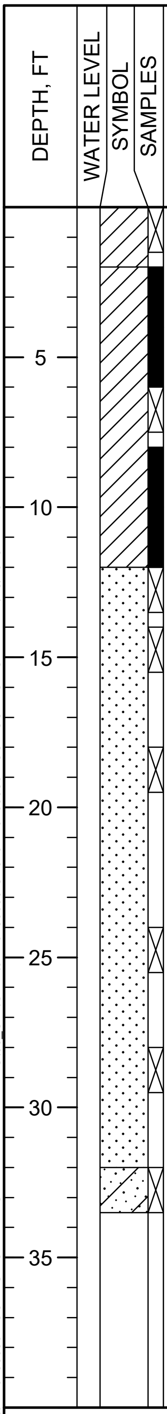
LOG OF BORING NO. BH-15
SHIP CHANNEL DEEPENING PROJECT
PORT OF CORPUS CHRISTI AUTHORITY
CORPUS CHRISTI, TEXAS

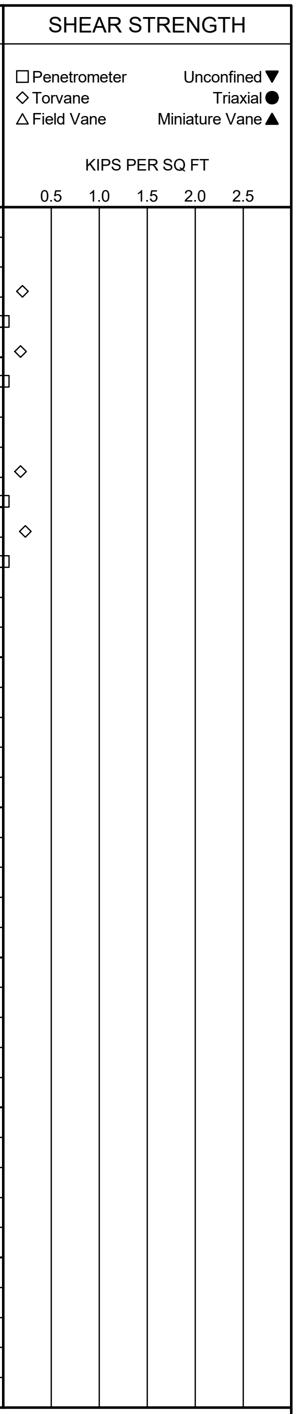
LOCATION: See Plate 2

COORDINATES: 1477794.217 N
17182291.468 E
(SPCS83 South Texas Zone)

MUDLINE EL.: -58.9' (MLLW)



SAMPLE TYPE	BLOWS PER FOOT	% RECOVERY / RQD	STRATUM DESCRIPTION	STRATUM ELEVATION, FT	UNIT DRY WT, PCF	PASSING NO. 200 SIEVE, %	WATER CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX (PI)
SPT	W. O. R.		SANDY LEAN CLAY (CL): very soft, olive gray, wet, with shell fragments							
				-60.9						
T			LEAN CLAY (CL): very soft, gray, wet, with sand and shell fragments							
T			- olive gray below 4'			81	56	43	15	28
SPT	W. O. R.									
T										
T						72				
				-70.9						
SPT	11		SAND (SP): very loose, olive gray, wet, with shell fragments and little clay							
SPT	W. O. R.									
SPT	3		- with abundant shell fragments				25			
			- 6" clay layer, 22' to 22.5' - with abundant shell fragments and clay							
SPT	3									
SPT	3		- with shell fragments and very little to no clay							
				-90.9						
SPT	13		CLAYEY SAND (SC): medium dense, greenish gray, with shell fragments and calcareous/calcium deposit pockets			28	20			
				-92.4						
			- olive gray sand (SP) with clay noted at bottom of SPS							



NOTES:
Depth to Mudline (ft) = 71.1
Depth to Water (ft) = 10.5
Water Depth (ft) = 60.6
Record Date&Time: 8/3/2018 6:45

DATE: August 3, 2018
TOTAL DEPTH: 33.5'
CAVED DEPTH: Not Applicable
DRY AUGER: Not Applicable
WET ROTARY: 0' to 33'
BACKFILL: NONE
HAMMER TYPE: Automatic Trip
LOGGER: A. Bull

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LOG OF BORING NO. BH-16
SHIP CHANNEL DEEPENING PROJECT
PORT OF CORPUS CHRISTI AUTHORITY
CORPUS CHRISTI, TEXAS

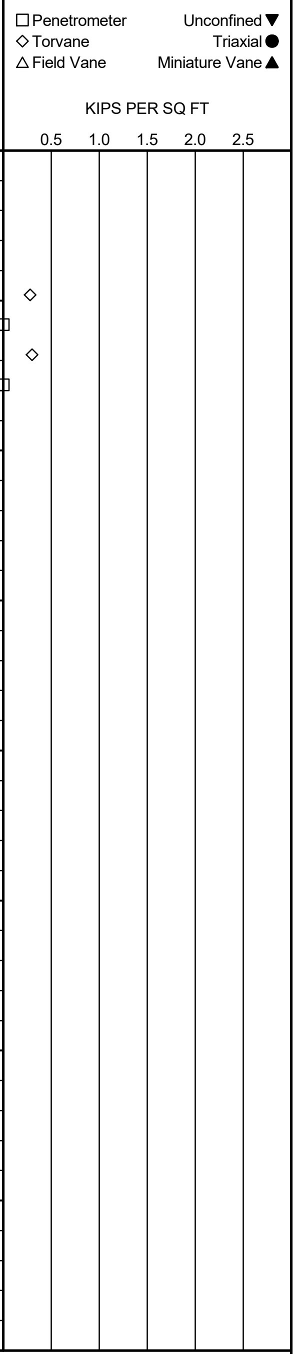
LOCATION: See Plate 2

COORDINATES: 1475902.092 N
17184004.727 E
(SPCS83 South Texas Zone)

MUDLINE EL.: -52.6' (MLLW)

DEPTH, FT	SAMPLE TYPE	BLOWS PER FOOT	STRATUM DESCRIPTION	STRATUM ELEVATION, FT	UNIT DRY WT, PCF	PASSING NO. 200 SIEVE, %	WATER CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX (PI)
	SPT	W.O.R.	SANDY LEAN CLAY (CL): very soft, olive gray, wet, high plasticity to 6'							
	SPT	W.O.R.					44	43	15	28
5	T		- gray, 4' to 8'							
	T		- with shell fragments							
	SPT	W.O.R.	- olive gray							
10	SPT	36	SILTY SAND (SM): dense, gray, with shell fragments	-62.6						
	SPT	10	- loose - with abundant shell fragments, 12' to 16'			22	28			
15	SPT	16	- medium dense, 14' to 28'							
	SPT	20	- with shell fragments to 28'							
20										
	SPT	24	- olive gray to 33'							
25						9				
	SPT	33	- dense, with trace of clay							
30										
	SPT	19	- medium dense, greenish gray and reddish brown below 33'			26	21			
35	SPT									
				-89.1						

SHEAR STRENGTH



NOTES:
Depth to Mudline (ft) = 64.8
Depth to Water (ft) = 10.8
Water Depth (ft) = 54
Record Date&Time: 8/3/2018 11:45

DATE: August 3, 2018
TOTAL DEPTH: 36.5'
CAVED DEPTH: Not Applicable
DRY AUGER: Not Applicable
WET ROTARY: 0' to 36'
BACKFILL: NONE
HAMMER TYPE: Automatic Trip
LOGGER: A. Bull

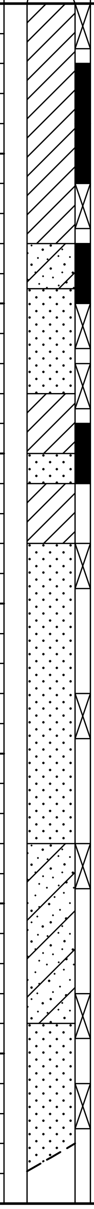
LOG OF BORING NO. BH-17
SHIP CHANNEL DEEPENING PROJECT
PORT OF CORPUS CHRISTI AUTHORITY
CORPUS CHRISTI, TEXAS

LOCATION: See Plate 2

COORDINATES: 1473486.788 N
17184830.376 E
(SPCS83 South Texas Zone)

MUDLINE EL.: -50.4' (MLLW)

SHEAR STRENGTH: ☐ Penetrometer, ◇ Torvane, △ Field Vane, Unconfined ▼, Triaxial ●, Miniature Vane ▲; KIPS PER SQ FT 0.5 1.0 1.5 2.0 2.5



DEPTH, FT	SAMPLE TYPE	BLOWS PER FOOT	% RECOVERY / RQD	STRATUM DESCRIPTION	STRATUM ELEVATION, FT	UNIT DRY WT, PCF	PASSING NO. 200 SIEVE, %	WATER CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX (PI)	SHEAR STRENGTH
	SPT	W.O.R.		SANDY LEAN CLAY (CL): very soft, olive gray, wet, with shell fragments and sand								
	T						86	41	40	16	24	◇
5	T			- gray								◇
	SPT	W.O.R.		- olive gray with sand seams below 6'								
	T			CLAYEY SAND (SC): very soft, olive gray, wet, with shell fragments - with clean sand starting at 9.5'	-58.4							◇
10	SPT	2		SAND (SP): very loose, olive gray, wet, with shell fragments	-59.9		27					
	SPT	4		- loose, gray, fine grained, with many shell fragments and sandy clay pockets								
	T			LEAN CLAY (CL): very soft, gray to greenish gray, moist to wet, with trace sand	-63.4			28	25	15	10	☐ ◇
15				SAND (SP): gray to greenish gray, moist to wet, fine grained, with sandy clay pockets and many shell fragments	-65.4							☐ ◇
				LEAN CLAY (CL): very soft, gray to greenish gray, moist	-66.4							
20	SPT	11		SAND (SP): medium dense, gray, wet, fine grained, with shell fragments and trace silt	-68.4		8					
25	SPT	53		- very dense								
30	SPT	0		CLAYEY SAND (SC): very loose, greenish gray, wet, fine grained	-78.4		15					
35	SPT	6		SAND (SP): loose, greenish gray, wet, fine grained, with silt, clay, and shell fragments	-84.4							
	SPT	10		- with trace silt, trace clay, and trace shell fragments below 37'	-88.4							

NOTES:
Depth to Mudline (ft) = 62.6
Depth to Water (ft) = 11.1
Water Depth (ft) = 51.5
Record Date&Time: 8/3/2018 16:50

DATE: August 3, 2018
TOTAL DEPTH: 38'
CAVED DEPTH: Not Applicable
DRY AUGER: Not Applicable
WET ROTARY: 0' to 38'
BACKFILL: NONE
HAMMER TYPE: Automatic Trip
LOGGER: A. Bull/J. Soto

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LOG OF BORING NO. BH-18
SHIP CHANNEL DEEPENING PROJECT
PORT OF CORPUS CHRISTI AUTHORITY
CORPUS CHRISTI, TEXAS

LOCATION: See Plate 2

COORDINATES: 1468718.997 N
17186588.25 E
(SPCS83 South Texas Zone)

MUDLINE EL.: -49.3' (MLLW)

STRATUM DESCRIPTION

CLAYEY SAND (SC): very loose, gray to olive gray, wet

STRATUM ELEVATION, FT: -51.3

SAND (SP): loose, gray to olive gray, moist to wet, fine grained
- with silt to 6'
- olive gray to 12'
- with shell fragments to 8'
- medium dense, with clay pockets
- very dense
- moist with silt to 12'
- dense
- fine to medium grained, gray, wet
- very dense to 24'
- with shell fragments to 13'
- fine grained to 18'
- moist below 14'
- fine to medium grained, gray to light gray, with many shells and shell fragments
- fine grained below 24'
- dense, gray, with trace silt and trace shell fragments
- gray to greenish gray, with many shell fragments and sandy clay pockets
- very dense below 28'
- light gray below 34'
- with silt

STRATUM ELEVATION, FT: -88.8

SAMPLE TYPE	BLOWS PER FOOT	% RECOVERY / RQD	UNIT DRY WT, PCF	PASSING NO. 200 SIEVE, %	WATER CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX (PI)
SPT	W.O.R.			36	36			
SPT	10							
SPT	7							
SPT	24			36	21			
SPT	56							
SPT	44							
SPT	61							
SPT	92							
SPT	73			7				
SPT	40							
SPT	56							
SPT	73			7				
SPT	97							

DEPTH, FT: 5, 10, 15, 20, 25, 30, 35

SHEAR STRENGTH

☐ Penetrometer Unconfined ▼
◇ Torvane Triaxial ●
△ Field Vane Miniature Vane ▲

KIPS PER SQ FT: 0.5 1.0 1.5 2.0 2.5

NOTES:
Depth to Mudline (ft) = 61.5
Depth to Water (ft) = 10.9
Water Depth (ft) = 50.6
Record Date&Time: 8/3/2018 21:55

DATE: August 3, 2018
TOTAL DEPTH: 39.5'
CAVED DEPTH: Not Applicable
DRY AUGER: Not Applicable
WET ROTARY: 0' to 40'
BACKFILL: NONE
HAMMER TYPE: Automatic Trip
LOGGER: J. Soto

LOG OF BORING NO. BH-19

SHIP CHANNEL DEEPENING PROJECT
PORT OF CORPUS CHRISTI AUTHORITY
CORPUS CHRISTI, TEXAS

LOCATION: See Plate 2

COORDINATES: 1466847.92 N
17188337.218 E
(SPCS83 South Texas Zone)

MUDLINE EL.: -50.3' (MLLW)

SHEAR STRENGTH: ☐ Penetrometer, ◇ Torvane, △ Field Vane, Unconfined ▼, Triaxial ●, Miniature Vane ▲; KIPS PER SQ FT: 0.5, 1.0, 1.5, 2.0, 2.5

DEPTH, FT	SAMPLE TYPE	BLOWS PER FOOT	% RECOVERY / RQD	STRATUM DESCRIPTION	STRATUM ELEVATION, FT	UNIT DRY WT, PCF	PASSING NO. 200 SIEVE, %	WATER CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX (PI)
	SPT	W. O. R.		SILTY SAND (SM): very loose, olive gray, fine grained			25	31			
	SPT	21		- medium dense to 6' fine grained to 10' - with little shells							
5	SPT	12		- with abundant shell fragments to 10'							
	SPT	48		- gray to 12' - dense							
	SPT	68		- very dense to 12'							
10											
	SPT	50		- with some shell fragments to 18'							
	SPT	20		- medium dense, olive gray			12				
15	SPT	41		- dense, gray to olive gray							
	SPT	48		- very dense, gray, with little shells							
20											
					-73.3						
25	SPT	11		SANDY LEAN CLAY (CL): stiff, greenish gray to brown, with sand seams and high plasticity			72	28	36	13	23
	SPT	9		- hard with gray sand seams, possibly clay with sand, high plasticity							
30											
					-83.3						
	SPT	50		SAND (SP): very dense, gray, with trace shells			13				
35											
	SPT	50			-86.3						

NOTES:
Depth to Mudline (ft) = 62.5
Depth to Water (ft) = 11.2
Water Depth (ft) = 51.3
Record Date&Time: 8/4/2018 13:00

DATE: August 4, 2018
TOTAL DEPTH: 36.5'
CAVED DEPTH: Not Applicable
DRY AUGER: Not Applicable
WET ROTARY: 0' to 36.5'
BACKFILL: NONE
HAMMER TYPE: Automatic Trip
LOGGER: A. Bull

LOG OF BORING NO. BH-20
SHIP CHANNEL DEEPENING PROJECT
PORT OF CORPUS CHRISTI AUTHORITY
CORPUS CHRISTI, TEXAS

LOCATION: See Plate 2

COORDINATES: 1464871.929 N
17189908.192 E
(SPCS83 South Texas Zone)

MUDLINE EL.: -51.8' (MLLW)

SHEAR STRENGTH

☐ Penetrometer — Unconfined ▼
◇ Torvane — Triaxial ●
△ Field Vane — Miniature Vane ▲

KIPS PER SQ FT: 0.5, 1.0, 1.5, 2.0, 2.5

DEPTH, FT	WATER LEVEL	SYMBOL	SAMPLES	SAMPLE TYPE	BLOWS PER FOOT	% RECOVERY / RQD	STRATUM DESCRIPTION	STRATUM ELEVATION, FT	UNIT DRY WT, PCF	PASSING NO. 200 SIEVE, %	WATER CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX (PI)	SHEAR STRENGTH
				SPT	WOR		SAND (SP): very loose, olive gray, wet			12	27				
				SPT	8		- loose, with trace shell fragments and trace clay								
							FAT CLAY (CH): very soft, olive gray, with sand pockets and shells	-55.8							
5				SPT	WOR			-56.8							
							SAND (SP): very loose, olive gray, with shell fragments - medium dense, 6' to 12' gray, 6' to 28' - with trace shell fragments								
				SPT	24										
				SPT	27										
10															
				SPT	25										
				SPT	45		- dense, with abundant shells								
				SPT	77		- very dense, with trace shell fragments								
15										7					
				SPT	28		- medium dense, with abundant shell fragments								
20															
				SPT	31		- with shells and few clay pockets - dense, 23' to 34'								
25															
				SPT	40		- greenish gray to brownish green, with clay			26					
30															
35				SPT	30		- medium dense, greenish gray								
								-87.8							

NOTES:

Depth to Mudline (ft) = 66.3
Depth to Water (ft) = 13.2
Water Depth (ft) = 53.1
Record Date&Time: 8/17/2018 07:20

DATE: August 17, 2018
TOTAL DEPTH: 36'
CAVED DEPTH: Not Applicable
DRY AUGER: Not Applicable
WET ROTARY: 0' to 36'
BACKFILL: NONE
HAMMER TYPE: Automatic Trip
LOGGER: A. Bull

LOG OF BORING NO. BH-21

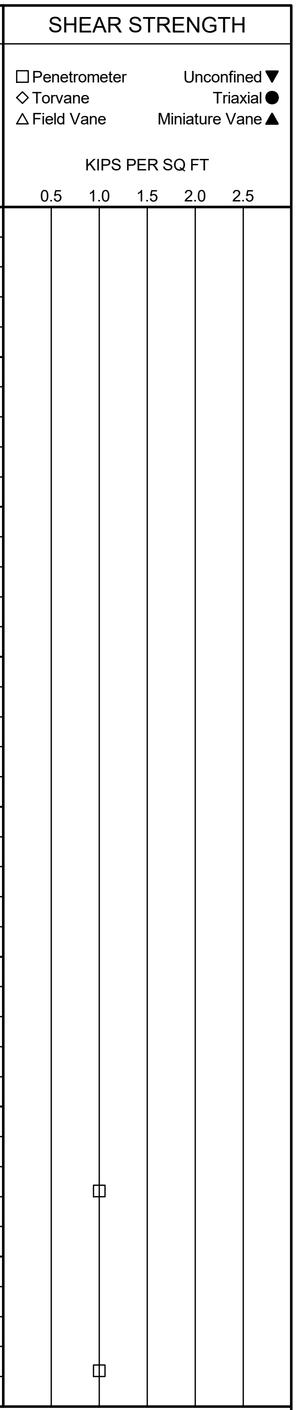
SHIP CHANNEL DEEPENING PROJECT
PORT OF CORPUS CHRISTI AUTHORITY
CORPUS CHRISTI, TEXAS

LOCATION: See Plate 2

COORDINATES: 1463044.417 N
17191731.071 E
(SPCS83 South Texas Zone)

MUDLINE EL.: -39.3' (MLLW)

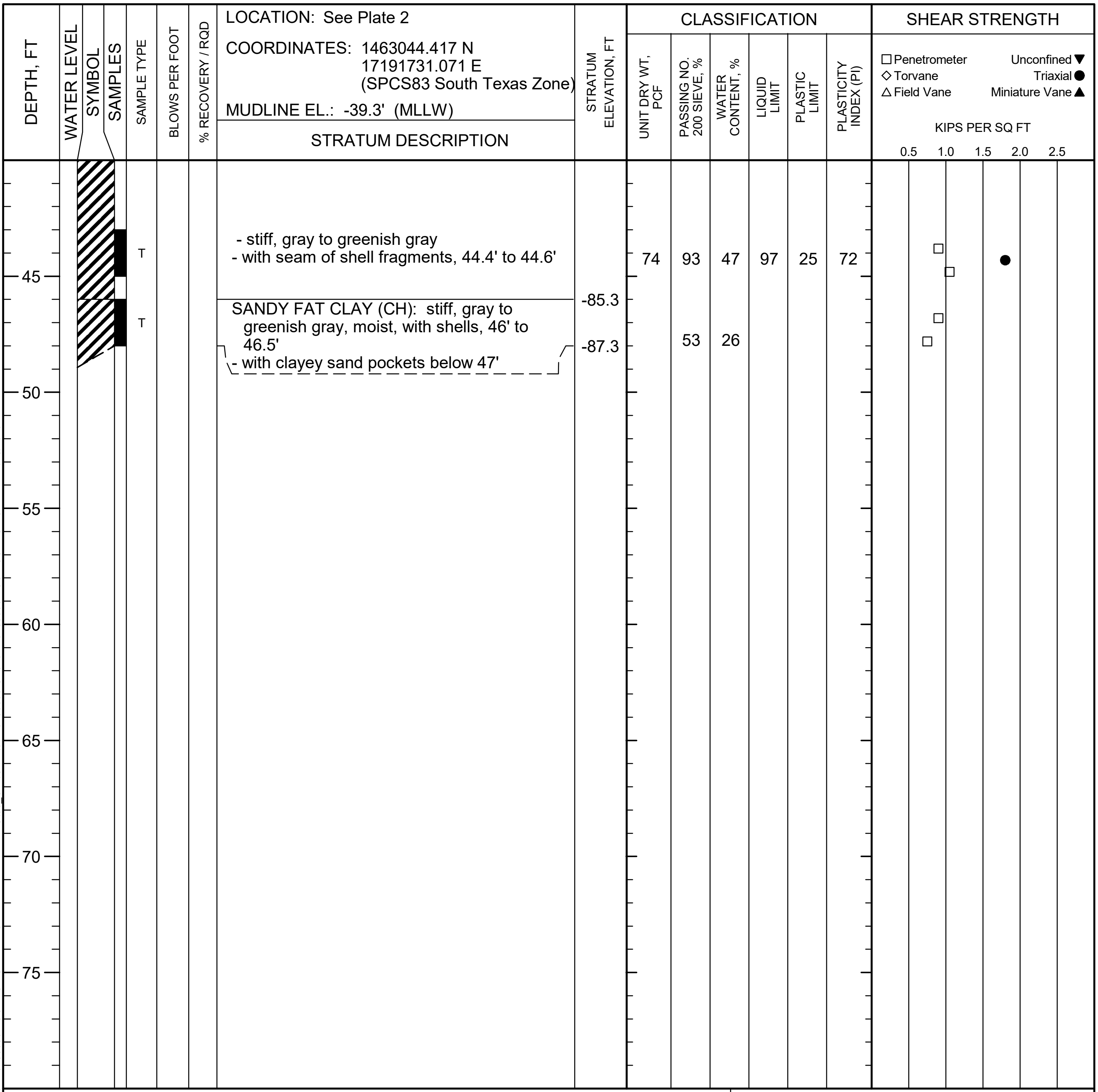
SAMPLE TYPE	BLOWS PER FOOT	STRATUM DESCRIPTION	STRATUM ELEVATION, FT	PASSING NO. 200 SIEVE, %	WATER CONTENT, %
SPT	W.O.H.	SAND (SP): very soft, olive gray to dark gray, wet, fine grained, with trace medium grained			
SPT	6	- loose		7	23
SPT	W.O.R.	- very loose, with silt	-44.3		
		LEAN CLAY (CL): very soft, gray to olive gray, moist to wet	-45.3		
SPT	13	SAND (SP): medium dense, olive gray, wet, fine grained			
SPT	17	- olive gray to gray - moist to wet to 12'			
SPT	26	- gray to 14' - with trace shell fragments			
SPT	31	- dense, moist, fine to medium grained sand, with many shells and shell fragments			
SPT	58	- very dense, moist - with many shells and shell fragments - gray to light gray, fine grained sand to 24'			
SPT	31	- dense, gray to light gray, moist to wet, with shells and shell fragments		8	25
SPT	58	- very dense, moist, fine to medium grained sand - gray below 24'			
SPT	49	- dense, fine grained sand, wet, with partings of organic material at 28.8'			
SPT	W.O.H.	FAT CLAY (CH): soft, gray to greenish gray, moist, very sticky	-72.3		
SPT	W.O.H.	- greenish gray to 43'			



NOTES:
Depth to Mudline (ft) = 54.1
Depth to Water (ft) = 13.3
Water Depth (ft) = 40.5
Record Date&Time: 8/6/2018 21:30

DATE: August 6, 2018
TOTAL DEPTH: 48'
CAVED DEPTH: Not Applicable
DRY AUGER: Not Applicable
WET ROTARY: 0' to 48'
BACKFILL: NONE
HAMMER TYPE: Automatic Trip
LOGGER: J. Soto

LOG OF BORING NO. BH-22
SHIP CHANNEL DEEPENING PROJECT
PORT OF CORPUS CHRISTI AUTHORITY
CORPUS CHRISTI, TEXAS



LOCATION: See Plate 2

COORDINATES: 1463044.417 N
17191731.071 E
(SPCS83 South Texas Zone)

MUDLINE EL.: -39.3' (MLLW)

STRATUM DESCRIPTION	STRATUM ELEVATION, FT	UNIT DRY WT, PCF	PASSING NO. 200 SIEVE, %	WATER CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX (PI)
- stiff, gray to greenish gray - with seam of shell fragments, 44.4' to 44.6'		74	93	47	97	25	72
SANDY FAT CLAY (CH): stiff, gray to greenish gray, moist, with shells, 46' to 46.5' - with clayey sand pockets below 47'	-85.3 -87.3		53	26			

NOTES:
Depth to Mudline (ft) = 54.1
Depth to Water (ft) = 13.3
Water Depth (ft) = 40.5
Record Date&Time: 8/6/2018 21:30

DATE: August 6, 2018
TOTAL DEPTH: 48'
CAVED DEPTH: Not Applicable
DRY AUGER: Not Applicable
WET ROTARY: 0' to 48'
BACKFILL: NONE
HAMMER TYPE: Automatic Trip
LOGGER: J. Soto

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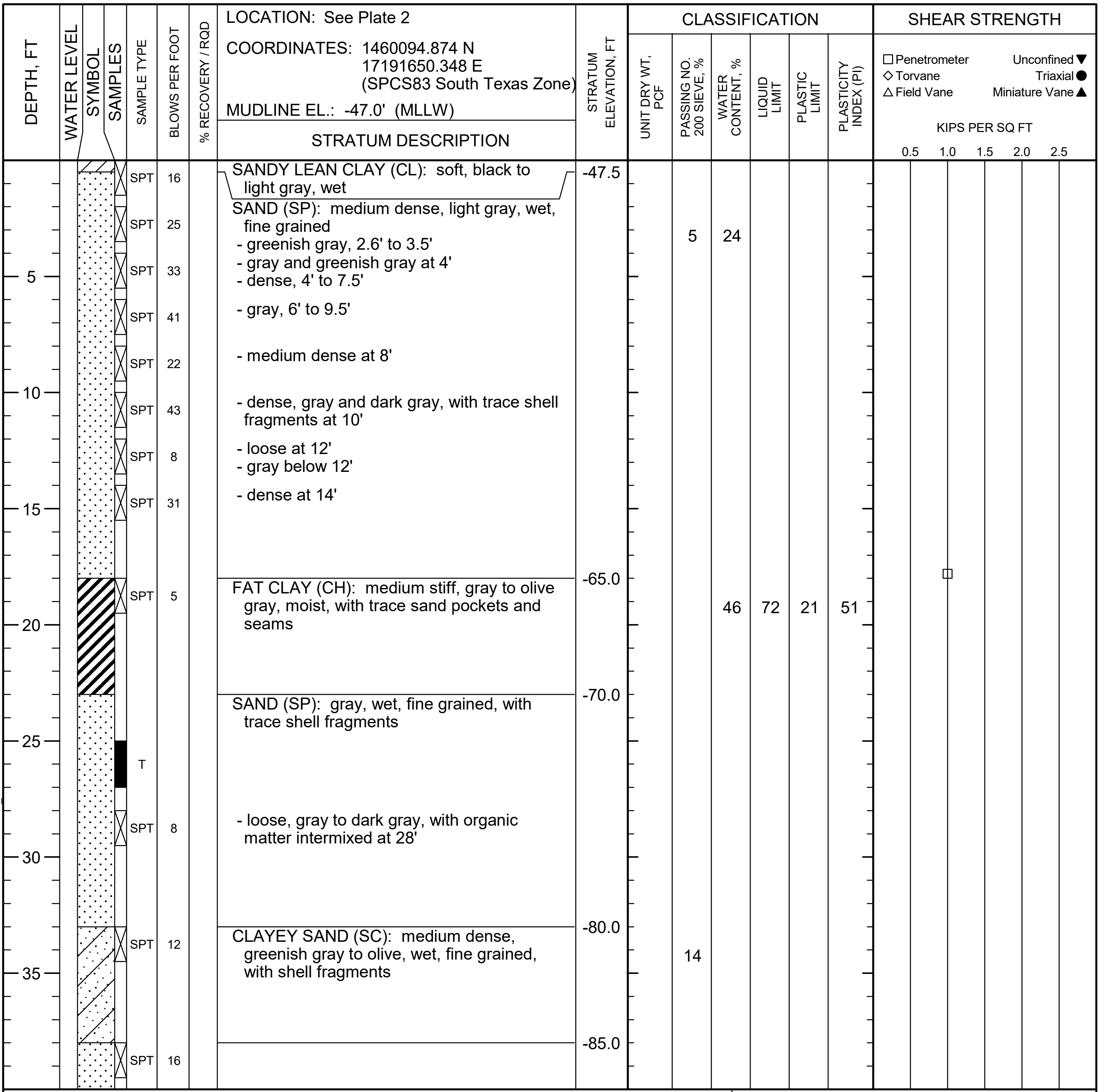
LOG OF BORING NO. BH-22
SHIP CHANNEL DEEPENING PROJECT
PORT OF CORPUS CHRISTI AUTHORITY
CORPUS CHRISTI, TEXAS

LOCATION: See Plate 2

COORDINATES: 1460094.874 N
17191650.348 E
(SPCS83 South Texas Zone)

MUDLINE EL.: -47.0' (MLLW)



STRATUM DESCRIPTION	STRATUM ELEVATION, FT	SAMPLE TYPE	BLOWS PER FOOT	% RECOVERY / RQD	UNIT DRY WT, PCF	PASSING NO. 200 SIEVE, %	WATER CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX (PI)
SANDY LEAN CLAY (CL): soft, black to light gray, wet	-47.5	SPT	16							
SAND (SP): medium dense, light gray, wet, fine grained		SPT	25			5	24			
- greenish gray, 2.6' to 3.5' - gray and greenish gray at 4' - dense, 4' to 7.5'		SPT	33							
- gray, 6' to 9.5'		SPT	41							
- medium dense at 8'		SPT	22							
- dense, gray and dark gray, with trace shell fragments at 10'		SPT	43							
- loose at 12' - gray below 12'		SPT	8							
- dense at 14'		SPT	31							
FAT CLAY (CH): medium stiff, gray to olive gray, moist, with trace sand pockets and seams	-65.0	SPT	5				46	72	21	51
SAND (SP): gray, wet, fine grained, with trace shell fragments	-70.0	T								
- loose, gray to dark gray, with organic matter intermixed at 28'		SPT	8							
CLAYEY SAND (SC): medium dense, greenish gray to olive, wet, fine grained, with shell fragments	-80.0	SPT	12			14				
	-85.0	SPT	16							

NOTES:
Depth to Mudline (ft) = 61.1
Depth to Water (ft) = 12.8
Water Depth (ft) = 48.3
Record Date&Time: 8/15/2018 20:45

DATE: August 16, 2018
TOTAL DEPTH: 41.5'
CAVED DEPTH: Not Applicable
DRY AUGER: Not Applicable
WET ROTARY: 0' to 41.5'
BACKFILL: NONE
HAMMER TYPE: Automatic Trip
LOGGER: J. Soto

LOG OF BORING NO. BH-26
SHIP CHANNEL DEEPENING PROJECT
PORT OF CORPUS CHRISTI AUTHORITY
CORPUS CHRISTI, TEXAS

LOCATION: See Plate 2

COORDINATES: 1460094.874 N
17191650.348 E
(SPCS83 South Texas Zone)

MUDLINE EL.: -47.0' (MLLW)

DEPTH, FT	WATER LEVEL	SYMBOL	SAMPLES	SAMPLE TYPE	BLOWS PER FOOT	% RECOVERY / RQD	STRATUM DESCRIPTION	STRATUM ELEVATION, FT	CLASSIFICATION: UNIT DRY WT, PCF	CLASSIFICATION: PASSING NO. 200 SIEVE, %	CLASSIFICATION: WATER CONTENT, %	CLASSIFICATION: LIQUID LIMIT	CLASSIFICATION: PLASTIC LIMIT	CLASSIFICATION: PLASTICITY INDEX (PI)	SHEAR STRENGTH, KIPS PER SQ FT (0.5, 1.0, 1.5, 2.0, 2.5)
		⁘	☒	SPT	36		SAND (SP): medium dense, greenish gray, wet, fine grained, with shells, shell fragments, and trace clay - dense, gray to greenish gray, moist to wet at 40' - with shell fragments 40' to 40.6'	-88.5							
45															
50															
55															
60															
65															
70															
75															

SHEAR STRENGTH legend:
☐ Penetrometer — Unconfined ▼
◇ Torvane — Triaxial ●
△ Field Vane — Miniature Vane ▲

NOTES:
Depth to Mudline (ft) = 61.1
Depth to Water (ft) = 12.8
Water Depth (ft) = 48.3
Record Date&Time: 8/15/2018 20:45

DATE: August 16, 2018
TOTAL DEPTH: 41.5'
CAVED DEPTH: Not Applicable
DRY AUGER: Not Applicable
WET ROTARY: 0' to 41.5'
BACKFILL: NONE
HAMMER TYPE: Automatic Trip
LOGGER: J. Soto

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LOG OF BORING NO. BH-26
SHIP CHANNEL DEEPENING PROJECT
PORT OF CORPUS CHRISTI AUTHORITY
CORPUS CHRISTI, TEXAS

LOCATION: See Plate 2

COORDINATES: 1458663.804 N
17193161.142 E
(SPCS83 South Texas Zone)

MUDLINE EL.: -65.5' (MLLW)

SHEAR STRENGTH: □ Penetrometer, ◇ Torvane, △ Field Vane, Unconfined ▼, Triaxial ●, Miniature Vane ▲ — KIPS PER SQ FT 0.5 1.0 1.5 2.0 2.5

DEPTH, FT	SAMPLE TYPE	BLOWS PER FOOT	% RECOVERY / RQD	STRATUM DESCRIPTION	STRATUM ELEVATION, FT	UNIT DRY WT, PCF	PASSING NO. 200 SIEVE, %	WATER CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX (PI)
	SPT	W.O.R.		CLAYEY SAND (SC): very loose, olive gray, with shells							
	SPT	12		- medium dense, greenish gray to light gray at 2' - with clean sand starting at 3.4'	-68.9		54	22			
5	SPT	5		SILTY SAND (SM): loose, gray, wet, with trace shell fragments							
	SPT	9		- gray to brownish gray, with shells at 6'							
	SPT	10		- gray to light gray, with few shells at 8'							
10	SPT	15		- gray at 10' - medium dense below 10'							
	SPT	12		- gray and brown, 12' to 15.5' - wet at 12'							
15	SPT	16		- with gravel, 15.3' to 18.2'			16				
	SPT	20		- brownish gray to gray at 18'							
20											
	SPT	24		-							
25					-90.5						
30											
35											

NOTES:
Depth to Mudline (ft) = 79.9
Depth to Water (ft) = 13.1
Water Depth (ft) = 66.8
Record Date&Time: 8/15/2018 17:10

DATE: August 15, 2018
TOTAL DEPTH: 25'
CAVED DEPTH: Not Applicable
DRY AUGER: Not Applicable
WET ROTARY: 0' to 25'
BACKFILL: NONE
HAMMER TYPE: Automatic Trip
LOGGER: A. Bull

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LOG OF BORING NO. BH-27
SHIP CHANNEL DEEPENING PROJECT
PORT OF CORPUS CHRISTI AUTHORITY
CORPUS CHRISTI, TEXAS

LOCATION: Aransas Pass

COORDINATES: 1457292.035 N
17194377.851 E
(SPCS83 South Texas Zone)

MUDLINE EL.: -74.0' (MLLW)

DEPTH, FT	WATER LEVEL	SYMBOL	SAMPLES	SAMPLE TYPE	BLOWS PER FOOT	% RECOVERY / RQD	STRATUM DESCRIPTION	STRATUM ELEVATION, FT	UNIT DRY WT, PCF	PASSING NO. 200 SIEVE, %	WATER CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX (PI)
				SPT	W.O.R.		SILTY SAND (SM): very loose, black to olive gray and light gray, wet, fine grained, with calcareous particles, 1.3' to 1.5'							
				SPT	8		- loose, 2' to 8' - gray to greenish gray, 2' to 8'			16	25			
5				SPT	10		- sulfur odor coming from drill area at 4'							
				SPT	9									
				SPT	12		- medium dense, 8' to 14' - gray to olive, 8' to 12'							
10				SPT	13									
				SPT	17		- green to greenish gray, 12' to 23' - with plot of shell fragments at 13' - with rock fragments, 12.4' to 12.7'							
15				SPT	39		- moist to wet at 14' - dense, 14' to 19.5'			17				
				SPT	44		- gray to greenish gray, moist at 18' - with calcareous particles, 18.8' to 19'							
20														
				SPT	58		- very dense, olive to olive green at 23' - wet below 23'							
25				SPT	41		- dense, gray to greenish gray at 25'							
								-100.5						
30														
35														

SHEAR STRENGTH

☐ Penetrometer ◇ Torvane △ Field Vane
Unconfined ▼ Triaxial ● Miniature Vane ▲

KIPS PER SQ FT

0.5 1.0 1.5 2.0 2.5

NOTES:
Depth to Mudline (ft) = 88.3
Depth to Water (ft) = 13.2
Water Depth (ft) = 75.1
Record Date&Time: 8/12/2018 02:00

DATE: August 12, 2018
TOTAL DEPTH: 26.5'
CAVED DEPTH: Not Applicable
DRY AUGER: Not Applicable
WET ROTARY: 0' to 26.5'
BACKFILL: NONE
HAMMER TYPE: Automatic Trip
LOGGER: J. Soto

LOG OF BORING NO. BH-28C

SHIP CHANNEL DEEPENING PROJECT
PORT OF CORPUS CHRISTI AUTHORITY
CORPUS CHRISTI, TEXAS

LOCATION: Aransas Pass

COORDINATES: 1455562.455 N
17194989.156 E
(SPCS83 South Texas Zone)

MUDLINE EL.: -50.3' (MLLW)

SHEAR STRENGTH legend:
□ Penetrometer
◇ Torvane
△ Field Vane
Unconfined ▼
Triaxial ●
Miniature Vane ▲

KIPS PER SQ FT: 0.5, 1.0, 1.5, 2.0, 2.5

DEPTH, FT	SAMPLE TYPE	BLOWS PER FOOT	% RECOVERY / RQD	STRATUM DESCRIPTION	STRATUM ELEVATION, FT	UNIT DRY WT, PCF	PASSING NO. 200 SIEVE, %	WATER CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX (PI)	SHEAR STRENGTH, KIPS PER SQ FT
	SPT	W.O.R.		SILTY SAND (SM): very loose, olive gray, with shell fragments								
	SPT	9		- loose, 2' to 6' - dark gray, 2.5' to 7.3'			6	28				
5	SPT	10		- organic order, 4' to 8'								
	SPT	31		- dense at 6' - brown, 7.3' to 11'								
	SPT	23		- medium dense below 8' - with shells, 8' to 14'								
10												
	SPT	15		- dark gray at 11'								
	SPT	19		- olive gray at 12'			20					
15	SPT	14		- greenish gray, with some shells, 14' to 19.5'								
	SPT	13										
20												
	SPT	11		- light gray, with cemented sand nodules and trace of clay at 23'								
25												
	SPT	19		LEAN CLAY (CL): very stiff to hard, brown to light gray, with sand partings	-78.3		74	21	46	15	31	□
30												
35	SPT	83		SAND (SP): very dense, gray, moist, fine grained	-84.3 -85.8							

NOTES:
Depth to Mudline (ft) = 63.5
Depth to Water (ft) = 11.7
Water Depth (ft) = 51.8
Record Date&Time: 8/10/2018 15:00

DATE: August 10, 2018
TOTAL DEPTH: 35.5'
CAVED DEPTH: Not Applicable
DRY AUGER: Not Applicable
WET ROTARY: 0' to 35.5'
BACKFILL: NONE
HAMMER TYPE: Automatic Trip
LOGGER: A. Bull

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LOG OF BORING NO. BH-29B

SHIP CHANNEL DEEPENING PROJECT
PORT OF CORPUS CHRISTI AUTHORITY
CORPUS CHRISTI, TEXAS

LOCATION: Aransas Pass

COORDINATES: 1453435.814 N
17195973.571 E
(SPCS83 South Texas Zone)

MUDLINE EL.: -55.1' (MLLW)

DEPTH, FT	SAMPLE TYPE	BLOWS PER FOOT	% RECOVERY / RQD	STRATUM DESCRIPTION	STRATUM ELEVATION, FT	UNIT DRY WT, PCF	PASSING NO. 200 SIEVE, %	WATER CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX (PI)	SHEAR STRENGTH, KIPS PER SQ FT
	SPT	W. O. R.		SANDY FAT CLAY (CH): medium dense, greenish gray to brown and gray, with few shells								
	SPT	16		- with shell fragments below 2'			53	21				
	SPT	6		- loose, greenish gray and brown at 4'								
5					-61.1							
	SPT	7		SAND (SP): loose, greenish gray to brown, with trace clay								
	SPT	12		- medium dense, brown with some greenish gray, with some clay at 8 '	-64.1							
10				FAT CLAY (CH): very stiff, brown to greenish gray, with sand pockets			89		59	17	42	□
	T			- hard, with sand seams, 11' to 14'		108		21				5.8 ●
	SPT	35										
					-69.1							
15	SPT	21		CLAYEY SAND (SC): medium dense, greenish gray to brown, moist, fine grained								
					-73.1							
	SPT	21		SILTY SAND (SM): medium dense, light gray, moist to wet, fine grained, with trace clay and trace silt - with calcareous particles, 18.5' to 18.7' - olive. 18.7' to 24.1'			14	22				
20												
	SPT	25		- moist, with shell fragments at 23' - greenish gray, 24.1' to 24.5'								
25												
	SPT	23		- olive to brown, with silt at 28' - with clay, 29.3' to 29.5'								
30												
				SANDY FAT CLAY (CH): very stiff, brown to gray, with shells	-89.1							
35	SPT	11										
					-91.1							

SHEAR STRENGTH: □ Penetrometer, ◇ Torvane, △ Field Vane, Unconfined ▼, Triaxial ●, Miniature Vane ▲

KIPS PER SQ FT: 0.5, 1.0, 1.5, 2.0, 2.5

NOTES:
Depth to Mudline (ft) = 67.5
Depth to Water (ft) = 11.0
Water Depth (ft) = 56.5
Record Date&Time: 8/9/2018 14:15

DATE: August 9, 2018
TOTAL DEPTH: 36'
CAVED DEPTH: Not Applicable
DRY AUGER: Not Applicable
WET ROTARY: 0' to 36'
BACKFILL: NONE
HAMMER TYPE: Automatic Trip
LOGGER: A. Bull/J. Soto

LOG OF BORING NO. BH-30
SHIP CHANNEL DEEPENING PROJECT
PORT OF CORPUS CHRISTI AUTHORITY
CORPUS CHRISTI, TEXAS

PLATE C-30

LOCATION: Aransas Pass

COORDINATES: 1453890.358 N
17196664.533 E
(SPCS83 South Texas Zone)

MUDLINE EL.: -47.2' (MLLW)

DEPTH, FT	SAMPLE TYPE	BLOWS PER FOOT	% RECOVERY / RQD	STRATUM DESCRIPTION	STRATUM ELEVATION, FT	UNIT DRY WT, PCF	PASSING NO. 200 SIEVE, %	WATER CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX (PI)	SHEAR STRENGTH, KIPS PER SQ FT
0	SPT	W.O.R.		SAND (SP): very loose, olive gray to brown and greenish gray, with shell fragments - with gravels at top 3"								
	SPT	18		- medium dense below 2' - brown, olive gray, and green, statified, with trace shells and gravel at 2'			5	23				
5	SPT	15		- cemented seam (2") at 5'								
	SPT	23		- grayish brown and brown, with 3" sandy clay seam at 6'								
	SPT	20		- brown, with fine shell fragments at 8'								
10	SPT	9		- olive gray, with abundant shell fragments at 10'	-57.7		63	22				
	SPT	6		SANDY FAT CLAY (CH): soft, greenish gray to gray, with shell fragments	-59.5							
	SPT	3		SAND (SP): loose, greenish gray, with shell fragments and trace clay - very loose, brown, 14' to 15.5'								
15												
	SPT	8		- with trace clay at 18'								
20												
	SPT	23		FAT CLAY (CH): hard, greenish gray to brown, with sand partings	-70.2			21	66	19	47	☐
25												
	SPT	29		SAND (SP): medium dense, gray to brown, wet, stratified	-75.2							
30												
	SPT	15		- greenish brown below 33'								
35												
	SPT	23										
40					-87.2							

SHEAR STRENGTH legend:
☐ Penetrometer
◇ Torvane
△ Field Vane
Unconfined ▼
Triaxial ●
Miniature Vane ▲
KIPS PER SQ FT: 0.5 1.0 1.5 2.0 2.5

NOTES:
Depth to Mudline (ft) = 60.5
Depth to Water (ft) = 11.6
Water Depth (ft) = 48.9
Record Date&Time: 8/12/2018 11:30

DATE: August 12, 2018
TOTAL DEPTH: 40'
CAVED DEPTH: Not Applicable
DRY AUGER: Not Applicable
WET ROTARY: 0' to 40'
BACKFILL: NONE
HAMMER TYPE: Automatic Trip
LOGGER: A. Bull

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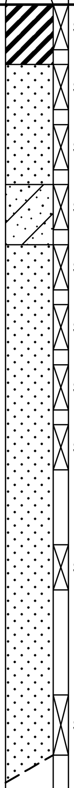
LOG OF BORING NO. BH-31
SHIP CHANNEL DEEPENING PROJECT
PORT OF CORPUS CHRISTI AUTHORITY
CORPUS CHRISTI, TEXAS

LOCATION: Aransas Pass

COORDINATES: 1452059.924 N
17197460.882 E
(SPCS83 South Texas Zone)

MUDLINE EL.: -61.7' (MLLW)



DEPTH, FT	WATER LEVEL	SAMPLE TYPE	BLOWS PER FOOT	% RECOVERY / RQD	STRATUM DESCRIPTION	STRATUM ELEVATION, FT	UNIT DRY WT, PCF	PASSING NO. 200 SIEVE, %	WATER CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX (PI)	SHEAR STRENGTH (KIPS PER SQ FT)
0		SPT	W.O.R.		SANDY FAT CLAY (CH): firm, greenish gray, with shells and gravel				22				
2		SPT	2		SAND (SP): very loose, greenish gray, with some clay	-63.7		31					
4		SPT	4										
6		SPT	7		CLAYEY SAND (SC): loose, greenish gray to gray	-67.7							
8		SPT	11		SAND (SP): medium dense, greenish gray, with trace clay	-69.7							
10		SPT	25		- with clay pockets, calcareous nodules, ferrous stains, and gravel at 10'			59					
12		SPT	21		- with cemented sand nodules, 12' to 19.5'								
14		SPT	7										
18		SPT	14										
23		SPT	12		- brown, with clay pockets at 23' - with sandy clay starting at 25'								
25						-86.7							

SHEAR STRENGTH
□ Penetrometer
◇ Torvane
△ Field Vane
Unconfined ▼
Triaxial ●
Miniature Vane ▲
KIPS PER SQ FT
0.5 1.0 1.5 2.0 2.5

NOTES:
Depth to Mudline (ft) = 73.4
Depth to Water (ft) = 10.3
Water Depth (ft) = 63.1
Record Date&Time: 8/13/2018 15:25

DATE: August 13, 2018
TOTAL DEPTH: 25'
CAVED DEPTH: Not Applicable
DRY AUGER: Not Applicable
WET ROTARY: 0' to 25'
BACKFILL: NONE
HAMMER TYPE: Automatic Trip
LOGGER: A. Bull

R:\04100\2018 PROJECTS\0001-0099\04.10180080 - CORPUS CHRISTI CHANNEL DEEPENING\00_GIS\GINT\04.10180080.GPJ 04.10180080 PCCA CORPUS CHRISTI 2/18/2019 BH-32

LOG OF BORING NO. BH-32
SHIP CHANNEL DEEPENING PROJECT
PORT OF CORPUS CHRISTI AUTHORITY
CORPUS CHRISTI, TEXAS

LOCATION: Aransas Pass

COORDINATES: 1451149.414 N
17197277.613 E
(SPCS83 South Texas Zone)

MUDLINE EL.: -26.5' (MLLW)

SHEAR STRENGTH: ☐ Penetrometer ◇ Torvane △ Field Vane; Unconfined ▼ Triaxial ● Miniature Vane ▲; KIPS PER SQ FT 0.5 1.0 1.5 2.0 2.5

DEPTH, FT	SAMPLE TYPE	BLOWS PER FOOT	STRATUM DESCRIPTION	STRATUM ELEVATION, FT	UNIT DRY WT, PCF	PASSING NO. 200 SIEVE, %	WATER CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX (PI)
	SPT	10	FILL: loose, gray to black, FILL: Concrete							
	SPT	5	CLAYEY SAND (SC): loose, gray, fine to medium grained, with shells	-28.5		15				
5	SPT	W.O.H.	- very loose below 4'							
	SPT	W.O.H.	- with shell fragments and sulfur odor at 6'			17				
	SPT	6	LEAN CLAY (CL): medium stiff, greenish gray, moist, with sand and trace shell fragments	-34.5			21			
10	SPT	10	CLAYEY SAND (SC): loose, greenish gray to white, moist to wet, with calcium nodules	-36.5						
	SPT	7	- calcareous nodules							
15	SPT	12	- light gray to gray, with white pockets and trace clay at 14' - medium dense, 14' to 19.5'			13				
	SPT	16	- gray and tan, wet at 18' - with seam of clay, 19' to 19.1'							
20										
	SPT	33	- dense, brown, moist at 23'							
25										
	SPT	5	SANDY LEAN CLAY (CL): medium stiff, greenish gray to brown, moist to wet, with shell fragments	-54.5			23	27	15	12
30										
	SPT	8	CLAYEY SAND (SC): loose, gray to tan, wet, fine grained, with trace shell fragments - borderline sand with clay	-59.5						
35										
	SPT	6		-65.2						
				-66.2						

NOTES:
Depth to Mudline (ft) = 36.7
Depth to Water (ft) = 8.2
Water Depth (ft) = 28.5
Record Date&Time: 8/9/2018 02:20

DATE: August 9, 2018
TOTAL DEPTH: 72.5'
CAVED DEPTH: Not Applicable
DRY AUGER: Not Applicable
WET ROTARY: 0' to 72.5'
BACKFILL: NONE
HAMMER TYPE: Automatic Trip
LOGGER: J. Soto/A. Bull

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LOG OF BORING NO. BH-33
SHIP CHANNEL DEEPENING PROJECT
PORT OF CORPUS CHRISTI AUTHORITY
CORPUS CHRISTI, TEXAS

LOCATION: Aransas Pass
COORDINATES: 1451149.414 N
17197277.613 E
(SPCS83 South Texas Zone)
MUDLINE EL.: -26.5' (MLLW)

Sample Type	Blows per Foot	Stratum Description	Stratum Elevation, FT	Passing No. 200 Sieve, %	Water Content, %
		LEAN CLAY (CL): medium stiff, greenish gray to brown, moist			
		CLAYEY SAND (SC): loose, gray to greenish gray, wet, fine grained, with trace shell fragments	-69.5		
SPT	16	FAT CLAY (CH): very stiff, olive to greenish gray, moist, with trace sand and red streaks			23
SPT	21	SAND (SP): medium stiff, gray, wet, with fine to medium grain sand	-74.5	13	
SPT	64	- very dense, 53' to 64.2'			
SPT	75	- fine grain, light gray below 58'			
SPT	68				
SPT	42	- dense, with trace clay and trace shell fragments at 68'			
SPT	64	- very dense, with shell fragments at 72'	-99.0		

Columns: DEPTH, FT (45, 50, 55, 60, 65, 70, 75); WATER LEVEL; SYMBOL; SAMPLES; SAMPLE TYPE; BLOWS PER FOOT; % RECOVERY / RQD; STRATUM DESCRIPTION; STRATUM ELEVATION, FT; CLASSIFICATION: UNIT DRY WT, PCF; PASSING NO. 200 SIEVE, %; WATER CONTENT, %; LIQUID LIMIT; PLASTIC LIMIT; PLASTICITY INDEX (PI)

SHEAR STRENGTH
□ Penetrometer Unconfined ▼
◇ Torvane Triaxial ●
△ Field Vane Miniature Vane ▲
KIPS PER SQ FT
0.5 1.0 1.5 2.0 2.5

NOTES:
Depth to Mudline (ft) = 36.7
Depth to Water (ft) = 8.2
Water Depth (ft) = 28.5
Record Date&Time: 8/9/2018 02:20

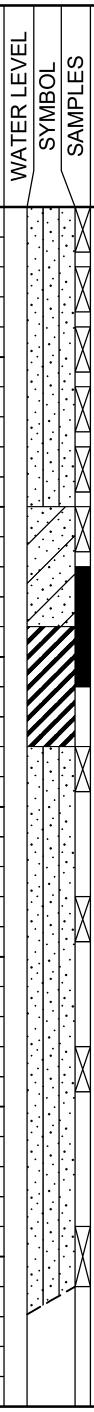
DATE: August 9, 2018
TOTAL DEPTH: 72.5'
CAVED DEPTH: Not Applicable
DRY AUGER: Not Applicable
WET ROTARY: 0' to 72.5'
BACKFILL: NONE
HAMMER TYPE: Automatic Trip
LOGGER: J. Soto/A. Bull

LOG OF BORING NO. BH-33
SHIP CHANNEL DEEPENING PROJECT
PORT OF CORPUS CHRISTI AUTHORITY
CORPUS CHRISTI, TEXAS

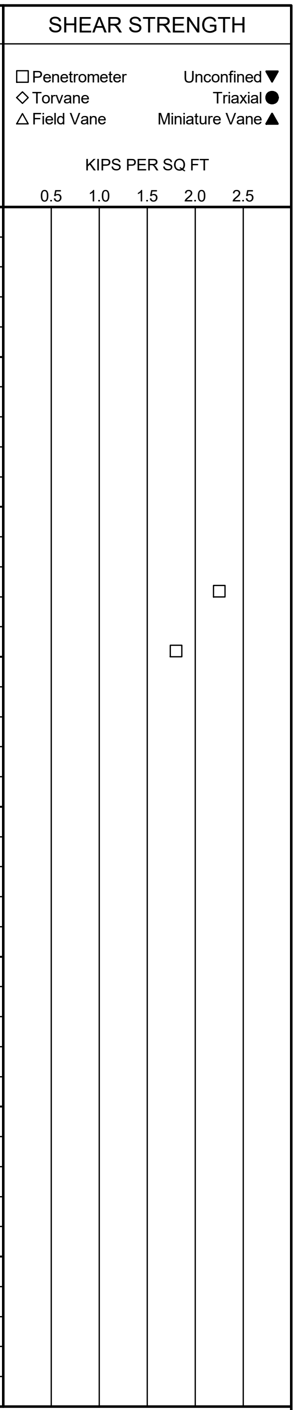
LOCATION: Aransas Pass

COORDINATES: 1451492.362 N
17198051.824 E
(SPCS83 South Texas Zone)

MUDLINE EL.: -52.6' (MLLW)



SAMPLE TYPE	BLOWS PER FOOT	% RECOVERY / RQD	STRATUM DESCRIPTION	STRATUM ELEVATION, FT	UNIT DRY WT, PCF	PASSING NO. 200 SIEVE, %	WATER CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX (PI)
SPT	WOR		SILTY SAND (SM): very loose, grayish brown, with shell fragments							
SPT	9		- loose, 2' to 6'			20				
SPT	6		- greenish gray, 4' to 10' - with shells below 4'							
SPT	4		- very loose							
SPT	12		- medium dense, with clay at 8'							
SPT	14		CLAYEY SAND (SC): medium dense, greenish gray to brown	-62.6		50				
T			- very stiff, brown sand and greenish gray clay pockets, with ferrous staining at 12'							
T			SANDY FAT CLAY (CH): very stiff, greenish gray to brown, with shells, 15' to 16'	-66.6			21	64	19	45
SPT	22		SILTY SAND (SM): medium dense, greenish gray, fine grained	-70.6		21				
SPT	30		- dense at 23' - light gray below 23'							
SPT	28		- medium dense below 28'							
SPT	15			-88.6						



NOTES:
Depth to Mudline (ft) = 65.7
Depth to Water (ft) = 11.5
Water Depth (ft) = 54.2
Record Date&Time: 8/12/2018 15:15

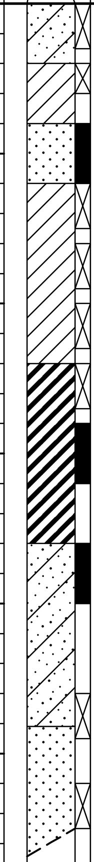
DATE: August 12, 2018
TOTAL DEPTH: 36'
CAVED DEPTH: Not Applicable
DRY AUGER: Not Applicable
WET ROTARY: 0' to 36'
BACKFILL: NONE
HAMMER TYPE: Automatic Trip
LOGGER: A. Bull

LOG OF BORING NO. BH-34
SHIP CHANNEL DEEPENING PROJECT
PORT OF CORPUS CHRISTI AUTHORITY
CORPUS CHRISTI, TEXAS

LOCATION: Aransas Pass

COORDINATES: 1450228.13 N
17197855.77 E
(SPCS83 South Texas Zone)

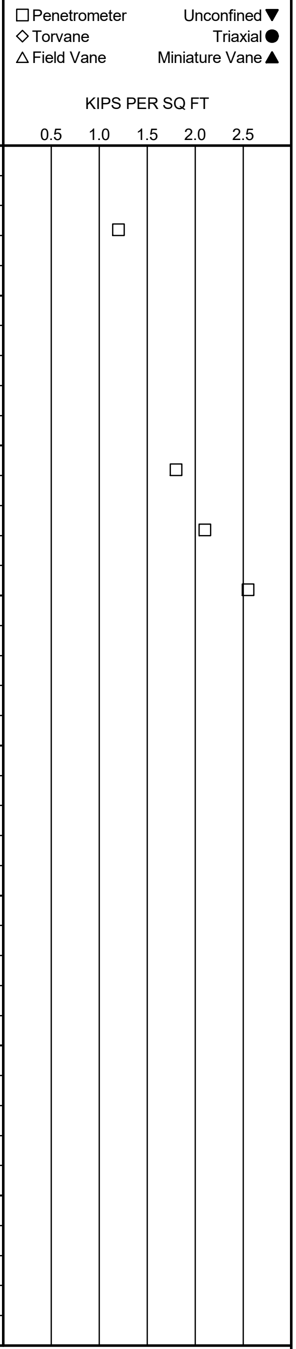
MUDLINE EL.: -59.5' (MLLW)



DEPTH, FT	SAMPLE TYPE	BLOWS PER FOOT	% RECOVERY / RQD	STRATUM DESCRIPTION	STRATUM ELEVATION, FT	UNIT DRY WT, PCF	PASSING NO. 200 SIEVE, %	WATER CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX (PI)
0	SPT	W.O.R.		CLAYEY SAND (SC): very loose, gray to greenish gray, wet, fine grained, with shell fragments	-61.5		26	24			
	SPT	W.O.R.		SANDY LEAN CLAY (CL): very soft, greenish gray, moist, with tan pockets, shell fragments, and sand pockets	-63.5			20	29	12	17
5	T			SAND (SP): greenish gray, moist to wet, with clay	-65.5						
	SPT SPT SPT	13 11 22		SANDY LEAN CLAY (CL): stiff, greenish gray, moist, with clayey sand seams and pockets	-71.5			24	34	14	20
10											
15	SPT T	20		FAT CLAY (CH): very stiff, brown to light gray, moist - hard, with sand partings and trace calcareous particles at 14'	-77.5			24	73	22	51
20	T SPT	 31		CLAYEY SAND (SC): light gray, wet, fine grained	-83.6		15				
25	SPT	15		SAND (SP): dense, brown to gray, wet, fine grained - medium dense, olive gray and greenish gray at 27' - with sandy clay seam, 27.1' to 27.2'	-87.0						
30											
35											

CLASSIFICATION

SHEAR STRENGTH



NOTES:

Depth to Mudline (ft) = 70.4
Depth to Water (ft) = 10.1
Water Depth (ft) = 60.3
Record Date&Time: 8/13/2018 19:00

DATE: August 12, 2018
TOTAL DEPTH: 27.5'
CAVED DEPTH: Not Applicable
DRY AUGER: Not Applicable
WET ROTARY: 0' to 27.5'
BACKFILL: NONE
HAMMER TYPE: Automatic Trip
LOGGER: J. Soto

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LOG OF BORING NO. BH-35
SHIP CHANNEL DEEPENING PROJECT
PORT OF CORPUS CHRISTI AUTHORITY
CORPUS CHRISTI, TEXAS

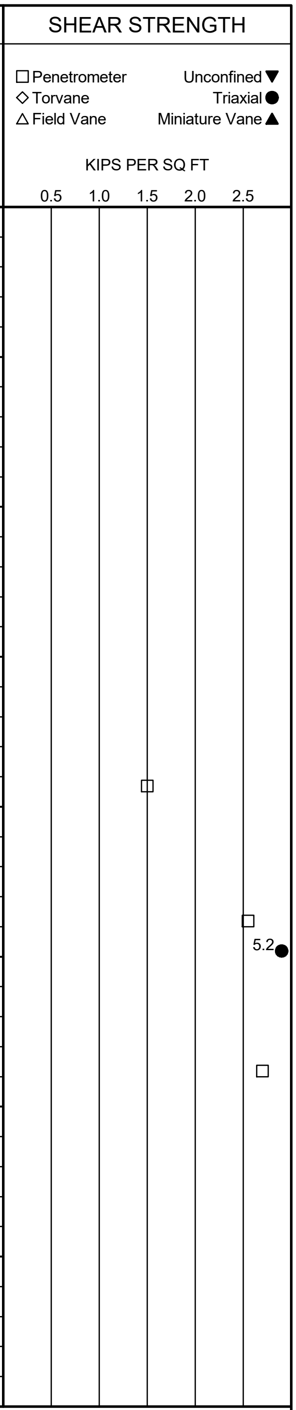
LOCATION: Aransas Pass

COORDINATES: 1448852.609 N
17197688.622 E
(SPCS83 South Texas Zone)

MUDLINE EL.: -45.5' (MLLW)

DEPTH, FT	SAMPLE TYPE	BLOWS PER FOOT	% RECOVERY / RQD	STRATUM DESCRIPTION	STRATUM ELEVATION, FT	UNIT DRY WT, PCF	PASSING NO. 200 SIEVE, %	WATER CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX (PI)
	SPT	W.O.R.		CLAYEY SAND (SC): very loose, gray to dark gray			21	35			
	SPT	W.O.R.		- with shell fragments							
5	SPT	W.O.R.		- dark gray and gray (stratified), with trace of clay							
	T			- with clay pockets, 6.5' to 7'							
	SPT	8		- loose, greenish gray, with shell fragments, 8' to 18'							
10	SPT	2		- with trace of clay, 8' to 12' - very loose			26	20			
	SPT	2		- greenish gray below 12'							
15	SPT	9		- loose, with 4" shell layer starting at 14.8'							
	SPT	9		SANDY FAT CLAY (CH): very stiff, brown, with sand pockets	-63.5						
20											
25	T			- brown, light gray, and greenish gray - hard below 23'		101	99	25 23	73	23	50
30	T			- greenish gray and brown, with white calcareous nodules and clear cementitious nodules							
	SPT	42		SAND (SP): dense, brown, with clay	-78.5						
35											
	SPT	21		- medium dense, light gray and brown - with shell fragments below 38'							

SHEAR STRENGTH



NOTES:
Depth to Mudline (ft) = 58.0
Depth to Water (ft) = 11.0
Water Depth (ft) = 47.0
Record Date&Time: 8/6/2018 13:20

DATE: August 8, 2018
TOTAL DEPTH: 41.5'
CAVED DEPTH: Not Applicable
DRY AUGER: Not Applicable
WET ROTARY: 0 to 41.5'
BACKFILL: NONE
HAMMER TYPE: Automatic Trip
LOGGER: A. Bull

LOG OF BORING NO. BH-36
SHIP CHANNEL DEEPENING PROJECT
PORT OF CORPUS CHRISTI AUTHORITY
CORPUS CHRISTI, TEXAS

LOCATION: Aransas Pass

COORDINATES: 1448852.609 N
17197688.622 E
(SPCS83 South Texas Zone)

MUDLINE EL.: -45.5' (MLLW)

Shear strength legend: ☐ Penetrometer, ◇ Torvane, △ Field Vane, Unconfined ▼, Triaxial ●, Miniature Vane ▲; KIPS PER SQ FT 0.5 1.0 1.5 2.0 2.5

DEPTH, FT	WATER LEVEL	SYMBOL	SAMPLES	SAMPLE TYPE	BLOWS PER FOOT	% RECOVERY / RQD	STRATUM DESCRIPTION	STRATUM ELEVATION, FT	UNIT DRY WT, PCF	PASSING NO. 200 SIEVE, %	WATER CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX (PI)	SHEAR STRENGTH
				SPT	47		- olive gray and brown	-87.0		24	23				
45															
50															
55															
60															
65															
70															
75															

NOTES:
Depth to Mudline (ft) = 58.0
Depth to Water (ft) = 11.0
Water Depth (ft) = 47.0
Record Date&Time: 8/6/2018 13:20

DATE: August 8, 2018
TOTAL DEPTH: 41.5'
CAVED DEPTH: Not Applicable
DRY AUGER: Not Applicable
WET ROTARY: 0 to 41.5'
BACKFILL: NONE
HAMMER TYPE: Automatic Trip
LOGGER: A. Bull

LOG OF BORING NO. BH-36
SHIP CHANNEL DEEPENING PROJECT
PORT OF CORPUS CHRISTI AUTHORITY
CORPUS CHRISTI, TEXAS

LOCATION: Aransas Pass

COORDINATES: 1448180.061 N
17198257.072 E
(SPCS83 South Texas Zone)

MUDLINE EL.: -67.2' (MLLW)

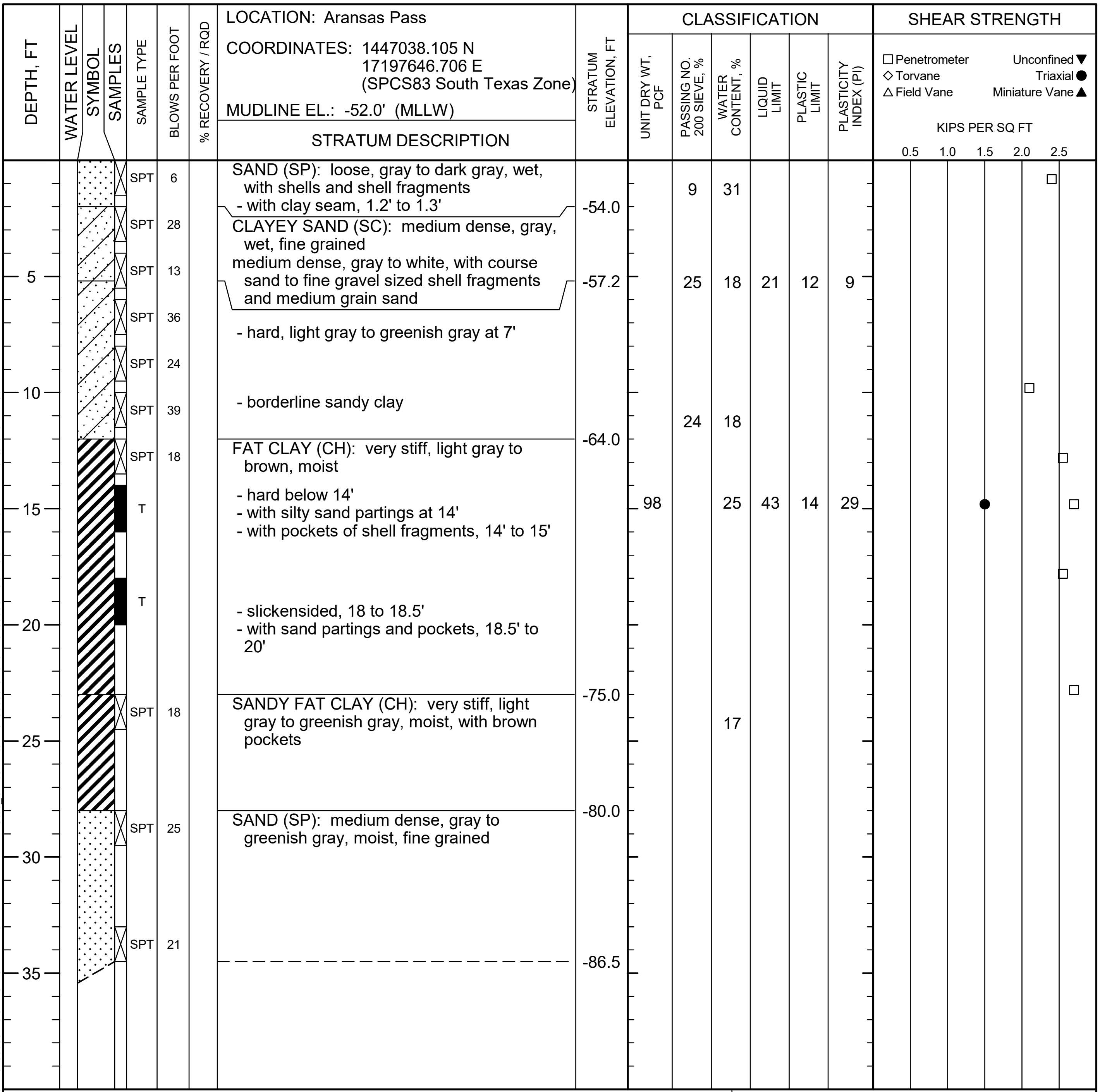
DEPTH, FT	SAMPLE TYPE	BLOWS PER FOOT	STRATUM DESCRIPTION	STRATUM ELEVATION, FT	PASSING NO. 200 SIEVE, %	WATER CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX (PI)	SHEAR STRENGTH, KIPS PER SQ FT
0		W.O.R.	SANDY LEAN CLAY (CL): very stiff, tan to light gray							
3	SPT	W.O.R.				28	38	12	26	☐
4			SILTY SAND (SM): loose, greenish gray to brown, fine grained	-71.2						
5	T									
7	SPT	23	- greenish gray, brown and light gray - medium dense to 10'		12	24				
9	SPT	17	- greenish brown							
11	SPT	9	- loose, greenish brown and light gray							
13	SPT	17	- medium dense, 12' to 16', brownish gray - with shell fragments below 12'							
15	SPT	27	- grayish brown							
19	SPT	37	- dense, brown to 19', gray below 19'		16	22				
23	SPT	46								
23.5				-90.7						

SHEAR STRENGTH: ☐ Penetrometer, ◇ Torvane, △ Field Vane, Unconfined ▼, Triaxial ●, Miniature Vane ▲

NOTES:
Depth to Mudline (ft) = 78.8
Depth to Water (ft) = 9.8
Water Depth (ft) = 69.0
Record Date&Time: 8/8/2018 10:10

DATE: August 8, 2018
TOTAL DEPTH: 23.5'
CAVED DEPTH: Not Applicable
DRY AUGER: Not Applicable
WET ROTARY: 0 to 23.5'
BACKFILL: NONE
HAMMER TYPE: Automatic Trip
LOGGER: A. Bull

LOG OF BORING NO. BH-37
SHIP CHANNEL DEEPENING PROJECT
PORT OF CORPUS CHRISTI AUTHORITY
CORPUS CHRISTI, TEXAS



LOCATION: Aransas Pass

COORDINATES: 1447038.105 N
17197646.706 E
(SPCS83 South Texas Zone)

MUDLINE EL.: -52.0' (MLLW)

STRATUM DESCRIPTION

Sample Type	Blows per Foot
SPT	6
SPT	28
SPT	13
SPT	36
SPT	24
SPT	39
SPT	18
T	
T	
SPT	18
SPT	25
SPT	21

Stratum Description	Stratum Elevation, ft
SAND (SP): loose, gray to dark gray, wet, with shells and shell fragments - with clay seam, 1.2' to 1.3'	-54.0
CLAYEY SAND (SC): medium dense, gray, wet, fine grained medium dense, gray to white, with course sand to fine gravel sized shell fragments and medium grain sand	-57.2
- hard, light gray to greenish gray at 7' - borderline sandy clay	-64.0
FAT CLAY (CH): very stiff, light gray to brown, moist - hard below 14' - with silty sand partings at 14' - with pockets of shell fragments, 14' to 15' - slickensided, 18 to 18.5' - with sand partings and pockets, 18.5' to 20'	-75.0
SANDY FAT CLAY (CH): very stiff, light gray to greenish gray, moist, with brown pockets	-80.0
SAND (SP): medium dense, gray to greenish gray, moist, fine grained	-86.5

Unit Dry Wt, pcf	Passing No. 200 Sieve, %	Water Content, %	Liquid Limit	Plastic Limit	Plasticity Index (PI)
	9	31			
	25	18	21	12	9
	24	18			
98		25	43	14	29
		17			

NOTES:
Depth to Mudline (ft) = 62.2
Depth to Water (ft) = 9.4
Water Depth (ft) = 51.8
Record Date&Time: 8/13/2018 20:20

DATE: August 13, 2018
TOTAL DEPTH: 34.5'
CAVED DEPTH: Not Applicable
DRY AUGER: Not Applicable
WET ROTARY: 0' to 34.5'
BACKFILL: NONE
HAMMER TYPE: Automatic Trip
LOGGER: J. Soto

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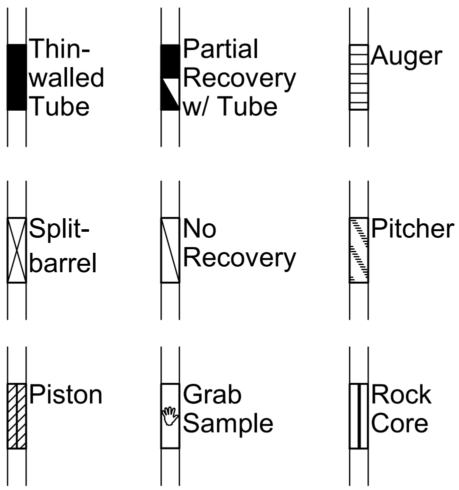
LOG OF BORING NO. BH-38
SHIP CHANNEL DEEPENING PROJECT
PORT OF CORPUS CHRISTI AUTHORITY
CORPUS CHRISTI, TEXAS

SOIL TYPES

- ▨ Fat CLAY (CH)
- ▨ Sandy Fat CLAY
- ▨ Lean CLAY (CL)
- ▨ Fill
- ▨ Clayey SAND (SC)
- ▨ Silty SAND (SM)
- ▨ Poorly graded SAND (SP)

SAMPLER TYPES



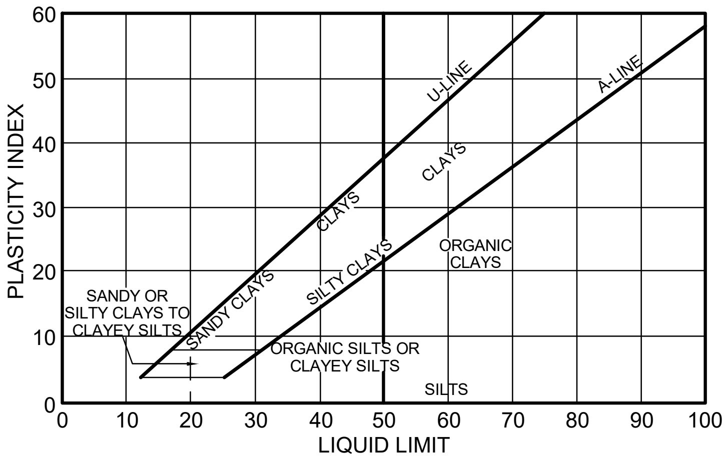
SOIL GRAIN SIZE

U.S. Standard Sieve

Boulders	Cobbles	Gravel		Sand			Silt	Clay
		Coarse	Fine	Coarse	Medium	Fine		

U.S. Standard Sieve	6"	3"	3/4"	4	10	40	200	
(mm)	152	76.2	19.1	4.76	2.00	0.420	0.074	0.002

PLASTICITY CHART



SOIL STRUCTURE

Slickensided	Having planes of weakness that appear slick and glossy.
Fissured	Containing shrinkage or relief cracks, often filled with fine sand or silt; usually more or less vertical.
Pocket	Inclusion of material of different texture that is smaller than the diameter of the sample.
Parting	Inclusion less than 1/8 inch thick extending through the sample.
Seam	Inclusion 1/8 inch to 3 inches thick extending through the sample.
Layer	Inclusion greater than 3 inches thick extending through the sample.
Laminated	Soil sample composed of alternating partings or seams of different soil type.
Interlayered	Soil sample composed of alternating layers of different soil type.
Intermixed	Soil sample composed of pockets of different soil type and layered or laminated structure is not evident.
Calcareous	Having appreciable quantities of carbonate.
Carbonate	Having more than 50% carbonate content.

TERMS AND SYMBOLS USED ON BORING LOGS

SOIL CLASSIFICATION (1 of 2)

PLATE C-39a

STANDARD PENETRATION TEST (SPT)

A 2-in.-OD, 1-3/8-ID split spoon sampler is driven 1.5 ft into undisturbed soil with a 140-pound hammer free falling 30 in. After the sampler is seated 6 in. into undisturbed soil, the number of blows required to drive the sampler the last 12 in. is the Standard Penetration Resistance or "N" value, which is recorded as blows per foot as described below.

SPLIT-BARREL SAMPLER DRIVING RECORD

Blows Per Foot	Description
25	25 blows drove sampler 12 inches, after initial 6 inches of seating.
50/7"	50 blows drove sampler 7 inches, after initial 6 inches of seating.
Ref/3"	50 blows drove sampler 3 inches during initial 6-inch seating interval.

NOTE: To avoid damage to sampling tools, driving is limited to 50 blows during or after seating interval.

DENSITY OF GRANULAR SOILS

Descriptive Term	*Relative Density, %	**Blows Per Foot (SPT)
Very Loose	< 15	0 to 4
Loose	15 to 35	5 to 10
Medium Dense	35 to 65	11 to 30
Dense	65 to 85	31 to 50
Very Dense	> 85	> 50

*Estimated from sampler driving record.
**Requires correction for depth, groundwater level, and grain size.

STRENGTH OF COHESIVE SOILS

Term	Undrained Shear Strength, ksf	Blows Per Foot (SPT) (approximate)
Very Soft	< 0.25	0 to 2
Soft	0.25 to 0.50	2 to 4
Firm	0.50 to 1.00	4 to 8
Stiff	1.00 to 2.00	8 to 16
Very Stiff	2.00 to 4.00	16 to 32
Hard	> 4.00	> 32

SHEAR STRENGTH TEST METHOD

U - Unconfined Q = Unconsolidated - Undrained Triaxial

P = Pocket Penetrometer T = Torvane V = Miniature Vane F = Field Vane

HAND PENETROMETER CORRECTION

Our experience has shown that the hand penetrometer generally overestimates the in-situ undrained shear strength of over consolidated Pleistocene Gulf Coast clays. These strengths are partially controlled by the presence of macroscopic soil defects such as slickensides, which generally do not influence smaller scale tests like the hand penetrometer. Based on our experience, we have adjusted these field estimates of the undrained shear strength of natural, overconsolidated Pleistocene Gulf Coast soils by multiplying the measured penetrometer reading by a factor of 0.6. These adjusted strength estimates are recorded in the "Shear Strength" column on the boring logs. Except as described in the text, we have not adjusted estimates of the undrained shear strength for projects located outside of the Pleistocene Gulf Coast formations.

Information on each boring log is a compilation of subsurface conditions and soil or rock classifications obtained from the field as well as from laboratory testing of samples. Strata have been interpreted by commonly accepted procedures. The stratum lines on the logs may be transitional and approximate in nature. Water level measurements refer only to those observed at the time and places indicated, and can vary with time, geologic condition, or construction activity.

TERMS AND SYMBOLS USED ON BORING LOGS

SOIL CLASSIFICATION (2 of 2)

Appendix C

Bioassay Methods, Analyses, and Reporting

Bioassay Methods, Analyses, and Reporting

1.0 OVERVIEW OF ELUTRIATE CHEMICAL ANALYSES AND BIOLOGICAL TESTING OF SEDIMENT

Elutriate chemical analyses and bioassays will be conducted to assess the potential for adverse impacts from the dredging and placing of new work construction sediments from the Corpus Christ Ship Channel (CCSC) Entrance Channel and Channel Extension.

2.0 GENERATION OF ELUTRIATE SAMPLES FOR CHEMICAL ANALYSES OF DISSOLVED CONSTITUENTS

The Standard Elutriate Test (SET) will be prepared according to USEPA and USACE (1991; 1998) guidance by agitating one part sediment and four parts site water for thirty (30) minutes, followed by a sixty (60) minute settling period. The supernatant will be siphoned, filtered, acidified according to instructions from the ANALTYICAL PROVIDER specified in Section 3.1 of the SOW and shipped overnight from ERDC to the ANALTYICAL PROVIDER specified in Section 3.1 of the SOW for chemical analyses (Tables 3, 4 and 5). This supernatant is defined as the 100% elutriate.

3.0 BIOLOGICAL TESTING OF SEDIMENT

Bioassays will be conducted to assess the potential for biological effects of dredged material in the water column during dredging and placement (elutriate toxicity tests on the suspended phase particulate) as well as after placement (sediment toxicity and bioaccumulation tests). Each type of bioassay will utilize at least two taxonomically and functionally dissimilar species. Elutriate toxicity tests will employ the fish *Menidia beryllina* or *Cyprinodon variegatus* and two life stages of the mysid shrimp *Americamysis bahia*. Sediment toxicity tests will use a surface deposit feeding amphipod (*Leptocheirus plumulosus* or *Ampelisca abdita)* and an epibenthic mysid shrimp (*A. bahia)*. Sediment bioaccumulation tests will be conducted with a bulk deposit-feeding polychaete worm (*Nereis virens)* and the facultative filter feeding and surface deposit feeding clam (*Macoma nasuta)*. Additional details for each test are provided below.

4.0 SUSPENDED PARTICULATE PHASE (SPP-ELUTRIATE) BIOASSAYS

The Standard Elutriate Test (SET) will be prepared according to guidance (USEPA/USACE 1991, 1998) by agitating one part sediment and four parts site water for thirty (30) minutes, followed by a sixty (60) minute settling period. The supernatant will be siphoned and used for testing; this supernatant is defined as the 100% elutriate. Elutriate bioassays will be conducted for 96-hours (or 48-h for zooplankton tests) using the 100% elutriate, in addition to 50% and 10% dilutions of the 100% elutriate water. Reconstituted or natural seawater (or PA water, if provided) will be used as the diluent.

Laboratory performance controls will consist of natural or reconstituted seawater (Crystal Sea Marine Mix®, Enterprises International, Baltimore, MD, USA or Instant Ocean Seasalt®, Mentor, OH, USA) to confirm test organism viability. All concentrations, including the control, will be replicated five (5) times. The standard test organisms Americamysis bahia (formerly Mysidopsis bahia) and Menidia beryllina will be used in testing in basic accordance with dredged material evaluation guidance (US EPA / US ACE 1991, 1998). The fish Cyprinodon variegatus will be used if the water salinity falls below the testing range for Menidia beryllina. Fish and shrimp survival tests will be conducted at 20 ± 1 ☐C.

Experimental conditions and additional suspended particulate phase bioassays information are summarized in Table 4-1.

4.1 ZOOPLANKTON (AMERICAMYSIS BAHIA)

Less than one (≤1) day old mysid shrimp Americamysis bahia will be exposed to the sediment elutriates. Shrimp will be shipped overnight from Aquatic Biosystems (Fort Collins, CO, USA; or a similar vendor) and immediately observed for potential shipment impacts while being fed brine shrimp (Artemia) upon receipt. The control and dilution water will be reconstituted seawater prepared using Instant Ocean Seasalt® or Crystal Sea Marine Mix®. Tests will be conducted in one (1) L glass beakers containing two hundred (200) mL test media. The larger foot print of the one (1) L beaker is required for to provide greater swimming area to avoid aggressive interactions. Ten (10) A. bahia will be added per replicate and will be fed twice daily to avoid cannibalism. The measurement endpoint is survival after forty-eight (48) h exposure.

4.2 CRUSTACEAN (AMERICAMYSIS BAHIA)

Four to five (4 to 5) day old mysid shrimp Americamysis bahia will be exposed to the sediment elutriates. Shrimp will be shipped overnight from Aquatic Biosystems (Fort Collins, CO, USA; or a similar vendor) and immediately observed for potential shipment impacts and fed brine shrimp (Artemia) upon receipt. The control and dilution water is reconstituted seawater prepared using Instant Ocean Seasalt® or Crystal Sea Marine Mix®. Tests will be conducted in one (1) L glass beakers containing two hundred (200) mL test media. The larger foot print of the one (1) L beaker is required for to provide greater swimming area to avoid aggressive interactions. Ten (10) A. bahia will be added per replicate and will be fed twice daily to avoid cannibalism. The measurement endpoint is survival after ninety-six (96) h exposure.

4.3 FISH (MENIDIA BERYLLINA)

The silverside fish Menidia beryllina will be exposed to the sediment elutriate water at nine to fourteen (9 to 14) days old. Fish will be shipped overnight from Aquatic Biosystems (Fort Collins, CO, USA; or a similar vendor) and immediately observed for potential shipment impacts and fed brine shrimp (Artemia) upon receipt. The M. beryllina will be held for a minimum of one (1) night prior to testing. The control and dilution water will be reconstituted seawater prepared using Crystal Sea Marine Mix® or Instant Ocean Seasalt®. Tests will be conducted in two hundred (200) mL or one (1) L beakers containing two hundred (200) mL test media. Ten (10) M. beryllina will be added per replicate and will be fed at 48-h into the bioassay. The measurement endpoint is survival after ninety-six (96) h exposure. The C. variegatus test is performed in the same fashion.

If sufficient mortality is observed in the above tests, NOEC, LOEC and LC50 values will be generated. Test acceptability criteria include water parameters within the specified range (USEPA/USACE 1991, 1998), at least ninety percent (90%) survival in the performance control and sensitivity to a reference toxicant (e.g., KCl) within acceptable control chart ranges (± two (2) S.D. from the mean).

4.4 WHOLE SEDIMENT TOXICITY (SOLID PHASE) BIOASSAYS

Whole sediment toxicity (solid phase) tests will be conducted to simulate exposure of benthic or epibenthic organisms to the in-place dredged material at the PA. Prior to testing, sediments will be thoroughly homogenized using an impeller mixer. Two standard test organisms, including 1) the amphipod Leptocheirus plumulosus or Ampelisca abdita and 2) Americamysis bahia, will be used in testing in basic accordance with dredged material evaluation guidance (USEPA/USACE 1991, 1998; USEPA 1994). Selection of the amphipods will depend on their suitability and relevance to the physical attributes of the test sediment.

Experimental conditions and additional whole sediment toxicity (solid phase) bioassay information are summarized in Table 4-2.

4.4.1 AMPHIPOD 10-D SEDIMENT TOXICITY BIOASSAY

Leptocheirus plumulosus (3-5 mm; no mature males or females) will be obtained from in-house cultures at the ERDC. If required, Ampelisca abdita (2 to 4 mm; no mature males or females) will be obtained from Aquatic Research Organism (Hampton, NH; or similar vendor). Amphipods will be sieved from culture/holding sediment and kept in clean reconstituted seawater overnight prior to test initiation. Approximately 175 mL (2 cm depth) of each test material and 825 mL overlying seawater (Crystal Sea Marine Mix®) will be placed into each of five replicate 1 L glass beakers. In addition, a performance control using well characterized sediment (Sequim Bay, WA, USA) and a reference sediment specific to the disposal site will be included in the study. Bulk sediment pore water ammonia concentrations will be measured upon sediment receipt.

The system will be allowed to equilibrate overnight under gentle aeration. The following day a chemistry ammonia duplicate will be sacrificed and pore water total ammonia will be measured. Pore water ammonia concentrations will be compared to species specific values listed in USEPA/USACE (1998) guidance. If ammonia levels exceed 60 mg/L for Leptocheirus plumulosus, or 30 mg/L for Ampelisca abdita, ammonia reduction procedures will be employed as described in section 11.2. of the Inland Testing Manual (USEPA/USACE, 2008). The study will be conducted at 25 ± 1°C and 20% salinity (Leptocheirus plumulosus) or 20 ± 1°C and 28% salinity (Ampelisca abdita) under a 24 hour light regime.The test will not be fed.

Water quality parameters will be measured from each replicate chamber (i.e., temperature, pH, dissolved oxygen, salinity and overlying water ammonia) at test initiation and termination. Water bath temperature will be monitored and recorded daily. Aeration will be provided to test chambers. In addition, daily observations (e.g., burrowing behavior) that may be significant to test results will be recorded. Following a 10-day exposure each beaker will be sieved and surviving organisms recovered and enumerated. Performance control survival must be ≥90% and reference toxicant test value must be within control chart ranges (± two (2) S.D. from the mean).

4.4.2 AMERICAMYSIS BAHIA 10-D SEDIMENT TOXICITY BIOASSAY

Americamysis bahia 10-d sediment toxicity testing will be conducted in basic accordance with standard guidance (USEPA/USACE 1991, 1998). Americamysis bahia (1-5 days old) will be obtained from Aquatic Biosystems (Fort Collins, CO, USA) or a similar vendor. Shrimp will be kept in clean reconstituted Instant Ocean® seawater overnight prior to test initiation. Approximately 175 mL of each test material and 825 mL overlying seawater (Instant Ocean Seasalt®) at 30‰ will be placed into each of five replicate 1 L glass beakers. In addition, a performance control using a well-characterized sediment (Sequim Bay, WA, USA) and a reference sediment specific to the disposal site will be included. Bulk sediment pore water ammonia concentrations will be measured upon sediment receipt.

The study will be conducted at 20 ± 1°C under a 16L:8D hour light regime. The test will be fed a concentrated suspension of Artemia nauplii ≤24 h old daily. Water quality parameters will be measured from each replicate chamber (i.e., temperature, pH, dissolved oxygen salinity and overlying water ammonia) at test initiation and termination. Water bath temperature will be monitored and recorded daily. Aeration will be provided to test chambers.

At test initiation, a minimum of ten (10) shrimp will be added to each replicate. Daily observations (e.g., swimming behavior) that may be significant to test results will be recorded daily. Following a 10-day exposure, sediment will be passed through a 425 µm sieve and surviving organisms recovered and enumerated. Performance control survival must be ≥90% and the reference toxicant test value must be within control chart ranges (± two (2) S.D. from the mean).

5.0 REFERENCE TOXICITY TESTS

5.1 SUSPENDED PARTICULATE PHASE TOXICITY REFERENCE TESTS

Forty-eight to ninety-six (48-96) hour reference toxicant tests will be conducted on each shipped batch of test organisms to assess test organism sensitivity relative to historic information recorded in laboratory control charts (± two (2) S.D. from the mean). Control charts from Aquatic Biosystems (or similar vendor) or ERDC will be used to compare to reference toxicity tests performed at ERDC. The selected reference toxicant is potassium chloride (KCl). Five concentrations (n = 1 to 3) will be prepared. Ten (10) organisms will be added to each replicate. The endpoint measured will be survival (LC50) after a 96-hour exposure.

5.2 WHOLE SEDIMENT TOXICITY (SOLID PHASE) REFERENCE TESTS

Reference toxicant tests will be conducted on each batch of test organisms used in whole sediment testing to assess test organism sensitivity relative to historic information recorded in laboratory control charts. In-house or vendor control charts will be used for comparison of both test organisms. The reference toxicant will be potassium chloride (KCl) or cadmium chloride (CdCl2). Six (6) concentrations will be prepared with three replicates per concentration containing 10 organisms each. The endpoint measured for both organisms will be survival after a 96-hour exposure.

6.0 BIOACCUMULATION BIOASSAYS

The standard organisms Nereis virens (polychaete worm) and Macoma nasuta (clam) will be used in whole sediment bioaccumulation testing in basic accordance with dredged material evaluation guidance (USEPA /USACE 1991, 1998). Approximately Six (6) L of each composite test material and twenty-four (24) L overlying seawater (Instant Ocean Seasalt®) will be placed into each of five (5) replicated, ten (10) gallon glass tanks. In addition, a reference sediment specific to the disposal site will be tested. The system will be allowed to equilibrate overnight under aeration.

The next day, approximately thirty-five (35) grams of live organism tissue will be added to each test chamber; an additional thirty-five (35) grams of unexposed tissue will be collected for background tissue residues. The static renewal bioassays will be conducted for twenty-eight (28) days and seventy percent (70%) of the water will be exchanged every Monday, Wednesday and Friday. Survival and mass of recoverable tissue will be measured at test termination. Prior to preservation, test organisms will be purged of undigested sediment (specifics are described below). Recovered tissue will be thoroughly homogenized using a tissumizer or will be ground to a powder by mortar and pestle over liquid nitrogen prior to residue analysis. Lipid analysis will be conducted using a method modified from Van Handel (1985) and is described in detail in Kennedy et al. (2010). All analyses will be performed on a wet tissue mass basis. The wet/dry ratio of tissue will also be determined.

Experimental conditions and additional bioaccumulation bioassay information are summarized in Table 4-3.

6.1 NEREIS VIRENS 28-D BIOACCUMULATION BIOASSAY

The polychaete worm Nereis virens will be field-collected (Aquatic Research Organisms, Hampton, NH, USA; or similar vendor) and acclimated to laboratory conditions for at least twenty-four (24) hours prior to testing. Tests will be conducted at 20 ± 1 ºC (20 ºC recommended) and any worms that do not burrow within the first two (2) hours following addition will be promptly replaced.

After twenty-eight (28) days exposure, the N. virens will be removed from the test sediment and allowed to purge their guts for twenty (24) hours in 3.75 L jars containing clean reconstituted seawater. Following gut purging, worms will be removed from water, thoroughly rinsed with deionized water, cleaned of any debris and either shipped immediately or frozen until shipped to the ANALTYICAL PROVIDER specified in Section 3.1 of the SOW for chemical analysis. Sample handling procedures will be confirmed with the ANALTICAL PROVIDER specified in Section 3.1 of the SOW one week prior to sample collection.

6.2 MACOMA NASUTA 28-D BIOACCUMULATION BIOASSAY

The bent nose clam Macoma nasuta will be field-collected (Aquatic Research Organisms, Hampton, NH, USA; or similar vendor) and acclimated to laboratory conditions for at least forty-eight (48) hours prior to testing. Tests will be conducted at 15 ± 1 ºC and any clams that do not burrow within the first twentyfour (24) hours following addition will be promptly replaced. After 28-days exposure, the M. nasuta will be removed from the test sediment and will be dissected to remove gut contents (undigested sediment) since purging in water is often insufficient to purge the gut of clams (Kennedy et al. 2010). Shells will be removed by cutting the hinge with a scalpel. Any remaining undigested sediment will be removed from the gut using a scalpel, and tissue will be thoroughly rinsed with deionized water and either shipped immediately or frozen until shipped to the ANALTYICAL PROVIDER specified in Section 3.1 of the SOW for chemical analysis. Sample handling procedures will be confirmed with the ANALTICAL PROVIDER Specified in Section 3.1 of the SOW one week prior to sample collection.

7.0 DATA ANALYSIS AND INTERPRETATION

7.1 STATISTICAL ANALYSES

For solid phase particulate bioassay data, statistical analyses will be conducted using Toxcalc® statistical software (Version 5.0, Tidepool Scientific Software, McKinleyville, CA) or SigmaStat® statistical software (SPSS, Chicago IL). All data will be statistically compared to data from references. Data normality (Kolmogorov–Smirnov test), homogeneity (Levene’s Test), and treatment differences compared to the reference (one way by ANOVA and Dunnett’s Method) will be determined at the $\alpha = 0.05$ level. Survival data will be arcsine-square-root transformed where appropriate. If normality cannot be achieved, t-tests will be used to compare elutriate treatments to the dilution water. The lethal median concentration producing 50% mortality (LC50) in elutriate or reference toxicity test dilutions will be determined by the Spearman–Karber method using Toxcalc® (verison 5.0, Tidepool Scientific Software, McKinleyville, CA).

For whole sediment and bioaccumulation bioassay data, statistical analyses will be conducted using Toxcalc® statistical software (Version 5.0, Tidepool Scientific Software, McKinleyville, CA), SigmaStat® (SPSS, Chicago IL) or SAS (SAS Institute, Cary, NC). All data will be statistically compared to data from the Reference Site (controls will not be included in statistical comparisons). For whole sediment testing, data normality will be evaluated using

Kolmogorov-Smirnov test. Homogeneity of variance will be evaluated using the Levene's median test. Where data are normal and homogeneous or can be made normal and/or homogeneous through a data transformation (e.g., arc-sine square root or log), the Dunnett's or Fisher's LSD method for all pair-wise comparisons will be utilized. Where data are not normal and/or variances not homogenous, the Steel Many Rank Test, Conover T Test or paired t-tests for unequal variance will be employed. Statistical significance will be determined at $\alpha = 0.05$.

7.2 DATA INTERPRETATION

US EPA R6 has issued a memo titled, "How to Report and Use Non-Detect Data When Evaluating MPRSA Section 103 Evaluations" (Oct 03, 2016). In addition to the data interpretation outlined below, non-detect data will be handled in a manner that is consistent with this draft memo. This memo is appended to this attachment as Supplemental Attachment 4-1.

7.2.1 Suspended Particulate Phase Toxicity Evaluation

Survival in all of the dredging site elutriate treatments will be compared to survival in the dilution water treatments. If survival is greater than, or equal to, survival in the dilution water treatment, the LPC for the suspended particulate phase has been met. If survival in the dredged material treatments is less than survival in the dilution water treatment, but the difference does not exceed 10%, the LPC for the suspended particulate phase will have been met.

If the difference in survival exceeds 10% the survival in the 100% dredged material elutriate treatment will be statistically compared to survival in the dilution water. If the 100% dredged material elutriate treatment is not statistically different from the dilution water, the LPC for the suspended particulate phase will have been met.

If survival in the 100% dredged material elutriate treatment is statistically lower than the dilution water, a numerical model will be required to determine compliance with the LPC (USEPA/USACE, 1991). The modeled concentrations of the dredged material in the water column outside the boundary of the disposal site during the 4-hour initial mixing period and the maximum concentration in the water column in the marine environment after the 4-hour mixing period will be compared with the LPC, as determined by multiplying the 48- or 96-hour LC50 by an appropriate application factor, to determine compliance.

If mortality is greater than 10% in the control treatment or in the dilution water treatment for a particular test species (30% mortality/abnormality for zooplankton), the test should be rejected and the bioassay repeated.

The default application factor is 0.01 but alternative factors can be used if justification is given. If both modeled concentrations are less than the LPC, compliance for the suspended particulate phase will have been met. If either of the modeled concentrations exceeds the LPC, the compliance for the suspended particulate phase is not met and placement of the dredged sediment cannot be conducted without appropriate management.

7.2.2 Whole Sediment Toxicity (Solid Phase) Bioassay Data Interpretation

Two conditions will be required to designate sediment as potentially toxic based on survival in whole sediment toxicity (solid phase) testing: 1) mortality that is more than 10% greater (A. bahia) or 20% greater (amphipod) than mortality in the reference; and 2) a statistically significant reduction in survival compared to survival in the reference sediment (USEPA/USACE 1998). If mortality exceeds reference mortality by the magnitude described in condition(1) above, dredging sediment toxicity data will be statistically compared to data from the reference sediments as described in the Inland Testing Manual (EPA/USCAE 1998). If both conditions are met, then the sediment will have failed to meet the LPC and will be deemed unsuitable for open water placement. If one or both of these conditions are not met, then sediment will have met the LPC for whole sediment toxicity (solid phase).

If greater than 10% mean mortality occurs in the control sediment, the test should be repeated.

7.2.3 Bioaccumulation Bioassay Test Data Interpretation

For bioaccumulation tests, tissue residues will be conservatively compared to the Food and Drug Administration (FDA) action levels (where available) using the 95th percentile of the data distribution. If concentrations of one or more contaminants statistically exceed the FDA action level, then the sediment will not meet the LPC for open water placement.

If tissue concentrations do not exceed the FDA action levels, then the tissue residue levels will be statistically compared to tissue concentrations of organisms exposed to reference sediment. In cases where tissue residues are less than detection limits, half the detection limit will be applied to statistical comparisons as recommended by Clark (1998). If tissue concentrations in organisms exposed to sediment from the dredging site do not statistically exceed the contaminant concentrations in tissues exposed to the reference sediment, adverse effects are not likely and the sediment will have met the LPC for bioaccumulation.

If tissue concentrations are statistically greater in organisms exposed to sediment from the dredging site than in organisms exposed to the reference sediment, further evaluation will be required by assessing the eight factors described in the Regional Implementation Agreement (USEPA/USACE 2003). The factors will be assessed in a weight-of evidence-approach (WOE) for determination of LPC compliance.

If a compliance decision still cannot be reached following evaluation of the eight factors, further actions will be developed and agreed upon by both the EPA and the USACE.

8.0 REPORTING

A report containing the finding of the toxicity and bioaccumulation studies will be provided. The report will include an executive summary, introduction, methods and results section. The report will include test endpoint tables providing means, standard deviations for survival, tissue mass, etc. Water quality analysis tables will include mean, standard deviation, N, and range of values for each endpoint measured. One (1) hard copy and an electronic PDF version of the report will be provided. Experimental data will be provided in an Excel Electronic Data Deliverable (EDD) (Supplemental Attachment 3-2).

9.0 REFERENCES

Kennedy AJ, Lotufo GR, Steevens JA, Bridges TS. 2010. *Determining Steady-state Tissue Residues forInvertebrates in Contaminated Sediment.* ERDC/EL TR-10-2, U.S. Army Engineer Research and Development Center, Vicksburg, MS. http://el.erdc.usace.army.mil/publications.cfm?Topic=techreport&Code=doer

US EPA and USACE (1991). *Evaluation of Dredged Material Proposed for Ocean Disposal (Testing Manual) ("Green Book").* EPA 503/8-91/001.
http://water.epa.gov/type/oceb/oceandumping/dredgedmaterial/gbook_index.cfm

US EPA. 1994. Methods for Measuring the Toxicity and Bioaccumulation of Sediment-associated Contaminants with Freshwater Invertebrates. EPA 600/R-99/064. US Environmental Protection Agency, Washington, DC. http://water.epa.gov/polwaste/sediments/cs/freshfact.cfm

US EPA and USACE (1998). *Evaluation of Dredged Material Proposed for Discharge in Waters of the U.S. -Testing Manual. Inland Testing Manual* (“ITM”). EPA-823-B-98-004. February 1998. http://water.epa.gov/type/oceb/oceandumping/dredgedmaterial/testing.cfm

US EPA and USACE (2003*). Regional Implementation Agreement for Testing and Reporting Requirements for Ocean Disposal of Dredged Material off the Louisiana and Texas Coasts Under Section 103 of The Marine Protection, Research and Sanctuaries Act.* U.S. Environmental Protection Agency, Region 6 and U.S. Army Corps of Engineers, Galveston and New Orleans Districts. July 2003 http://www.epa.gov/region6/water/ecopro/em/ocean/text/ria.pdf

Van Handel, E. 1985. Rapid determination of total lipids in mosquitoes. *Journal of the American Mosquito Control Association* 1:302–304.

Table 4-1: Suspended Particulate Phase Bioassays Information and Conditions

Parameter	Zooplankton (*Americamysis bahia*)	Invertebrate (*Americamysis bahia*)	Fish (*Menidia beryllina*)	Fish (*Cyprinodon variegatus*)*
Supplier	Aquatic Bio Systems, INC, Fort Collins, CO, or similar	Aquatic Bio Systems, INC, Fort Collins, CO, or similar	Aquatic Bio Systems, INC, Fort Collins, CO, or similar	Aquatic Bio Systems, INC, Fort Collins, CO, or similar
Age class	Neonate, ≤ 1 day old	Juvenile, 1-5 day old (24h range)	Larval, 9-14 day old (24h range)	Larval, 1-14 day old (24h range)
Test Procedures	OTM, ITM (EPA/USACE 1991, 1998)	OTM, ITM (EPA/USACE 1991, 1998)	OTM, ITM (EPA/USACE 1991, 1998)	OTM, ITM (EPA/USACE 1991, 1998)
Test type/duration	Static non-renewal – 48h	Static non-renewal – 96h	Static non-renewal – 96h	Static non-renewal – 96h
Control water	Laboratory reconstituted salt water, Crystal Sea/Instant Ocean	Laboratory reconstituted salt water, Crystal Sea/Instant Ocean	Laboratory reconstituted salt water, Crystal Sea/Instant Ocean	Laboratory reconstituted salt water, Crystal Sea/Instant Ocean
Test temperature	Recommended: 20 ± 1$_o$C	Recommended: 20 ± 1$_o$C	Recommended: 20 ± 1$_o$C	Recommended: 20 ± 1$_o$C
Test salinity	Range: 15 - 30 ppt (± 10%)	Range: 15 - 30 ppt (± 10%)	Range: 20 - 30 ppt (± 10%)	Range: 5 - 30 ppt (± 10%)
Test dissolved oxygen	Recommended: >4.5 mg/L	Recommended: >4.5 mg/L	Recommended: >4.5 mg/L	Recommended: >4.5 mg/L
Test pH	Recommended:7.8 ± 0.5	Recommended:7.8 ± 0.5	Recommended: 7.8 ± 0.5	Recommended: 7.8 ± 0.5
Control performance	≥ 90% survival	≥ 90% survival	≥ 90% survival	≥ 90% survival
Test photoperiod	16L:8D	16L:8D	16L:8D	16L:8D
Test chamber	1 L beaker	1 L beaker	250mL or 1 L beaker	250mL beaker
Exposure volume	200 mL	200 mL	200 mL	200 mL
SPP concentrations	100, 50, 10%	100, 50, 10%	100, 50, 10%	100, 50, 10%
Replicates/concentration	5	5	5	5
Organisms/replicate	10	10	10	10
Feeding	500 Artemia *Artemia nauplii* prior to test, am and pm daily	500 Artemia *Artemia nauplii* prior to test, am and pm daily	500 *Artemia nauplii* prior to test, pm 24h, am 72h	500 *Artemia nauplii* prior to test, pm 24h, am 72h
Water renewal	no	no	no	no
Endpoint	Survival	Survival	Survival	Survival

Table 4-2: Whole Sediment Toxicity (Solid Phase) Bioassays Information and Conditions

Parameter	*Leptocheirus plumulosus*	**Ampelisca abdita*	*Americamysis bahia*
Supplier	Aquatic Bio Systems, Inc., Fort Collins, CO, or similar; in-house cultures	Aquatic Research organisms Inc., Hampton, NH or similar	Aquatic Bio Systems, Inc., Fort Collins, CO, or similar
Age class	2-4 mm (500-710 µm);	3-5 mm; no mature males or females	1-5 day old (24h range)
Test Procedures	OTM, ITM (EPA/USACE 1991, 1998); EPA 1994	OTM, ITM (EPA/USACE 1991, 1998); EPA 1994	OTM, ITM (EPA/USACE 1991, 1998)
Test type/duration	10-d	10-d	10-d
Control water	Laboratory reconstituted salt water (e.g., Crystal Sea®)	Laboratory reconstituted salt water (e.g., Crystal Sea®)	Laboratory reconstituted salt water (e.g., Instant Ocean®)
Test temperature	Recommended: 25 ± 1$_{o}$C	Recommended: 20 ± 1$_{o}$C	Recommended: 20 ± 1$_{o}$C
Test salinity	20‰	28‰	30‰
Test dissolved oxygen	Recommended: >4.5 mg/L	Recommended: >4.5 mg/L	Recommended: >4.5 mg/L
Test photoperiod	Continuous light	Continuous Light	16L:8D
Test chamber	1 L beaker	1 L beaker	1 L beaker
Sediment volume	175 mL (2 cm depth)	175 mL (2 cm depth)	175 mL (2 cm depth)
Overlying water volume	825 mL	825 mL	825 mL
Replicates/sediment	5	5	5
Organisms/replicate	20	20	20
Feeding	none	none	Concentrated suspension of *Artemia nauplii*
Water renewal	none	none	none
Endpoint	Survival	Survival	Survival
Acceptability Criteria	≥ 90% Survival in Control	≥ 90% Survival in Control	≥ 90% Survival in Control

* replacement amphipod if sediment is too dense for *L. plumulosus*

Table 4-3: Bioaccumulation Bioassays Information and Conditions

Parameter	*Neries virens*	*Macoma nasuta*
Supplier	Aquatic Research organisms Inc., Hampton, NH or similar	Aquatic Research organisms Inc., Hampton, NH or similar
Test Procedures	OTM, ITM (EPA/USACE 1991, 1998)	OTM, ITM (EPA/USACE 1991, 1998)
Test type/duration	28-d	28-d
Control water	Laboratory reconstituted salt water (e.g., Instant Ocean®)	Laboratory reconstituted salt water (e.g., Instant Ocean®)
Test temperature	Recommended: 20 ± 1$_{o}$C	Recommended: 15 ± 1$_{o}$C
Test salinity	30‰	30‰
Test dissolved oxygen	Recommended: >4.5 mg/L	Recommended: >4.5 mg/L
Test photoperiod	16L:8D	16L:8D
Test chamber	10 gal aquarium	10 gal aquarium
Sediment volume	Target tissue mass dependent; 200 grams wet sediment per gram wet tissue	Target tissue mass dependent; 200 grams wet sediment per gram wet tissue
Overlying water volume	~20 L	~20 L
Replicates/sediment	5	5
Organisms/replicate	1 gram wet tissue per 200 grams wet sediment (target: 35 grams)	1 gram wet tissue per 200 grams wet sediment (target: 35 grams)
Feeding	none	none
Water renewal	70% renewal 3 times per week (i.e., M,W,F)	70% renewal 3 times per week (i.e., M,W,F)
Endpoint	Tissue residue Level	Tissue residue level
Acceptability Criteria	Adequate tissue mass for tissue residue analysis	Adequate tissue mass for tissue residue analysis

10.0 SUPPLEMENT INFORMATION: HOW TO REPORT AND USE NON-DETECT DATA WHEN EVALUATING MPSRA SECTION103 EVALUATIONS (OCTOBER 03, 2016)

How to Report and Use Non-Detect Data When Evaluating MPRSA Section 103 Evaluations

The purpose of this document is to clarify how non-detect data are reported and used in calculations, statistical analyses, comparisons to water quality standards and marine water quality criteria, and chemical summations when evaluating water, elutriate, sediment, and tissue data.

Background Information

Quality Assurance/Quality Control (QA/QC)

To support sediment management decisions, it is imperative that QA/QC procedures be implemented during field and laboratory activities. It is also important that the quality of the data be evaluated and reported.

Standard laboratory QA/QC procedures may include, depending on the particular method and analyte, matrix spikes/matrix spike duplicates, laboratory duplicates, method blanks, surrogate spikes, laboratory control samples, calibration protocols, and other procedures necessary to quantify the accuracy and precision of the analytical results. Laboratory QA/QC procedures are prescribed in the analytical method specifications or laboratory standard operating procedures (SOPs).

Analytical Sensitivity

Analytical sensitivity is characterized by method detection limits (MDLs) and laboratory reporting limits (LRLs) [also known as reporting limits, practical quantitation limits, and others] (ERDC/TN EEDP-04-36).

The Method Detection Limit (MDL) is a minimum concentration of a substance that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero (ERDC/TN EEDP-04-36). MDL studies are conducted using ideal, laboratory-prepared samples of a spiked clean matrix.

The Laboratory Reporting Limit (LRL) is established by the low standard of the initial calibration curve. At a minimum, the LRL should be three to five times the MDL.

For analysis of dioxins and PCB congeners using high-resolution gas chromatographic/mass spectrometric (GC/MS) methods, the sample-specific estimated detection limit (EDL) is analogous to the MDL and the MDL may be estimated based on the lower calibration limit, statistical analysis of historical method blank data, or other method specified by the laboratory.

To generate useable data, achieve data quality objectives, and support sediment management decisions, the LRLs should be less than the target detection limits (TDLs) listed in the RIA (Appendix C).

For undetected compounds, laboratories should report both the MDL and the LRL. If problems or questions arise regarding the ability to achieve sufficiently low MDLs and LRLs, the contractor should contact the USACE project manager who then would consult with Region 6. In all cases, sediments or extracts should be archived under proper storage conditions until the chemistry data are deemed acceptable by the regulatory agencies. This retains the option for re-analysis and lower-level quantitation, if necessary.

Detection Limit Terminology

Method Detection Limit (MDL) – Statistically-derived minimum level that can be measured and reported with 99% confidence that it is greater than zero.

Laboratory Reporting Limit (LRL) – minimum level a lab will report with confidence in quantitative accuracy.

Target Detection Limit (TDL) – Performance goal for project set to be lower than prevailing regulatory limits (WQC, WQS, NOAA SQUIRT tables)

MDL < LRL ≤TDL

Proposed Policy for Treatment of Non-Detected Chemical Data

1. All Analysis (water, elutriate, sediment, tissues)
    a. If analyte concentrations are equal to or greater than the MDL but below the LRL, the result will be qualified with a "J" flag as having lower precision and greater uncertainty. "J" values represent potential concentrations of contaminants that are detected below the laboratory reporting limit (LRL) and are acceptable for use in sediment management decisions
    b. Whenever "J" values are reported, they should be used as real values in the calculation of mean concentrations and for all statistical analyses.
    c. If the LRL exceeds the Target Detection Limit (TDL), then the LRL should be used in calculations and for all statistical analyses.
    d. If analyte concentrations are below the MDL, they should be reported in the summary tables as <###.##, where ###.## is the LRL.

2. Water and elutriate data used in comparison to state water quality standards (WQS) and/or Federal (marine) water quality criteria (WQC)
    a. When the disposal site is in federal jurisdiction, marine WQC is used for comparison.
    b. If the site overlaps with both state and federal waters, the data should be compared to the lowest number from either the marine WQC or the state WQS.
    c. When comparing results to the marine WQC, the Criterion Maximum Concentration (CMC) and not the Criteria Continuous Concentration (CCC) should be used (EPA, 2006).

3. "Non-detects" in tissue data used in calculation of means and statistical comparisons
    a. When the TDL **is not** met
        i. If 1 to 4 of the treatment tissue replicates are reported as non-detect (U-flagged) substitute the LRL.
        ii. If all five treatment tissue replicates are reported non-detect (U- flagged) then carry the analyte forward to the risk assessment phase (RIA Section 10.2.3). There is no need to compare to reference tissue results because the conservative assumption is to use "zero" (see 3(a)iii) for the reference tissues in which case the treatment reps are all greater than the reference tissues.
        iii. For reference tissue replicates reported as non-detect (U-flagged) substitute "zero".
    b. If the TDL is met
        i. If 1 or 2 treatment tissue replicates are reported as non-detect; then substitute the LRL for U-flagged data
        ii. If 3 or 4 of the treatment tissue replicates are reported as non-detect; then substitute one-half the LRL for the U-flagged data
        iii. For reference tissue replicates reported as "non-detect" substitute one-half the LRL
    c. For all calculations,
        i. if the LRL exceeds the TDL, then the LRL should be used (no half substitutions allowed) except for the reference.

4. Tissue Chemistry Reporting for PCB Aroclors and PAHs
    a. PCB Aroclors should be reported as
        i. Individual Aroclors and
        ii. Total PCB Aroclors
            - Sum of the following Aroclors: Aroclor-1016, 1221, 1232, 1242, 1248, 1254, and 1260.
            - If present, Aroclor-1262 and Aroclor-1268 should be reported, but not included in the total PCB summation.
        iii. Statistical comparison of Treatment tissue means to reference tissue means will be made on the basis of mean Total PCBs and not individual PCBs.
        iv. It should be noted that total PCBs calculated by summing PCB Aroclor mixtures is not comparable to total PCBs calculated by summing individual PCB congeners due to fundamental differences in the methods of analysis and quantitation.

    b. PAHs should be reported as
        i. Individual PAHs
        ii. Total low molecular weight (LMW) PAH
            - Include naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, and anthracene. 2-methylnaphthalene and methylnaphthalene are not routinely analyzed.
        iii. Total high molecular weight (HMW) PAH
        Include the following compounds: fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b+k)fluoranthenes, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene.
        iv. Total PAHs = sum of all LPAH and HPAH compounds
        v. Statistical comparison of Treatment tissue means to reference tissue means will be made the basis of mean Total PAH and not individual PAHs.

5. Dioxin/Furans (water, elutriate, sediment and tissue) should be reported as individual dioxin/furan congeners (carbon un-normalized)
    a. Total Toxic Equivalency Quotients (TEQs)
        i. Each cogener result is multiplied by the appropriate Mammalian Toxicity Equivalency Factor (TEF) found in the *2005 world health Organization Reevaluation of Human and Mammalian Toxic Equivalency Factors for Dioxins and Dioxin-Like Compounds* (Van de B erg et al., 2006)
        ii. Total TEQ = sum TEFs
        iii. Statistical comparison of Treatment tissue means to reference tissue means will be made on the basis of mean Total TEQ and not individual dioxin/furan congeners.
    b. Rules for Chemical Summation for TEFs are as follows:
        i. Group summation is performed using all detected concentrations.
        ii. Undetected results are included in the summations at half the value of the LRL
        iii. The estimated values between the MDL and the LRL (i.e., J-flagged

values) are included in the summation at face value.

iv. If the LRL exceeds the TDL, then the LRL should be used

v. If all constituents in a chemical group are undetected, the group sum is reported as undetected, and the highest MDL and LRL of all the constituents are reported as the MDL and LRL for the group sum.

OBJECTIVE

The objective of this work is to use a technically justifiable, Lines-of-Evidence (LOE) to reduce the COC list for the CCSC New Work Predredging Evaluation study that covers the area from the open waters of the Gulf of Mexico (Station -30+00) through to the Ferry Landing (Station +70+00).

APPROACH

The starting COC list is from the Regional Implementation Agreement (RIA) between the US-ACE Galveston District (SWG) and US EPA Region 6 (R6). Media were worked through sequentially, from sediment, to tissue to surface water. The reduction of the COC list from the more comprehensive list in the USEPA/USACE Regional Implementation Agreement (RIA) is project specific and site specific to this portion of the CCSC associated with new work (widening and deepening).

SEDIMENT

For sediment (SD), the overall operating premise for the section of the CCSC being evaluated in this particular effort is that this portion of the ship channel is dredged regularly as part of the SWG's Operations maintenance program and is not heavily industrialized. The maintenance material from these dredging events are tested and have always been approved for ocean placement at the Maintenance ODMDS.

The starting list of COCs for SD can be found in Table 1 with strikethrough to show which analytes have been removed. The following rationale were applied as LOE to remove COCs:

i) Metals:
   a. Common elements were removed from further evaluation (i.e., aluminum and iron)
   b. Metals without SD criteria, metals not detected in maintenance dredging and metals associated specifically with industry were removed from further evaluation (i.e., barium, Cr+3, Cr+6, cobalt, manganese, organotin, thallium, tin
ii) Conventional/Ancillary Parameters:
   a. Constituents for which there are no criteria with which to evaluate or are not used in the evaluation were removed (i.e., cyanides, total recoverable petroleum hydrocarbons, total phenols, acid volatile sulfides, total sulfides, total volatile solids, specific gravity, total moisture content and oil/grease)
iii) LPAH/HPAH:
   a. Uncommon LPAHs/HPAHs or those without criteria were removed from the list (1- methylnaphthalene, 1-methylphenanthrene, 2,6-dimethylnapthalene, methyl naphthalene, 2- methylnapthalene, benzo(e)pyrene, perylene)
iv) Organonitrogen Compounds were removed
v) Phthalate Esters: this category was removed based upon lack of related industry in this reach of the CCSC, widespread presence in the environment and the ease with which they can be introduced during sampling and analysis

vi) Phenols/Substituted Phenols: with the exception of pentachlorophenol, this category was removed based upon lack of related industry in this reach of the CCSC

vii) Dioxins/Dibenzofurans: this category was removed based upon lack of related industry in this reach of the CCSC

viii) PCBs: Since the testing involves whole sediment testing, all but total PBCs will be removed from the analysis list. Based upon Sloan (1993, 2005) and EPA Method 8082, Total PCBs is calculated from individual congeners. Table 9-3 in the Inland Testing Manual, defines total PCBs as the sum of 18 congeners. These 18 congeners are: PCB-8, -18, -28, -44, -52, -66, -77, -101, 105, -118, -126, -128, - 138, -153, -169, -170, -180, -187

ix) Pesticides: constituents not detected or detected infrequently in maintenance material, without criteria or not tested for in the other regions were removed (i.e., 2,4-DDE, 2,4-DDT, 2,4-DDD, a- chlordane, alpha/beta/delta/gamma BHC, chlorbenside, dacthal, heptachlor epoxide, hexachlorobenzene, malathion, parathion, total chlorinated pesticides, trans nonachlor)

x) Chlorinated Hydrocarbons: Associated specifically with industry, these were removed.

xi) Volatile Organic Compounds: Associated specifically with industry, these were removed

xii) Halogenated Ethers: Associated specifically with industry, these were removed

xiii) Miscellaneous: Associated specifically with industry, these were removed

xiv) Butyltins: Associated specifically with industry, these were removed The COC list resulting from this evaluation is presented in Table 2.

TISSUE

The COC list for tissue will parallel the COC list for sediment, with the exception of the conventional/ancillary parameters, which will be medium specific parameter and include percent lipids (Table 3).

SURFACE WATER

For surface water (SW), the overall operating premise for the section of the CCSC being evaluated in this particular effort is also that this portion of the ship channel is dredged regularly as part of the SWG's Operations maintenance program and is not industrialized. The surface water from these dredging events has also been tested and has never shown impacts that prohibited ocean placement at the Maintenance ODMDS.

The starting list of COCs for SW can be found in Table 4 with strikethrough to show which analytes have been removed. The following rationale were applied as LOE to remove COCs:

i. Metals:

  a. Common elements were removed from further evaluation (i.e., aluminum)

  b. Metals not detected in maintenance dredging and metals associated specifically with industry were removed from further evaluation (i.e., Cr+6, organotin, tin)

ii. Conventional/Ancillary Parameters: parameters that are not used in the evaluation for placement

c. Constituents for which there are no criteria with which to evaluate or are not used in the evaluation were removed (i.e., cyanides, total petroleum hydrocarbons, total recoverable petroleum hydrocarbons, total phenols, total sulfides, total settleable solids)

iii. Organonitrogen Compounds: Associated specifically with industry, these were removed

iv. Phthalate Esters: this category was removed based upon lack of related industry in this reach of the CCSC, widespread presence in the environment and the ease with which they can be introduced during sampling and analysis

v. Phenols/Substituted Phenols: with the exception of pentachlorophenol, this category was removed based upon lack of related industry in this reach of the CCSC

vi. Dioxins/Dibenzofurans: this category was removed based upon lack of related industry in this reach of the CCSC

vii. PCBs: All but total PBCs will be removed from the analysis list. Since the testing involves whole sediment testing, all but total PBCs will be removed from the analysis list. Based upon Sloan (1993, 2005) and EPA Method 8082, Total PCBs is calculated from individual congeners. Table 9- 3 in the Inland Testing Manual, defines total PCBs as the sum of 18 congeners. These 18 congeners are: PCB-8, -18, -28, -44, -52, -66, -77, -101, 105, -118, -126, -128, -138, -153, -169, - 170, -180, -187

viii. Chlorinated Hydrocarbons: Associated specifically with industry, these were removed.

ix. Volatile Organic Compounds: Associated specifically with industry, these were removed

x. Halogenated Ethers: Associated specifically with industry, these were removed

xi. Miscellaneous: Associated specifically with industry, these were removed The COC list resulting from this evaluation is presented in Table 5.

Table 5 shows additional analytes that have been removed based on a lack of Texas Surface Water Quality Standards (TSWQS) or federal water quality criteria. This removed the following from the COC list:

i. Metals: antimony, barium, beryllium, Cr+3, chromium (total), cobalt, iron, manganese, thallium

ii. LPAH/HPAH compounds

iii. PCBs: Total PCBs

iv. Pesticides: 4,4’-DDD, 4,4’-DDE

The COC list resulting from both of these evaluations is presented in Table 6.

Summary:

Table 7 presents the final COC list with TDLs and screening benchmarks (i.e., NOAA ERL, Region 6, NOAA ERM) for sediment.

Table 8 presents the final COC list with TDLs and screening benchmarks (i.e., TSWQS, EPA WQC) for surface water.

REFERENCES:

Sloan, R.J. 1993. Update on 1992 Hudson River Fish PCB Results. Internal memorandum and short textual report with tables and figures summarizing PCB results in fish from 1977 through 1992. Bureau of Environmental Protection, Division of Fish and Wildlife, New York State Department of Environmental Conservation, Albany, New York. July 13, 1993. 37 p.

R.J. Sloan, M.W. Kane, L.C. Skinner Of Time, PCBs and the Fish of the Hudson River, NY State Department of Environmental Conservation, Albany, NY (2005) Available at: http://www.dec.ny.gov/docs/wildlife_pdf/hrpcbtrend.pdf 287 pp

USEPA/USACE (2003) Regional Implementation Agreement (RIA).

https://www.epa.gov/ocean-dumping/regional-implementation-agreement-testing-and-reporting-requirements-ocean-disposal

SEPA (2016). Hazardous Waste Test Methods/SW-846. Test Method 8082A: Polychlorinated Biphenyls (PCBs) by Gas Chromatography

https://www.epa.gov/hw-sw846

https://www.epa.gov/hw-sw846/sw-846-test-method-8082a-polychlorinated-biphenyls-pcbs-gas-chromatography