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June 6, 2013 Reference No. 027545-00

Mr. Shawn Ghose
Remedial Project Manager
United States Environmental Protection Agency 6SF-RA
1445 Ross Avenue, Suite 1200
Dallas, Texas 75202

Dear Mr. Ghose:

Re: Final Feasibility Study Report
Star Lake Canal Superfund Site
Jefferson County, Texas
CERCLA Docket No. 06-02-06

Conestoga-Rovers & Associates (CRA) and Cardno ENTRIX, on behalf of Chevron Environmental Management Company (CEMC) and Huntsman Petrochemical LLC (Huntsman), submit herein to the U.S. Environmental Protection Agency (EPA) the Final Feasibility Study (FS) Report for the Star Lake Canal Superfund Site located in Jefferson County, Texas (Site). This complete electronic copy of the Final FS Report includes the revised report text page and tables and replaces the submittal of June 12, 2012.

Please contact CRA or Mr. Gary Jacobson of CEMC at (713) 432-2636 if you require clarification.

Yours truly,

CONESTOGA-ROVERS & ASSOCIATES

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# FINAL
# FEASIBILITY STUDY REPORT

## STAR LAKE CANAL SUPERFUND SITE
## JEFFERSON COUNTY, TEXAS
## CERCLA DOCKET NO. 06-02-06

**Prepared for:**

**Chevron Environmental Management Company and Huntsman Petrochemical LLC**

**JUNE 2012**
**REF. NO. 027545-00 (20)**

# EXECUTIVE SUMMARY

Conestoga-Rovers & Associates (CRA) and Cardno ENTRIX, on behalf of Chevron Environmental Management Company (CEMC) and Huntsman Petrochemical LLC (Huntsman), submit herein to the United States Environmental Protection Agency (EPA) the Draft Feasibility Study (FS) Report for the Star Lake Canal Superfund Site (Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA] Docket No. 06-02-06) located in Jefferson County, Texas (Site). The EPA entered into an Administrative Settlement Agreement and Order on Consent (AOC) for Remedial Investigation/Feasibility Study (RI/FS) with CEMC and Huntsman for the Site on December 22, 2005. The AOC required that a RI/FS be completed for the Site in accordance with relevant EPA Guidance documents. This submittal is intended for use as the basis for the Record of Decision expected subsequently.

The location of the Site is shown on the vicinity map included as Figure 1-1 and an aerial photograph included as Figure 1-2. The Site includes the two industrial canals (Star Lake Canal and Jefferson Canal) and the adjacent wetlands. Molasses Bayou is located southeast of the Star Lake Canal and intersects the canal at two locations. Gulf States Utility Canal is a canal that was excavated during the placement of a utility line and is located approximately 100 feet northwest of Star Lake Canal. Gulf States Utility Canal extends parallel to Star Lake Canal from northeast of Atlantic Road to the Neches River. Star Lake Canal and Jefferson Canal are used by nearby industries for permitted discharge of industrial effluents. Historical unpermitted and permitted discharges have resulted in the deposition of potentially hazardous constituents at the Site.

Industrial operations have occurred in areas surrounding the Site since the early 1940s. Initial construction of industrial facilities occurred under the direction of the United States government during World War II, and subsequent operations have continued through the present. Wastewater effluents from these operations were routed to the Site. Jefferson Canal and Star Lake Canal were excavated in the late 1940s to receive stormwater and industrial wastewater. In approximately February 1983, the Jefferson County Drainage District Number 7 (DD #7) dredged Jefferson Canal by dragline after acquiring an easement on the canal from Texaco Chemical Company (TCC). The DD #7 deposited dredged materials onto the banks of Jefferson Canal in and around an area north of FM Road 366. The deposited dredged material was subsequently determined to be impacted with potentially hazardous constituents. The approximate location of the dredged material is shown on Figure 1-2 of the *Tier 1 RI Report*.

Chevron is currently the parent corporation of Texaco Inc. as a result of a merger in October 2001. Texaco Inc. was the parent corporation of TCC until TCC was sold to

Huntsman in April 1994. TCC was a successor in interest to various entities that operated what are now called the C4 and Oxides and Olefins (O&O) Plants in Port Neches, Texas, and which owned all or part of Star Lake Canal and Jefferson Canal. Huntsman is the current owner of a significant portion of Star Lake Canal and a portion of Jefferson Canal. Huntsman acquired ownership in April 1994 when it purchased TCC. As a result of that acquisition, Huntsman also acquired the C4 and O&O Plants in Port Neches.

The methods and procedures contained in this Final FS Report describe activities that were conducted during the FS. The remainder of this Final FS Report is organized into seven sections:

- Section 2.0 includes a timeline of events for the project and a summary of the results of the Tier 1 and Tier 2 RIs. In addition, this section includes a summary of the Alignment Document and the Sensitivity Analysis completed in preparation for the FS scoping.
- Section 3.0 includes identification of the Remedial Action Objectives (RAOs), Applicable or Relevant and Appropriate Requirements (ARARs), constituents of concern (COCs), Preliminary Remediation Goals (PRGs), and general response actions for the FS. This section also includes the screening of potential technology types and process options against effectiveness, implementability, and cost.
- Section 4.0 describes methods and procedures used to assemble the selected general response actions and prepare remedial action alternatives for each Area of Investigation (AOI).
- Section 5.0 describes the process used to further refine the remedial action alternatives and a detailed analysis of the alternatives with respect to the nine evaluation criteria.
- Section 6.0 provides a detailed cost estimate for each of the remedial alternatives within each AOI with a precision of plus 50 percent or minus 30 percent.
- Section 7.0 presents the comparative analysis of the remedial alternatives for each of the seven AOIs of the Site to identify the advantages and disadvantages of each remedial alternative relative to one another within an AOI, and provide key information for use in determination of the selected remedy.

In addition, the Final FS is supported by figures, tables, and an appendix.

The FS documents alternatives that meet the objective of the RI/FS process and summarizes the advantages, disadvantages, and comparison of all alternatives that were extended through the FS process to include cost estimation.

Section 3.4 of the text identifies and screens the technology types and process options. Table 3-7 is the criteria and scoring that is applied to all technology types and process options in Table 3-8. The technology types and process options are then evaluated on the numerical scoring, and the process options were either retained for further evaluation or eliminated. Table 3-9 shows the technology types and process options that were retained after the screening process (Tables 3-7 and 3-8). Section 4.0 of the text develops the remedial alternatives for each AOI. Table 4-1 took the retained technology types and process options and applied them to each AOI to form remedial alternatives for each polygon. Tables 6-1 through 6-7 provide the cost estimates for the remedial alternatives of Jefferson Canal AOI, Jefferson Canal Spoil Pile AOI, Former Star Lake AOI, Star Lake Canal AOI, Gulf States Utility Canal AOI, Molasses Bayou Waterway AOI, and Molasses Bayou Wetlands AOI, respectively. Tables 7-1 through 7-7 use a criteria and numerical scoring system for a comparative analysis of remedial alternatives for each AOI.

The RAOs for the Site follow:

Ecological

- Protect benthic invertebrates by reducing direct contact exposure with COCs (Table 3-4A) in areas where sediment is designated as medium-high or high using the ERM-Q/PEL-Q method
- Protect UTL receptors by reducing ingestion/direct contact with sediment concentrations in excess of PRGs (Table 3-4A) in areas where sediment is designated as medium-high or high using the ERM-Q/PEL-Q method.
- Protect UTL receptors by reducing or eliminating exposure to COCs (Table 3-4B) in soil from the Jefferson Canal Spoil Pile.

Human Health

- The Human Health Risk Assessment (HHRA) identified human health risk that was not sufficient to require establishment of a human health RAO.

Sediment PRGs were developed for the protection of upper trophic level (UTL) receptors of concern (ROCs) and benthic invertebrates. The ecological PRG, which is protective of both of these receptor groups, is the lowest concentration of the UTL sediment PRG and the benthic invertebrate sediment PRG for each constituent of potential ecological concern (COPEC). According to 30 TAC §350.77, protective

concentration levels for ecological receptors are primarily intended to be protective for more mobile or wide-ranging ecological receptors and, where appropriate, benthic invertebrate communities. Therefore, a PRG that protects UTL ROCs and benthic invertebrates in sediment is considered a protective concentration for ecological receptors in sediment and is equal to the ecological sediment PRG.

Soil PRGs were developed for the protection of UTL ROCs. According to 30 TAC §350.77, protective concentration levels for ecological receptors are primarily intended to be protective for more mobile or wide-ranging ecological receptors and, where appropriate, benthic invertebrate communities. Therefore, the UTL soil PRG is considered a protective concentration for ecological receptors and is equal to the ecological soil PRG.

The HHRA identified human health risk that was not sufficient to require establishment of human health PRGs for sediment or soil.

A list of potentially acceptable technologies and technology process options, corresponding to the identified general response actions, were developed and screened by evaluation of the process options with respect to technical implementability. Each proposed potential technology was further evaluated during the FS for technical implementability, cost, and effectiveness in meeting the RAOs.

The alternative development process focused on the most viable options for remediation of the Site sediment and soil, as appropriate. Alternatives formed for each AOI are as follows:

**Jefferson Canal AOI**

Alternative 1: No Action

Alternative 2a: Containment: Soil Cap and Pipe Containment of JC-7, Partial 12-inch Removal/Disposal, and Partial Containment: 12-inch soil cap

Alternative 2b: Containment: Soil Cap and Pipe Containment of JC-7, Partial 12-inch Removal/Disposal, and Containment: 12-inch soil cap on area outside the pipeline servitude and 12-inch Erosion Control Mat on the pipeline servitude

Alternative 2c: Containment: Soil Cap and Pipe Containment of JC-7, Partial 12-inch Removal/Disposal, and Partial Containment: 12-inch Armored Cap

Alternative 2d: Containment: Soil Cap and Pipe Containment of JC-7, Partial 12-inch Removal/Disposal, and Containment: 12-inch Armored Cap on area outside the pipeline servitude and 12-inch Erosion Control Mat on the pipeline servitude

Alternative 3a: Partial 12-inch Removal/Disposal and Partial Containment: 12-inch soil cap

Alternative 3b: Partial 12-inch Removal/Disposal and Containment: 12-inch soil cap on area outside the pipeline servitude and 12-inch Erosion Control Mat on the pipeline servitude

Alternative 3c: Partial 12-inch Removal/Disposal and Partial Containment: 12-inch Armored Cap

Alternative 3d: Partial 12-inch Removal/Disposal and Containment: 12-inch Armored Cap on area outside the pipeline servitude and 12-inch Erosion Control Mat on the pipeline servitude

**Jefferson Canal Spoil Pile AOI**

Alternative 1: No Action

Alternative 2a: Containment: 2-foot Composite Cap

Alternative 2b: Removal/Disposal of mounds to grade and Containment: 2-foot Composite Cap

Alternative 2c: Partial Containment: 2-foot Composite Cap

Alternative 3a: Partial 12-inch Removal/Disposal, Removal/Disposal of mounds to grade, and Containment: 2-foot Composite Cap

Alternative 3b: Partial 12-inch Removal/Disposal, Removal/Disposal of mounds to grade, and Partial Containment: 2-foot Composite Cap

**Former Star Lake AOI**

Alternative 1: No Action

Alternative 2a: Partial 12-inch Removal/Disposal and Partial Containment: 12-inch Impermeable Cap (minimizes erosion)

Alternative 2b: Partial 12-inch Removal/Disposal and Containment: 12-inch Impermeable Cap (minimizes erosion) on area outside the pipeline servitude and 12-inch Erosion Control Mat and 12-inch Composite Cap on the pipeline servitude

Alternative 3a: Partial 12-inch Removal/Disposal and Partial Containment: 12-inch Composite Cap

Alternative 3b: Partial 12-inch Removal/Disposal and Containment: 12-inch Composite Cap on area outside the pipeline servitude and 12-inch Erosion Control Mat and 12-inch Composite Cap on the pipeline servitude

**Star Lake Canal AOI**

Alternative 1: No Action

Alternative 2: 12-inch Removal/Disposal and Containment: 12-inch Impermeable Cap (minimizes erosion)

Alternative 3: 12-inch Removal/Disposal and Containment: 12-inch Armored Cap

**Gulf States Utility Canal AOI**

Alternative 1: No Action

Alternative 2: Containment: 12-inch Composite Cap

Alternative 3: 12-inch Removal/Disposal and Containment: 12-inch Armored Cap

Alternative 4: 12-inch Removal/Disposal

**Molasses Bayou Waterway AOI**

Alternative 1: No Action

Alternative 2a: Monitored Natural Recovery

Alternative 2b: Monitored Natural Recovery and 12-inch Removal/Disposal and Containment: 12-inch Armored Cap

Alternative 3: 12-inch Removal/Disposal and Containment: 12-inch Armored Cap

**Molasses Bayou Wetland AOI**

Alternative 1: No Action

Alternative 2a: Monitored Natural Recovery

Alternative 2b: Monitored Natural Recovery and Containment: 12-inch Composite Cap

Alternative 2c: Monitored Natural Recovery and 12-inch Removal/Disposal and Containment: 12-inch Armored Cap

Alternative 2d: Monitored Natural Recovery and 12-inch Removal/Disposal

Alternative 3: Containment: 12-inch Composite Cap

Alternative 4: Partial 12-inch Removal/Disposal and Partial Containment: 12-inch Armored Cap

Alternative 5: Partial 12-inch Removal/Disposal

The nine criteria used in the FS process during the evaluation of remedial alternatives provide the framework for conducting a detailed analysis for selection of appropriate remedial actions. These criteria are characterized by the role of the criteria during the remedy selection process. There are threshold, balancing, and modifying criteria to be considered in this evaluation process.

The threshold criteria are:

- Overall protection of human health and the environment
- Compliance with the ARARs

The balancing criteria are:

- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, and volume
- Short-term effectiveness
- Implementability
- Cost

The modifying criteria are:

- State acceptance
- Community acceptance

The evaluations performed in this FS have identified a number of elements that may require further consideration during the remedial design. Additional sediment and soil data should be obtained in identified locations to more precisely define the horizontal and vertical limits of removal and cap placement to reduce the risk posed by the COCs. This is crucial at and near pipelines in the vicinity of the Star Lake Canal Superfund Site. In addition, the evaluation of pipeline casements, coordination with pipeline owners, and/or completion of a geophysical survey to locate and map pipelines could be conducted in the RD phase. At the Jefferson Canal AOI, a hydraulic analysis would be conducted in order to size the pipe to safely convey the design storm event.

TABLE OF CONTENTS


Page

1.0 INTRODUCTION ..... 1
1.1 OBJECTIVE ..... 1
1.2 SITE DESCRIPTION ..... 2
1.3 SITE HISTORY ..... 3
1.4 REPORT ORGANIZATION ..... 5

2.0 PROJECT SUMMARY ..... 7
2.1 TIMELINE OF EVENTS ..... 7
2.2 REMEDIAL INVESTIGATION SUMMARY ..... 9
2.2.1 TIER 1 RI SAMPLE COLLECTION SUMMARY ..... 10
2.2.2 TIER 2 RI SAMPLE COLLECTION SUMMARY ..... 11
2.2.3 CONCEPTUAL SITE MODEL ..... 15
2.2.3.1 BANK SOIL ..... 16
2.2.3.2 AIR ..... 17
2.2.3.3 GROUNDWATER ..... 17
2.2.3.4 CANAL SEDIMENT ..... 18
2.2.3.5 WETLAND SEDIMENT ..... 20
2.2.3.6 SURFACE WATER ..... 21
2.2.3.7 FISH/SHELLFISH ..... 23
2.2.3.8 ECOLOGICAL TISSUE ..... 24
2.2.4 HUMAN HEALTH RISK ASSESSMENT ..... 24
2.2.5 BASELINE ECOLOGICAL RISK ASSESSMENT ..... 28
2.2.5.1 BENTHIC INVERTEBRATES ..... 29
2.2.5.2 TERRESTRIAL INVERTEBRATES ..... 30
2.2.5.3 AQUATIC INVERTEBRATES AND FISH ..... 31
2.2.5.4 UPPER TROPHIC LEVEL RECEPTORS ..... 32
2.2.6 REMEDIAL INVESTIGATION CONCLUSIONS ..... 33
2.3 ALIGNMENT DOCUMENT ..... 35
2.4 SENSITIVITY ANALYSIS ..... 38
2.4.1 EVALUATION OF UPPER TROPHIC LEVEL RISK ..... 38
2.4.2 DEVELOPMENT OF REMEDIATION SCENARIOS ..... 38
2.4.3 REFINEMENT OF COPEC LIST FOR SENSITIVITY ANALYSIS ..... 40
2.4.4 THIESSEN POLYGONS ..... 41
2.4.5 EXPOSURE MODELING FOR EACH REMEDIATION SCENARIO ..... 41
2.4.6 EVALUATION OF REMEDIATION SCENARIO RESULTS ..... 42
2.4.7 SELECTION OF REMEDIATION SCENARIO ..... 43
2.4.8 SCENARIO 10B RISK ANALYSIS MODIFICATIONS ..... 44
2.4.8.1 PENTACHLOROPHENOL ..... 45
2.4.8.2 ALUMINUM ..... 46
2.4.8.3 HEXAVALENT CHROMIUM ..... 46
2.4.8.4 COPPER ..... 48
2.4.8.5 MANGANESE ..... 49
2.4.9 CONCLUSIONS ..... 51

3.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES .....52
3.1 REMEDIAL ACTION OBJECTIVES .....52
3.1.1 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS) .....53
3.1.2 CONSTITUENTS OF CONCERN .....54
3.2 DEVELOPMENT OF REMEDIATION GOALS .....76
3.2.1 PRELIMINARY REMEDIATION GOALS FOR PROTECTION OF UPPER TROPHIC LEVEL RECEPTORS IN SEDIMENT .....76
3.2.2 PRELIMINARY REMEDIATION GOALS FOR PROTECTION OF BENTHIC INVERTEBRATES IN SEDIMENT .....76
3.2.3 ECOLOGICAL PRELIMINARY REMEDIATION GOALS IN SEDIMENT .....77
3.2.4 PRELIMINARY REMEDIATION GOALS FOR PROTECTION OF UPPER TROPHIC LEVEL RECEPTORS IN SOIL .....77
3.2.5 ECOLOGICAL PRELIMINARY REMEDIATION GOALS IN SOIL .....78
3.2.6 HUMAN HEALTH PRELIMINARY REMEDIATION GOALS .....78
3.3 GENERAL RESPONSE ACTIONS .....78
3.4 IDENTIFICATION AND SCREENING OF TECHNOLOGY TYPES AND PROCESS OPTIONS .....78
3.4.1 IDENTIFICATION AND SCREENING OF TECHNOLOGIES .....79
3.4.2 EVALUATION OF TECHNOLOGIES AND SELECTION OF REPRESENTATIVE TECHNOLOGIES .....80

4.0 EVALUATION OF GENERAL RESPONSE ACTIONS AND DEVELOPMENT OF REMEDIAL ACTION ALTERNATIVES .....83
4.1 GENERAL REPONSE ACTION SCREENING CRITERIA .....83
4.2 EVALUATION OF GENERAL RESPONSE ACTIONS .....84
4.2.1 GENERAL RESPONSE ACTION 1 – NO ACTION .....85
4.2.2 GENERAL RESPONSE ACTION 2 – MONITORED NATURAL RECOVERY (MNR) .....85
4.2.3 GENERAL RESPONSE ACTION 3 – CONTAINMENT .....87
4.2.4 GENERAL RESPONSE ACTION 4 – REMOVAL AND DISPOSAL .....89
4.3 DEVELOPMENT OF ALTERNATIVES .....90
4.4 PIPELINES .....93

5.0 DETAILED ANALYSIS OF REMEDIAL ACTION ALTERNATIVES .....94
5.1 REGULATORY REQUIREMENTS .....94
5.2 EVALUATION CRITERIA .....95
5.3 INDIVIDUAL ANALYSIS OF ALTERNATIVES .....97
5.3.1 JEFFERSON CANAL .....98
5.3.1.1 ALTERNATIVE 1 – NO ACTION .....99
5.3.1.2 ALTERNATIVE 2A – CONTAINMENT: SOIL CAP AND PIPE AT JC-7, PARTIAL 12-INCH REMOVAL/DISPOSAL, AND PARTIAL CONTAINMENT: 12-INCH SOIL CAP .....99
5.3.1.3 ALTERNATIVE 2B – CONTAINMENT: SOIL CAP AND PIPE AT JC-7, PARTIAL 12-INCH REMOVAL/DISPOSAL, CONTAINMENT: 12-INCH SOIL CAP ON AREA OUTSIDE THE

PIPELINE SERVITUDE AND A 12-INCH EROSION CONTROL MAT ON PIPELINE SERVITUDE ....102
5.3.1.4 ALTERNATIVE 2C – CONTAINMENT: SOIL CAP AND PIPE AT JC-7, PARTIAL 12-INCH REMOVAL/DISPOSAL, AND PARTIAL CONTAINMENT: 12-INCH ARMORED CAP....105
5.3.1.5 ALTERNATIVE 2D – CONTAINMENT: SOIL CAP AND PIPE AT JC-7, PARTIAL 12-INCH REMOVAL/DISPOSAL, CONTAINMENT: 12-INCH ARMORED CAP ON AREA OUTSIDE THE PIPELINE SERVITUDE AND A 12-INCH EROSION CONTROL MAT ON PIPELINE SERVITUDE....107
5.3.1.6 ALTERNATIVE 3A – PARTIAL 12-INCH REMOVAL/DISPOSAL AND PARTIAL CONTAINMENT: 12-INCH SOIL CAP ....110
5.3.1.7 ALTERNATIVE 3B – PARTIAL 12-INCH REMOVAL/DISPOSAL AND CONTAINMENT: 12-INCH SOIL CAP ON AREA OUTSIDE PIPELINE SERVITUDE AND A 12-INCH EROSION CONTROL MAT ON THE PIPELINE SERVITUDE ....112
5.3.1.8 ALTERNATIVE 3C – PARTIAL 12-INCH REMOVAL/DISPOSAL AND PARTIAL CONTAINMENT: 12-INCH ARMORED CAP ....114
5.3.1.9 ALTERNATIVE 3D – PARTIAL 12-INCH REMOVAL/DISPOSAL AND CONTAINMENT: 12-INCH ARMORED CAP ON AREA OUTSIDE PIPELINE SERVITUDE AND A 12-INCH EROSION CONTROL MAT ON THE PIPELINE SERVITUDE ....116
5.3.2 JEFFERSON CANAL SPOIL PILE ....119
5.3.2.1 ALTERNATIVE 1 – NO ACTION....120
5.3.2.2 ALTERNATIVE 2A – CONTAINMENT: TWO-FOOT COMPOSITE CAP ....120
5.3.2.3 ALTERNATIVE 2B – REMOVAL/DISPOSAL OF MOUNDS TO GRADE AND CONTAINMENT: TWO-FOOT COMPOSITE CAP....122
5.3.2.4 ALTERNATIVE 2C – PARTIAL CONTAINMENT: TWO-FOOT COMPOSITE CAP....124
5.3.2.5 ALTERNATIVE 3A – PARTIAL 12-INCH REMOVAL/DISPOSAL, REMOVAL/DISPOSAL OF MOUNDS TO GRADE, AND CONTAINMENT: TWO-FOOT COMPOSITE CAP ....125
5.3.2.6 ALTERNATIVE 3B – PARTIAL 12-INCH REMOVAL/DISPOSAL, REMOVAL/DISPOSAL OF MOUNDS TO GRADE, AND PARTIAL CONTAINMENT: TWO-FOOT COMPOSITE CAP....127
5.3.3 FORMER STAR LAKE....129
5.3.3.1 ALTERNATIVE 1 – NO ACTION....130
5.3.3.2 ALTERNATIVE 2A – PARTIAL 12-INCH REMOVAL/DISPOSAL AND PARTIAL CONTAINMENT: 12-INCH IMPERMEABLE CAP....131
5.3.3.3 ALTERNATIVE 2B – PARTIAL 12-INCH REMOVAL/DISPOSAL AND CONTAINMENT: 12-INCH IMPERMEABLE CAP ON AREA OUTSIDE PIPELINE SERVITUDE AND 12-INCH EROSION CONTROL MAT AND 12-INCH COMPOSITE CAP ON THE PIPELINE SERVITUDE ....133

5.3.3.4 ALTERNATIVE 3A – PARTIAL 12-INCH REMOVAL/DISPOSAL AND PARTIAL CONTAINMENT: 12-INCH COMPOSITE CAP .....135
5.3.3.5 ALTERNATIVE 3B – PARTIAL 12-INCH REMOVAL/DISPOSAL, CONTAINMENT: 12-INCH COMPOSITE CAP ON AREA OUTSIDE PIPELINE SERVITUDE AND 12-INCH EROSION CONTROL MAT AND 12-INCH COMPOSITE CAP ON THE PIPELINE SERVITUDE .....137
5.3.4 STAR LAKE CANAL .....139
5.3.4.1 ALTERNATIVE 1 – NO ACTION .....140
5.3.4.2 ALTERNATIVE 2 –12-INCH REMOVAL/DISPOSAL AND CONTAINMENT: 12-INCH IMPERMEABLE CAP .....140
5.3.4.3 ALTERNATIVE 3 – 12-INCH REMOVAL/DISPOSAL AND CONTAINMENT: 12-INCH ARMORED CAP .....142
5.3.5 GULF STATES UTILITY CANAL .....144
5.3.5.1 ALTERNATIVE 1 – NO ACTION .....144
5.3.5.2 ALTERNATIVE 2 – CONTAINMENT: 12-INCH COMPOSITE CAP .....145
5.3.5.3 ALTERNATIVE 3 – 12-INCH REMOVAL/DISPOSAL AND CONTAINMENT: 12-INCH ARMORED CAP .....146
5.3.5.4 ALTERNATIVE 4 – 12-INCH REMOVAL/DISPOSAL .....148
5.3.6 MOLASSES BAYOU WATERWAY .....149
5.3.6.1 ALTERNATIVE 1 – NO ACTION .....150
5.3.6.2 ALTERNATIVE 2A – MONITORED NATURAL RECOVERY .....150
5.3.6.3 ALTERNATIVE 2B – MONITORED NATURAL RECOVERY AND 12-INCH REMOVAL/DISPOSAL AND CONTAINMENT: 12-INCH ARMORED CAP .....152
5.3.6.4 ALTERNATIVE 3 – 12-INCH REMOVAL/DISPOSAL AND CONTAINMENT: 12-INCH ARMORED CAP .....154
5.3.7 MOLASSES BAYOU WETLAND .....155
5.3.7.1 ALTERNATIVE 1 – NO ACTION .....156
5.3.7.2 ALTERNATIVE 2A – MONITORED NATURAL RECOVERY .....156
5.3.7.3 ALTERNATIVE 2B – MONITORED NATURAL RECOVERY AND CONTAINMENT: 12-INCH COMPOSITE CAP .....158
5.3.7.4 ALTERNATIVE 2C – MONITORED NATURAL RECOVERY AND 12-INCH REMOVAL/DISPOSAL AND CONTAINMENT: 12-INCH ARMORED CAP .....160
5.3.7.5 ALTERNATIVE 2D – MONITORED NATURAL RECOVERY AND 12-INCH REMOVAL/DISPOSAL .....162
5.3.7.6 ALTERNATIVE 3 – CONTAINMENT: 12-INCH COMPOSITE CAP .....164
5.3.7.7 ALTERNATIVE 4 – PARTIAL 12-INCH REMOVAL/DISPOSAL AND PARTIAL CONTAINMENT: 12-INCH ARMORED CAP .....165
5.3.7.8 ALTERNATIVE 5 – PARTIAL 12-INCH REMOVAL/DISPOSAL .....167

6.0 COST .....169
6.1 COST ESTIMATION ASSUMPTIONS .....172
6.1.1 TOPOGRAPHY .....172
6.1.2 AREA AND VOLUME CALCULATIONS .....174
6.1.3 EXCAVATION, TRANSPORTATION, AND MATERIALS .....174

6.1.4 SAMPLE COLLECTION AND ANALYSIS....175
6.1.5 COST PRECISION....176
6.1.6 OPERATION AND MAINTENANCE COSTS....176
6.2 JEFFERSON CANAL....177
6.2.1 ALTERNATIVE 1 – NO ACTION....177
6.2.2 ALTERNATIVE 2A – CONTAINMENT: SOIL CAP AND PIPE AT JC-7, PARTIAL 12-INCH REMOVAL/DISPOSAL, AND PARTIAL CONTAINMENT: 12-INCH SOIL CAP....177
6.2.3 ALTERNATIVE 2B – CONTAINMENT: SOIL CAP AND PIPE AT JC-7, PARTIAL 12-INCH REMOVAL/DISPOSAL, AND CONTAINMENT: 12-INCH SOIL CAP ON AREA OUTSIDE THE PIPELINE SERVITUDE AND A 12-INCH EROSION CONTROL MAT ON THE PIPELINE SERVITUDE....178
6.2.4 ALTERNATIVE 2C – CONTAINMENT: SOIL CAP AND PIPE AT JC-7, PARTIAL 12-INCH REMOVAL/DISPOSAL, AND PARTIAL CONTAINMENT: 12-INCH ARMORED CAP....178
6.2.5 ALTERNATIVE 2D – CONTAINMENT: SOIL CAP AND PIPE AT JC-7, PARTIAL 12-INCH REMOVAL/DISPOSAL, AND CONTAINMENT: 12-INCH ARMORED CAP ON AREA OUTSIDE THE PIPELINE SERVITUDE AND A 12-INCH EROSION CONTROL MAT ON THE PIPELINE SERVITUDE....179
6.2.6 ALTERNATIVE 3A – PARTIAL 12-INCH REMOVAL/DISPOSAL AND PARTIAL CONTAINMENT: 12-INCH SOIL CAP....180
6.2.7 ALTERNATIVE 3B – PARTIAL 12-INCH REMOVAL/DISPOSAL AND CONTAINMENT: 12-INCH SOIL CAP ON AREA OUTSIDE THE PIPELINE SERVITUDE AND A 12-INCH EROSION CONTROL MAT ON THE PIPELINE SERVITUDE....181
6.2.8 ALTERNATIVE 3C – PARTIAL 12-INCH REMOVAL/DISPOSAL AND PARTIAL CONTAINMENT: 12-INCH ARMORED CAP....182
6.2.9 ALTERNATIVE 3D – PARTIAL 12-INCH REMOVAL/DISPOSAL AND CONTAINMENT: 12-INCH ARMORED CAP ON AREA OUTSIDE THE PIPELINE SERVITUDE AND A 12-INCH EROSION CONTROL MAT ON THE PIPELINE SERVITUDE....182
6.3 JEFFERSON CANAL SPOIL PILE....183
6.3.1 ALTERNATIVE 1 - NO ACTION....183
6.3.2 ALTERNATIVE 2A - CONTAINMENT: TWO-FOOT COMPOSITE CAP....183
6.3.3 ALTERNATIVE 2B – REMOVAL/DISPOSAL OF MOUNDS TO GRADE AND CONTAINMENT: TWO-FOOT COMPOSITE CAP....184
6.3.4 ALTERNATIVE 2C – PARTIAL CONTAINMENT: TWO-FOOT COMPOSITE CAP....185
6.3.5 ALTERNATIVE 3A – PARTIAL 12-INCH REMOVAL/DISPOSAL, REMOVAL DISPOSAL OF MOUNDS TO GRADE, AND CONTAINMENT: TWO-FOOT COMPOSITE CAP....185

6.3.6 ALTERNATIVE 3B – PARTIAL 12-INCH REMOVAL/DISPOSAL, REMOVAL AND DISPOSAL OF MOUNDS TO GRADE, AND PARTIAL CONTAINMENT: TWO-FOOT COMPOSITE CAP .....186
6.4 FORMER STAR LAKE .....187
6.4.1 ALTERNATIVE 1 – NO ACTION .....187
6.4.2 ALTERNATIVE 2A – PARTIAL 12-INCH REMOVAL/DISPOSAL AND PARTIAL CONTAINMENT: 12-INCH IMPERMEABLE CAP .....187
6.4.3 ALTERNATIVE 2B – PARTIAL 12-INCH REMOVAL/DISPOSAL AND CONTAINMENT: 12-INCH IMPERMEABLE CAP ON AREA OUTSIDE OF PIPELINE SERVITUDE AND A 12-INCH EROSION CONTROL MAT AND COMPOSITE CAP ON THE PIPELINE SERVITUDE .....188
6.4.4 ALTERNATIVE 3A – PARTIAL 12-INCH REMOVAL/DISPOSAL AND PARTIAL CONTAINMENT: 12-INCH COMPOSITE CAP .....189
6.4.5 ALTERNATIVE 3B – PARTIAL 12-INCH REMOVAL/DISPOSAL AND CONTAINMENT: 12-INCH COMPOSITE CAP ON AREA OUTSIDE OF THE PIPELINE SERVITUDE AND A 12-INCH EROSION CONTROL MAT AND COMPOSITE CAP ON THE PIPELINE SERVITUDE .....190
6.5 STAR LAKE CANAL .....191
6.5.1 ALTERNATIVE 1 – NO ACTION .....191
6.5.2 ALTERNATIVE 2 – 12-INCH REMOVAL/DISPOSAL AND CONTAINMENT: 12-INCH IMPERMEABLE CAP .....191
6.5.3 ALTERNATIVE 3 – 12-INCH REMOVAL/DISPOSAL AND CONTAINMENT: 12-INCH ARMORED CAP .....191
6.6 GULF STATES UTILITY CANAL .....192
6.6.1 ALTERNATIVE 1 – NO ACTION .....192
6.6.2 ALTERNATIVE 2 – CONTAINMENT: 12-INCH COMPOSITE CAP .....192
6.6.3 ALTERNATIVE 3 – 12-INCH REMOVAL/DISPOSAL AND CONTAINMENT: 12-INCH ARMORED CAP .....193
6.6.4 ALTERNATIVE 4 – 12-INCH REMOVAL AND DISPOSAL .....194
6.7 MOLASSES BAYOU WATERWAY .....194
6.7.1 ALTERNATIVE 1 – NO ACTION .....194
6.7.2 ALTERNATIVE 2A – MONITORED NATURAL RECOVERY .....195
6.7.3 ALTERNATIVE 2B – MONITORED NATURAL RECOVERY AND 12-INCH REMOVAL AND DISPOSAL AND CONTAINMENT: 12-INCH ARMORED CAP .....195
6.7.4 ALTERNATIVE 3 - 12-INCH REMOVAL/DISPOSAL AND CONTAINMENT: 12-INCH ARMORED CAP .....197
6.8 MOLASSES BAYOU WETLAND .....197
6.8.1 ALTERNATIVE 1 – NO ACTION .....197
6.8.2 ALTERNATIVE 2A – MONITORED NATURAL RECOVERY .....198
6.8.3 ALTERNATIVE 2B – MONITORED NATURAL RECOVERY AND CONTAINMENT: 12-INCH COMPOSITE CAP .....198

6.8.4 ALTERNATIVE 2C – MONITORED NATURAL RECOVERY AND 12-INCH REMOVAL AND DISPOSAL AND CONTAINMENT: 12-INCH ARMORED CAP ....199
6.8.5 ALTERNATIVE 2D – MONITORED NATURAL RECOVERY AND 12-INCH REMOVAL AND DISPOSAL....200
6.8.6 ALTERNATIVE 3 – CONTAINMENT: 12-INCH COMPOSITE CAP.....201
6.8.7 ALTERNATIVE 4 – PARTIAL 12-INCH REMOVAL/DISPOSAL AND PARTIAL CONTAINMENT: 12-INCH ARMORED CAP....202
6.8.8 ALTERNATIVE 5 – PARTIAL 12-INCH REMOVAL AND DISPOSAL .203

7.0 COMPARATIVE ANALYSIS OF ALTERNATIVES ....204
7.1 JEFFERSON CANAL ....204
7.2 JEFFERSON CANAL SPOIL PILE ....206
7.3 FORMER STAR LAKE....206
7.4 STAR LAKE CANAL....207
7.5 GULF STATES UTILITY CANAL....208
7.6 MOLASSES BAYOU WATERWAY....208
7.7 MOLASSES BAYOU WETLAND ....209
7.8 SUMMARY OF PREFERRED ALTERNATIVES....210

8.0 REFERENCES....211

FIGURES
(Following text)


| | |
|---|---|
| FIGURE 1-1 | VICINITY MAP |
| FIGURE 1-2 | AERIAL PHOTOGRAPH |
| FIGURE 1-3 | SITE MAP - AREAS OF INVESTIGATION |
| FIGURE 1-4 | JEFFERSON CANAL SPOIL PILE TOPOGRAPHIC MAP |
| FIGURE 1-5 | PIPELINES IN THE VICINITY OF JEFFERSON CANAL SPOIL PILE |
| FIGURE 1-6 | PROPERTY BOUNDARY MAP |
| FIGURE 2-1 | TIER 1 REMEDIAL INVESTIGATION SAMPLE LOCATIONS |
| FIGURE 2-2 | TIER 2 REMEDIAL INVESTIGATION SAMPLE LOCATIONS |
| FIGURE 2-3 | TIER 1 AND TIER 2 REMEDIAL INVESTIGATION SOIL SAMPLE LOCATIONS – JEFFERSON CANAL SPOIL PILE AOI |
| FIGURE 2-4 | ECOLOGICAL CONCEPTUAL SITE MODEL |
| FIGURE 2-5 | HUMAN HEALTH CONCEPTUAL SITE MODEL |
| FIGURE 2-6 | MAGNITUDE OF PCL EXCEEDANCES FOR ALL COPECS AND ALL RECEPTORS FOR SEDIMENT |
| FIGURE 2-7 | MAGNITUDE OF PCL EXCEEDANCES FOR ALL COPECS AND ALL RECEPTORS FOR SOIL |
| FIGURE 2-8 | THIESSEN POLYGONS |
| FIGURE 2-9 | SCENARIO 10B THIESSEN POLYGONS |
| FIGURE 5-1 | THIESSEN POLYGONS FOR JEFFERSON CANAL AOI |
| FIGURE 5-2A | THIESSEN POLYGONS FOR JEFFERSON CANAL SPOIL PILE AOI |
| FIGURE 5-2B | EXCAVATION PLAN |
| FIGURE 5-2C | SOIL COVER PLAN |
| FIGURE 5-2D | COLORIMETRIC PLAN – CUT AND FILL AREAS |
| FIGURE 5-2E | CROSS SECTIONS |
| FIGURE 5-3 | THIESSEN POLYGONS FOR FORMER STAR LAKE AOI |
| FIGURE 5-4 | THIESSEN POLYGONS FOR STAR LAKE CANAL AOI |
| FIGURE 5-5 | THIESSEN POLYGONS FOR GULF STATES UTILITY CANAL AOI |
| FIGURE 5-6 | THIESSEN POLYGONS FOR MOLASSES BAYOU WATERWAY AOI |
| FIGURE 5-7 | THIESSEN POLYGONS FOR MOLASSES BAYOU WETLAND AOI |

TABLES


| | |
|---|---|
| TABLE 2-1 | HAZARD QUOTIENTS FOR RECEPTORS OF CONCERN |
| TABLE 2-2 | DESCRIPTION OF REMEDIATION SCENARIOS |
| TABLE 2-3 | REFINEMENT OF COPEC LIST FOR SENSITIVITY ANALYSIS |
| TABLE 2-4 | REMEDIATION CONCENTRATIONS USED IN SENSITIVITY ANALYSIS |
| TABLE 2-5 | PERCENTAGE OF HAZARD QUOTIENTS DROPPING BELOW ONE |
| TABLE 2-6 | SUMMARY OF HAZARD QUOTIENTS WITHIN EACH REMEDIATION |
| TABLE 2-7 | HAZARD QUOTIENT RESULTS FOR SCENARIO 10B |
| TABLE 2-8 | HAZARD QUOTIENT RESULTS FOR SCENARIO 10B AFTER RISK ANALYSIS MODIFICATIONS |
| TABLE 3-1 | CHEMICAL-SPECIFIC APPICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS |
| TABLE 3-2 | LOCATION-SPECIFIC APPICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS |
| TABLE 3-3 | ACTION-SPECIFIC APPICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS |
| TABLE 3-4A | PRELIMINARY REMEDIATION GOALS - SEDIMENT |
| TABLE 3-4B | PRELIMINARY REMEDIATION GOALS - SOIL |
| TABLE 3-5 | GENERAL RESPONSE ACTIONS |
| TABLE 3-6 | POTENTIAL TECHNOLOGY TYPES AND PROCESS OPTIONS |
| TABLE 3-7 | CRITERIA AND NUMERICAL SCORING FOR RANKING OF REMEDIAL TECHNOLOGY |
| TABLE 3-8 | INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS |
| TABLE 3-9 | REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS RETAINED AFTER SCREENING |
| TABLE 4-1 | REMEDIAL ALTERNATIVES |
| TABLE 5-1 | INDIVIDUAL ANALYSIS OF REMEDIAL ALTERNATIVES FOR JEFFERSON CANAL AOI |
| TABLE 5-2 | INDIVIDUAL ANALYSIS OF REMEDIAL ALTERNATIVES FOR JEFFERSON CANAL SPOIL PILE AOI |
| TABLE 5-3 | INDIVIDUAL ANALYSIS OF REMEDIAL ALTERNATIVES FOR FORMER STAR LAKE AOI |
| TABLE 5-4 | INDIVIDUAL ANALYSIS OF REMEDIAL ALTERNATIVES FOR STAR LAKE CANAL AOI |

TABLE 5-5 INDIVIDUAL ANALYSIS OF REMEDIAL ALTERNATIVES FOR GULF STATES UTILITY CANAL AOI

TABLE 5-6 INDIVIDUAL ANALYSIS OF REMEDIAL ALTERNATIVES FOR MOLASSES BAYOU WATERWAY AOI

TABLE 5-7 INDIVIDUAL ANALYSIS OF REMEDIAL ALTERNATIVES FOR MOLASSES BAYOU WETLAND AOI

TABLE 6-1 REMEDIAL ALTERNATIVE COST ESTIMATE FOR JEFFERSON CANAL AOI

TABLE 6-2 REMEDIAL ALTERNATIVE COST ESTIMATE FOR JEFFERSON CANAL SPOIL PILE AOI

TABLE 6-3 REMEDIAL ALTERNATIVE COST ESTIMATE FOR FORMER STAR LAKE AOI

TABLE 6-4 REMEDIAL ALTERNATIVE COST ESTIMATE FOR STAR LAKE CANAL AOI

TABLE 6-5 REMEDIAL ALTERNATIVE COST ESTIMATE FOR GULF STATES UTILITY CANAL AOI

TABLE 6-6 REMEDIAL ALTERNATIVE COST ESTIMATE FOR MOLASSES BAYOU WATERWAY AOI

TABLE 6-7 REMEDIAL ALTERNATIVE COST ESTIMATE FOR MOLASSES BAYOU WETLAND AOI

TABLE 7-1 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR JEFFERSON CANAL AOI

TABLE 7-2 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR JEFFERSON CANAL SPOIL PILE AOI

TABLE 7-3 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR FORMER STAR LAKE AOI

TABLE 7-4 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR STAR LAKE CANAL AOI

TABLE 7-5 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR GULF STATES UTILITY CANAL AOI

TABLE 7-6 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR MOLASSES BAYOU WATERWAY AOI

TABLE 7-7 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR MOLASSES BAYOU WETLAND AOI

# APPENDICES

APPENDIX A DRAFT FEASIBILITY STUDY REPORT REVIEW COMMENT RESPONSE TABLE

APPENDIX B PIPELINE INFORMATION

## LIST OF ACRONYMS

| | | |
|---|---|---|
| AHR | - | Aryl Hydrocarbon Receptor |
| AOC | - | Administrative Order on Consent |
| AOI | - | Area of Investigation |
| ARAR | - | Applicable or Relevant and Appropriate Requirement |
| ATSDR | - | Agency for Toxic Substances and Disease Registry |
| AVS | - | Acid-Volatile Sulfide |
| BAF | - | bioaccumulation factors |
| BERA | - | Baseline Ecological Risk Assessment |
| CAA | - | Clean Air Act |
| CCA | - | Copper Chromated Arsenic |
| CEMC | - | Chevron Environmental Management Company |
| CERCLA | - | Comprehensive Environmental Response, Compensation, and Liability Act |
| COC | - | Constituent of Concern |
| COPCs | - | Constituents of Potential Concern |
| COPECs | - | Constituents of Potential Ecological Concern |
| CRA | - | Conestoga-Rovers & Associates |
| CSM | - | Conceptual Site Model |
| CT | - | Central Tendency |
| DDD | - | Dichlorodiphenyldichloroethylene |
| DDE | - | Dichlorodiphenyldichloroethane |
| DDT | - | Dichlorodiphenyltrichloroethane |
| DHHS | - | Department of Health and Human Services |
| EPA | - | United States Environmental Protection Agency |
| ERM | - | Effects Range-Median |
| ERM-Q | - | Effects Range Median Quotient |
| FS | - | Feasibility Study |
| GMATC | - | Geometric Mean Acceptable Toxic Concentration |
| g/mol | - | Grams per mole |
| H | - | Hazard Ratio |
| HHRA | - | Human Health Risk Assessment |
| HI | - | Hazard Index |
| HQ | - | Hazard Quotient |
| IARC | - | International Agency for Research on Cancer |
| $K_H$ | - | Henry's Law constant |
| $K_{OC}$ | - | Soil organic carbon water partition coefficient |
| LHHC | - | Limiting Human Health Criteria |
| LNVA | - | Lower Neches Valley Authority |

| | | |
|---|---|---|
| LOAEL | - | Lowest-Observed Adverse Effects Level |
| log $K_{ow}$ | - | Octanol/water partition coefficient |
| mg/day | - | Milligrams per day |
| mg/kg | - | Milligrams per kilogram |
| mg/L | - | Milligrams per liter |
| mg/m$^3$ | - | Milligrams per cubic meter |
| mmHg | - | Millimeters of mercury |
| µg/day | - | Micrograms per day |
| µg/dL | - | Micrograms per deciliter |
| µg/kg/day | - | Micrograms per kilogram per day |
| µg/L | - | Micrograms per liter |
| MNR | - | Monitored Natural Recovery |
| NAAQS | - | National Ambient Air Quality Standards |
| NPV | - | Net Present Value |
| ng/m$^3$ | - | Nanograms per cubic meter |
| NOAEL | - | No-Observed Adverse Effects Level |
| NPL | - | National Priorities List |
| O&M | - | Operation and Maintenance |
| OMB | - | Office of Management and Budget |
| OSHA | - | Occupational Safety and Health Administration |
| PAH | - | Polycyclic Aromatic Hydrocarbon |
| PCB | - | Polychlorinated Biphenyl |
| PCDF | - | Polychlorinated Dibenzofurans |
| PCL | - | Protective Concentration Level |
| PDS | - | Post Digestion Spike |
| PEL | - | Probable Effects Level |
| PEL-Q | - | Probable Effects Level Quotient |
| ppm | - | Parts per million |
| PRG | - | Preliminary Remediation Goal |
| PRP | - | Potentially Responsible Party |
| RAGS | - | Risk Assessment Guidance for Superfund |
| RAO | - | Remedial Action Objective |
| RBEL | - | Risk Based Exposure Level |
| RCRA | - | Resource Conservation and Recovery Act |
| RDA | - | Recommended Dietary Allowance |
| RI | - | Remedial Investigation |
| RI/FS | - | Remedial Investigation/Feasibility Study |
| RME | - | Reasonable Maximum Exposure |

| | | |
|---|---|---|
| ROCs | - | Receptors of Concern |
| SARA | - | Superfund Amendments and Reauthorization Act |
| SDWA | - | Safe Drinking Water Act |
| SEM | - | Simultaneously Extractable Metals |
| SLERA | - | Screening Level Ecological Risk Assessment |
| SQL | - | Sample Quantitation Limit |
| SVOC | - | Semi-Volatile Organic Compound |
| TCDD | - | 2,3,7,8-tetrachloridibenzo[p]dioxin |
| TCEQ | - | Texas Commission on Environmental Quality |
| TEF | - | Toxicity Equivalency Factor |
| TNRCC | - | Texas Natural Resource Conservation Commission |
| TPWD | - | Texas Parks and Wildlife Department |
| TRRP | - | Texas Risk Reduction Program |
| TRV | - | Toxicity Reference Value |
| TSCA | - | Toxic Substances Control Act |
| TU | - | Toxic Unit |
| UCL | - | Upper Confidence Limit |
| USACE | - | United States Army Corps of Engineers |
| UTL | - | Upper Trophic Level |
| VOC | - | Volatile Organic Compound |

# 1.0 INTRODUCTION

Conestoga-Rovers & Associates (CRA) and Cardno ENTRIX, on behalf of Chevron Environmental Management Company (CEMC) and Huntsman Petrochemical LLC (Huntsman), submit herein to the United States Environmental Protection Agency (EPA) the Final Feasibility Study (FS) Report for the Star Lake Canal Superfund Site (Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA] Docket No. 06-02-06) located in Jefferson County, Texas (Site). The EPA entered into an Administrative Settlement Agreement and Order on Consent (AOC) for Remedial Investigation/Feasibility Study (RI/FS) with CEMC and Huntsman for the Site on December 22, 2005. The AOC required that a RI/FS be completed for the Site in accordance with relevant EPA Guidance. This submittal is to be used as the basis for the Record of Decision expected subsequently. A vicinity map that shows the location of the Site is included as Figure 1-1.

## 1.1 OBJECTIVE

The RI/FS process represents the methodology for characterization of the nature and extent of risks posed by potential constituents at a site and for evaluation of potential remedial alternatives for the Site. The objective of the FS is to develop and evaluate a number of alternative methods to achieve the remedial action objectives (RAOs) developed for the Site. The process facilitates proposal of a selected remedy that most appropriately eliminates, reduces, or controls risks to human health and the environment. The FS process includes several steps outlined in EPA guidance including:

- Summary of the results of the RI, the Human Health Risk Assessment (HHRA), the Baseline Ecological Risk Assessment (BERA), and refinement of the conceptual site model (CSM), as necessary
- Establish RAOs and associated preliminary remediation goals
- Identify and screen remedial technology types, general response actions, and specific process options based on Site conditions and constraints
- Assemble the technology types and process options into remedial alternatives and complete screening of remedial alternatives
- Complete a detailed evaluation and comparative analysis of remedial alternatives and recommend a preferred remedy

Preparation and completion of the FS work was consistent with, but not limited to, the following EPA guidance:

- *USEPA Contaminated Sediment Remediation Guidance for Hazardous Waste Sites*, EPA/540/R-05/012, December 2005
- *USEPA Interim Final, Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*, EPA/540/G-89/004, October 1988
- *USEPA Guidance for Conducting Treatability Studies Under CERCLA,* EPA/540/R-92/071a, October 1992
- *USEPA and USACE A Guide to Developing and Documenting Cost Estimates During the Feasibility Study,* EPA/540/R-00/002, July 2000

## 1.2 SITE DESCRIPTION

The location of the Site is shown on the vicinity map included as Figure 1-1 and an aerial photograph included as Figure 1-2. The Site includes the two industrial canals (Star Lake Canal and Jefferson Canal) and the adjacent wetlands. Molasses Bayou is located southeast of the Star Lake Canal and intersects the canal at two locations. Gulf States Utility Canal is a canal that was excavated during the placement of a utility line and is located approximately 100 feet northwest of Star Lake Canal. Gulf States Utility Canal extends parallel to Star Lake Canal from northeast of Atlantic Road to the Neches River.

Star Lake Canal and Jefferson Canal are used by nearby industries for permitted discharge of industrial effluents. Historical unpermitted and permitted discharges have resulted in the deposition of potentially hazardous constituents at the Site.

In general, the areas of investigation (AOIs) as discussed in the FS are defined as those areas contiguous to and including potentially impacted media at the Site. During the RI, the Site was divided to include a total of nine AOIs including Star Lake Canal, Former Star Lake, Gulf States Utility Canal, Molasses Bayou Upstream Watercourse, Molasses Bayou Downstream Watercourse, Molasses Bayou Wetland, Jefferson Canal Upstream, Jefferson Canal Downstream, and Jefferson Canal Spoil Piles. The RI sediment, surface water, soil, and biological tissue sample analytical results were used to determine the preliminary nature and extent of the impact at the Site and to delineate AOIs based on areas that require further evaluation. For the FS, the Site is divided into seven AOIs including Jefferson Canal, Jefferson Canal Spoil Pile, Former Star Lake, Star Lake Canal, Gulf States Utility Canal, Molasses Bayou Waterway, and Molasses Bayou Wetland. The

Site AOIs are shown on Figure 1-3. A topographic survey map of Jefferson Canal Spoil Pile is included as Figure 1-4.

Figure 1-5 shows several pipelines that run south to north through the Jefferson Canal Spoil Pile. These pipelines were considered during the evaluation of all remedial alternatives for the Jefferson Canal Spoil Pile AOI in this FS submittal.

## 1.3 SITE HISTORY

Industrial operations have occurred in areas surrounding the Site since the early 1940s. Initial construction of industrial facilities occurred under the direction of the United States government during World War II, and subsequent operations have continued through the present. Wastewater effluents from these operations were routed to the Site. Jefferson Canal and Star Lake Canal were excavated in the late 1940s to receive stormwater and industrial wastewater.

In approximately February 1983, the Jefferson County Drainage District Number 7 (DD #7) dredged Jefferson Canal by dragline after acquiring an easement on the canal from Texaco Chemical Company (TCC). The DD #7 deposited dredged materials onto the banks of Jefferson Canal in and around an area north of FM Road 366. The deposited dredged material was subsequently determined to be impacted with potentially hazardous constituents. The approximate location of the dredged material is shown on Figure 1-2 of the *Tier 1 RI Report*.

Chevron is currently the parent corporation of Texaco Inc. as a result of a merger in October 2001. Texaco Inc. was the parent corporation of TCC until TCC was sold to Huntsman in April 1994. TCC was a successor in interest to various entities that operated what are now called the C4 and Oxides and Olefins (O&O) Plants in Port Neches, Texas, and which owned all or part of Star Lake Canal and Jefferson Canal.

Huntsman is the current owner of a significant portion of Star Lake Canal and a portion of Jefferson Canal. Huntsman acquired ownership in April 1994 when it purchased TCC. As a result of that acquisition, Huntsman also acquired the C4 and O&O Plants in Port Neches. Ameripol Synpol Corporation (Ameripol) is the current owner of a portion of the west-to-east segment of Star Lake Canal.

Property adjacent to and near the Site is owned by various individuals, companies, and agencies. Figure 1-6 shows an outline of the property parcels and lists the property

owner, acreage, address, and owner location for each parcel. Over the years, numerous other industrial facilities have conducted operations that have had potential adverse impacts to Star Lake Canal, Jefferson Canal and the Site.

Texas enforcement investigations conducted during the 1970s focused on laboratory detections of pentachlorophenol and toxaphene constituents in Jefferson Canal. Enforcement action in 1983 identified that sediments impacted with toxaphene may have been dredged from the canal and placed on its banks. In 1983, an analytical report from a single sample of disposed dredged material revealed concentrations of toxaphene, acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(p)pyrene, benzo(b)fluoranthene, chrysene, fluoranthene, fluorene, naphthalene, phenanthrene, pyrene, and biphenyls above the laboratory sample quantitation limits.

On March 21 and March 23, 1983, the Texas Department of Water Resources (TDWR) collected sediment samples from Jefferson Canal, and dredged spoil samples from the banks of Jefferson Canal, and made observations on rainfall and runoff from the dredged materials. Samples were noted to have a strong aromatic odor characteristic of phenolic compounds. The TDWR inspection also revealed rainfall and runoff from dredged materials along the Jefferson Canal bank entering Jefferson Canal. A further review of state records indicated that sampling of dredged materials from Jefferson Canal sediments documented the presence of concentrations of polycyclic aromatic hydrocarbons (PAHs) including naphthalene, acenaphthene, acenaphthylene, fluorene, phenanthrene, anthracene, pyrene, benzo(a)anthracene, benzo-b-fluoranthene, benzo(a)pyrene, benzo-a-fluoranthene, and chrysene at concentrations above the laboratory sample quantitation limits. Soil samples on property adjacent to Jefferson Canal were found to contain toxaphene and possibly pentachlorophenol at concentrations above the laboratory sample quantitation limits.

A Texas Natural Resources Conservation Commission (TNRCC) [presently Texas Commission on Environmental Quality (TCEQ)] Screening Site Inspection (SSI) Report of Star Lake Canal, dated September 1997, indicated that the following constituents were detected in samples collected from Jefferson and Star Lake Canals above the laboratory sample quantitation limit: acenaphthene, acenaphthylene, anthracene, arsenic, barium, benzo(b)fluoranthene, benzo(k)fluoranthene, cyanide, fluoranthene, fluorene, mercury, 2-methylnaphthalene, naphthalene, aroclor-1254 (a polychlorinated biphenyl [PCB]), phenanthrene, pyrene, and thallium. A Table of organic constituents in the samples contained a hand-written entry that indicated that benzo(a)anthracene, chrysene, and benzo(a)pyrene were also detected.

A TNRCC (presently TCEQ) Expanded Site Inspection (ESI) Report for the Star Lake Canal Site, dated January 1999, indicated that samples showed detections of other constituents not listed in the 1997 SSI report, including: acetone, aldrin, benzene, benzo(g,h,i)pyrelene, chromium, copper, 4,4'-DDD, endosulfan I, ethylbenzene, heptachlor epoxide, indeno(1,2,3-cd)pyrelene, selenium, silver, styrene, toluene, and total xylenes. However, arsenic, barium, cyanide, and mercury previously reported in the 1997 SSI report were not reported in the ESI.

On July 22, 1999, the EPA proposed the addition of the Star Lake Canal Site to the National Priority List (NPL). On August 28, 2000, and pursuant to Section 105 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, 42 U.S.C. § 9605) the Site was added to the NPL (40 C.F.R. Part 300, App. B). On December 22, 2005, the AOC was signed by the EPA, CEMC and Huntsman.

## 1.4 REPORT ORGANIZATION

The methods and procedures contained in this Final FS Report describe activities that were conducted during the FS. The remainder of this Final FS Report is organized into seven sections:

- **Section 2.0 – Project Summary -** This section includes a timeline of events for the project and a summary of the results of the Tier 1 and Tier 2 RIs. In addition, this section includes a summary of the Alignment Document and the Sensitivity Analysis completed in preparation for the FS scoping.
- **Section 3.0 – Identification and Screening of Technologies –** This section includes identification of the Remedial Action Objectives (RAOs), Applicable or Relevant and Appropriate Requirements (ARARs), COCs, Preliminary Remediation Goals (PRGs), and general response actions for the FS. This section also includes the screening of potential technology types and process options against effectiveness, implementability, and cost.
- **Section 4.0 –Evaluation of General Response Actions and Development of Remedial Action Alternatives-** This section describes methods and procedures used to assemble the selected general response actions and prepare remedial action alternatives for each AOI.
- **Section 5.0 – Detailed Analysis of Remedial Action Alternatives -** This section describes the process used to further refine the remedial action alternatives and a detailed analysis of the alternatives with respect to the nine evaluation criteria.

- **Section 6.0 - Cost -** This section provides a detailed cost estimate for each of the remedial alternatives within each AOI.
- **Section 7.0 – Comparative Analysis of Remedial Alternatives -** This section presents the comparative analysis of the remedial alternatives for each of the seven AOIs of the Site to identify the advantages and disadvantages of each remedial alternative relative to one another within an AOI, and provide key information for use in determination of the selected remedy.
- **Section 8.0 - References -** A list of all references is provided in this section.

In addition, the Final FS Report is supported by figures, tables, and an appendix.

## 2.0 PROJECT SUMMARY

The following section provides a timeline of events for the project starting in 2008 and a summary of the results of the Tier 1 and Tier 2 RIs. In addition, this section includes a summary of the Alignment Document and Sensitivity Analysis completed in preparation for the FS scoping.

### 2.1 TIMELINE OF EVENTS

The Draft Tier 2 RI Work Plan was submitted to the EPA, the TCEQ, and the trustee group on May 16, 2008. CEMC, Huntsman, CRA, and Cardno ENTRIX participated in a meeting with the EPA, the TCEQ, and the trustee group to discuss the Draft Tier 2 RI Work Plan at the TCEQ offices in Austin, Texas on June 5, 2008. The EPA, TCEQ, and the trustee group submitted review comments on the Draft Tier 2 RI Work Plan to CEMC and Huntsman on June 20, 2008. Supplemental information including residential property boundary maps, Federal Emergency Management Agency (FEMA) flood plain maps, and documentation of institutional controls at the Site was submitted to the EPA, TCEQ, and the trustee group on July 11, 2008. Responses to the Draft Tier 2 RI Work Plan comments were submitted to the EPA, TCEQ, and the trustee group on July 31, 2008. A Revised Draft Tier 2 RI Work Plan was submitted to the EPA and the trustees on August 22, 2008. The EPA, TCEQ, and the trustee group submitted review comments on the Revised Draft Tier 2 RI Work Plan on September 23, 2008, September 26, 2008, October 30, 2008, and November 3, 2008. CEMC and Huntsman submitted responses to the review comments on October 15, 2008, and November 18, 2008. A Revised Draft Tier 2 RI Work Plan Addendum, that included additional revisions based on the review comments, was submitted to the EPA, TCEQ, and the trustee group on January 23, 2009. The EPA, TCEQ, and the trustee group submitted review comments on the Revised Draft Tier 2 RI Work Plan Addendum on February 27, 2009. The EPA submitted an approval letter for the Tier 2 RI Work Plan to CEMC on March 9, 2009. On March 13, 2009, CEMC and Huntsman submitted comment responses and the Final Tier 2 RI Work Plan that incorporated all previous revisions was submitted to the EPA, TCEQ, and the trustee group on May 15, 2009.

A Tier 2 RI Work Plan Addendum (Jefferson Canal Spoil Pile Investigation) that outlined the scope of work for the investigation and evaluation of the spoil piles identified on the bank of Jefferson Canal was submitted to the EPA, TCEQ, and the trustee group on October 16, 2009. The EPA, TCEQ, and the trustee group submitted review comments on November 5, 2009, and November 18, 2009. CEMC and Huntsman

submitted review comment responses in a correspondence dated December 8, 2009. On February 22, 2010, CEMC and Huntsman requested an extension of the project schedule for completion of the spoil pile investigation prior to submittal of the Draft Tier 2 RI Report. The schedule extension request included a revised submittal date of September 10, 2010. The EPA approved the schedule extension request in an email dated March 1, 2010.

The Tier 2 RI sediment, surface water, soil, and tissue sample collection activities were completed from April 2009 through April 2010. The Draft Tier 2 RI Report was submitted in September 2010. The EPA, TCEQ, and the trustee group submitted review comments on the Draft Tier 2 RI Report in December 2010 and February 2011. On February 15, 2011, a meeting was held between the EPA, CEMC, and Huntsman. The Final Tier 2 RI Report was submitted on April 21, 2011. On June 2, 2011, the EPA issued review comments on the Final Tier 2 RI Report to CEMC and Huntsman and responses to the review comments were submitted by email on June 17, 2011. On July 13, 2011, CEMC and Huntsman submitted a hard copy of the revised pages of the Final Tier 2 RI Report. An electronic copy of the entire Final Tier 2 RI Report with the incorporated revisions was submitted on July 13, 2011. On July 22, 2011, the EPA submitted review comments on the revised pages of the Final Tier 2 RI Report. CEMC and Huntsman submitted responses to the review comments by email on July 29, 2011. The EPA approved the Tier 2 RI Report in a letter dated November 9, 2011.

Concurrent with the Tier 2 Report process, CEMC and Huntsman submitted the Alignment Document on June 17, 2011. During the meeting on February 15, 2011, CEMC agreed to prepare a document that would define those areas within the Site that might contribute the most significant amount of risk to upper trophic level receptors instead of referring to risk across the entire Site. Following submittal of the Alignment Document, a remediation scenario sensitivity analysis was conducted to evaluate the contributions of the various soil and sediment sample areas to overall Site risk.

Representatives of EPA, TCEQ, CEMC, Huntsman, CRA, Cardno ENTRIX, and the trustee group participated in FS scoping meetings/conference calls on June 28, 2011, August 31, 2011, September 14, 2011, October 13, 2011, and November 9, 2011 at the EPA offices in Dallas, Texas and by telephone. The meetings/conference calls included discussion of the Final Tier 2 RI Report, the Alignment Document, the remediation scenario sensitivity analysis, the project schedule, and the FS Work Plan.

In a letter dated December 5, 2011, the EPA requested that preliminary remedial alternatives be developed to address Scenarios 10b and 11b developed during the

sensitivity analysis. The EPA also requested a project schedule to include completion of the Draft FS by March 31, 2012. On December 29, 2011, CEMC and Huntsman submitted a preliminary evaluation of remedial alternatives to the EPA. The correspondence included a summary of the proposed scope of work and schedule for completion of the FS. On December 29, 2011, CEMC and Huntsman submitted a preliminary evaluation of remedial alternatives to the EPA. This evaluation included a summary of the proposed scope of work and schedule for completion of the FS.

On January 27, 2012, CRA on behalf of CEMC and Huntsman submitted the Draft FS Work Plan to the EPA, in accordance with the proposed project schedule dated December 29, 2011. On February 3, 2012, a letter received from the EPA requested a meeting with representatives of CEMC and Huntsman at the Region 6 office in Dallas to discuss the proposed alternatives and required submittal of the Draft FS by April 16, 2012. A letter dated February 24, 2012 was received from the EPA for clarification on dates for completion of the Draft FS and the March 1, 2012 submittal of remedial alternatives that will be evaluated in the Final FS. On March 1, 2012, Chevron and Huntsman submitted the Preliminary Evaluation of Remedial Alternatives and a schedule for the FS to the EPA. These documents were submitted in response to the EPA letters dated February 3 and February 24, 2012. On March 9, 2012, CRA and Cardno ENTRIX, on behalf of Chevron and Huntsman, submitted Draft PRGs to the EPA for review. Representatives of EPA, TCEQ, CEMC, Huntsman, CRA, Cardno ENTRIX, and the trustee group participated in an FS meeting/conference all on March 19, 2012, at the EPA offices in Dallas, Texas, to discuss the March 1, 2012, and March 9, 2012, submittals.

The Draft FS Report was submitted to the EPA, TCEQ, and the trustee group on April 16, 2012. The EPA issued review comments on the Draft FS Report by email on May 4, 2012. The email included review comments from the EPA, the TCEQ, and the trustees. CEMC, Huntsman, CRA, and Cardno ENTRIX participated in a conference call with EPA, TCEQ, and the trustee group to discuss the agency comments on the Draft FS Report on May 15, 2012. A table that outlines the Draft FS Report agency review comments, responses, and a report revision reference is included in Appendix A of this Final FS Report.

## 2.2 REMEDIAL INVESTIGATION SUMMARY

The following sections provide a summary of results for the Tier 1 and Tier 2 RIs, presents an ecological CSM and a human health CSM for the Site, and summarizes the findings of the HHRA and the BERA.

### 2.2.1 TIER 1 RI SAMPLE COLLECTION SUMMARY

The Tier 1 RI sediment and surface water sample locations are shown on Figure 2-1.

***Surface Water***

A total of 31 surface water samples were collected from the Site at 31 sample locations, 8 samples from Star Lake Canal, 7 samples from Jefferson Canal, 3 samples from Gulf States Utility Canal, and 13 samples from Molasses Bayou.

***Sediment***

A total of 104 sediment samples were collected from the Site at 54 locations, 27 samples from 9 locations in Star Lake Canal, 21 samples from 7 locations in Jefferson Canal, 9 samples from 3 locations in Gulf States Utility Canal, and 47 samples from 35 locations in Molasses Bayou.

Surface sediment samples represent the top six inches of sediment and were collected in areas that may have accumulated re-suspended sediment and/or erosion materials and represent a less dynamic erosion/sedimentation system. Mid and refusal depth sediment samples represent the middle and bottom six inches of sediment, respectively. Mid-depth and refusal depth sediment samples were obtained where significant inflows and a more dynamic erosion/sedimentation system have the potential to bring in large volumes of water possibly laden with erosional material and where historical surface sediment sample collection revealed detectable concentrations of constituents. Surface, mid-depth, and refusal depth sediment samples were collected from all locations in Star Lake Canal, Jefferson Canal, and Gulf States Utility Canal. Surface sediment samples were collected from 35 locations throughout Molasses Bayou. Mid-depth and refusal depth sediment samples were collected from six locations, MB-1, MB-18, MB-21, MB-24, MB-27, and MB-28 in Molasses Bayou.

***Soil***

A total of four soil samples were collected from the Site at four locations along the western bank of Jefferson Canal. The soil samples were collected along the western bank of Jefferson Canal between the Lower Neches Valley Authority (LNVA) Canal and the Star Lake Canal in the area where dredged material spoil piles had been identified in the previous investigations. Tier 1 RI soil sample locations are shown on Figure 2-3.

### 2.2.2 TIER 2 RI SAMPLE COLLECTION SUMMARY

This section provides a detailed summary of the samples collected during the Tier 2 RI. The Tier 2 RI sediment and surface water sample locations are shown on Figure 2-2.

***Surface Water***

A total of 34 surface water samples were collected from the Site at 34 sample locations during the Tier 2 RI, 2 samples from Star Lake Canal, 7 samples from Gulf States Utility Canal, 7 samples from Molasses Bayou Upstream, 5 samples from Molasses Bayou Downstream, 7 samples from Jefferson Canal Upstream, and 6 samples from Jefferson Canal Downstream AOIs.

Surface water samples were collected at two locations, SLC-10 and SLC-11, in Star Lake Canal, on April 8, 2009, and April 14, 2009, respectively. Surface water samples were collected from seven locations, GSUC-4 through GSUC-10, in Gulf States Utility Canal on April 14 and 15, 2009, respectively. Surface water samples were collected from seven locations, MB-49, MB-52, MB-53, MB-54, MB-57, MB-60, and MB-61, in the Molasses Bayou Upstream Watercourse AOI on April 8, 2009, and April 15, 2009. Surface water samples were collected from five locations, MB-36 and MB-43 through MB-46, in the Molasses Bayou Downstream Watercourse AOI on April 15 and 16, 2009. Surface water samples were collected from four locations, JC-18 through JC-21, in Jefferson Canal Upstream AOI on April 16 and 17, 2009. In addition, surface water samples were collected from three locations, JC-22 through JC-24, in the stormwater conveyance within the Huntsman PNPP facility on April 16, 2009. Surface water samples were collected from six locations, JC-12 through JC-17, in Jefferson Canal Downstream AOI on April 16, 2009.

***Sediment***

A total of 154 sediment samples were collected from the Site at 64 locations during the Tier 2 RI, 6 samples from 2 locations in Star Lake Canal, 30 samples from 10 locations in Former Star Lake, 29 samples from 9 locations in Gulf States Utility Canal, 23 samples from 8 locations in Molasses Bayou Upstream Watercourse, 15 samples from 7 locations in Molasses Bayou Downstream Watercourse, 14 samples from 14 locations in Molasses Bayou Wetland, 23 samples from 8 locations in Jefferson Canal Upstream, and 30 samples from 10 locations in Jefferson Canal Downstream AOIs.

Surface (0- to 6-inch) sediment samples represent the top six inches of sediment and were collected in areas that may have accumulated re-suspended sediment and/or erosion materials and represent a less dynamic erosion/sedimentation system. The 6- to 12-inch and 12- to 18-inch sediment samples represent the middle and bottom six inches

of sediment, respectively. The 6- to 12-inch and 12- to 18-inch sediment samples were obtained where significant inflows and a more dynamic erosion/sedimentation system have the potential to bring in large volumes of water possibly laden with erosional material and where historical surface sediment sample collection revealed detectable concentrations of constituents. In addition, 12- to 18-inch and 18- to 24-inch sediment samples were collected to provide vertical delineation of impacted sediment at several locations across the Site.

The 0- to 6-inch, 6- to 12-inch, and 12- to 18-inch sediment samples were collected from Star Lake Canal in 2 locations, SLC-10 and SLC-11, on April 8 and 14, 2009. The 0- to 6-inch, 6- to 12-inch, and 12- to 18-inch sediment samples were collected from Former Star Lake in 10 locations, SL-1 through SL-10, on April 7 and 8, 2009. The 0- to 6-inch, 6- to 12-inch, and 12- to 18-inch sediment samples were collected from 7 locations, GSUC-4 through GSUC-10, and 12- to 18-inch and 18- to 24-inch sediment samples were collected from GSUC-2R and GSUC-3R in Gulf States Utility Canal on April 6, 2009. The 0- to 6-inch, 6- to 12-inch, and 12- to 18-inch sediment samples were collected from seven sample locations, MB-49, MB-52, MB-53, MB-54, MB-57, MB-60, and MB-61, and 12- to 18-inch and 18- to 24-inch sediment samples were collected from one location, MB-18R, in Molasses Bayou on April 6 and 7, 2009. Three 0- to 6-inch sediment samples were collected from three sample locations, MB-39, MB-42, and MB-46, and the 0- to 6-inch, 6- to 12-inch, and 12- to 18-inch sediment samples were collected from four sample locations, MB-36, and MB-43 through MB-45, in Molasses Bayou on April 7 and 8, 2009. Fourteen 0- to 6-inch sediment samples were collected from 14 sample locations, MB-37, MB-38, MB-40, MB-41, MB-47, MB-48, MB-50, MB-51, MB-55, MB-56, MB-58, MB-59, MB-62, and MB-63 in the Molasses Bayou Wetland AOI on April 7, 2009. The 0- to 6-inch, 6- to 12-inch, and 12- to 18-inch sediment samples were collected from four locations, JC-18 through JC-21, and 12- to 18-inch and 18- to 24-inch sediment samples were collected from one location, JC-5R, in Jefferson Canal on April 14 through April 16, 2009. In addition, 9 sediment samples (3 samples from 3 locations) were collected from the stormwater conveyance within the Huntsman PNPP facility. The 0- to 6-inch, 6- to 12-inch, and 12- to 18-inch sediment samples were collected from three locations, JC-22 through JC-24, in the most upstream portion of Jefferson Canal, in the stormwater conveyance within the Huntsman PNPP facility, on April 16, 2009. The 0- to 6-inch, 6- to 12-inch, and 12- to 18-inch sediment samples were collected from four locations, JC-1 through JC-4, in Jefferson Canal on October 18 and 19, 2006. The 0- to 6-inch, 6- to 12-inch, and 12- to 18-inch sediment samples were collected from six locations, JC-12 through JC-17, in Jefferson Canal on April 9, 2009.

***Soil***

A total of 104 samples were collected from 25 soil borings installed in and around the spoil pile material in the Jefferson Canal Spoil Pile AOI on April 21 through 27, 2010. A total of eight borings, JCSP-1 through JCSP-8, were installed in the identified spoil material to a depth of approximately 60 inches (five feet) below the typical ground surface. Samples were collected from each of the spoil material borings from a location within the spoil material, at depth intervals of 0 to 6 inches, 6 to 12 inches, 12 to 24 inches, and at the total depth of the boring (54 to 60 inches) bgs. A total of 17 soil borings (JCSP-9 through JCSP-25) were installed in areas around the perimeter of the identified spoil material to a depth of approximately 60 inches (5 feet) bgs for delineation of the horizontal extent of potential soil impact from the spoil material. Samples were collected from each of the perimeter borings at depth intervals of 0 to 6 inches, 6 to 12 inches, 12 to 24 inches, and 54 to 60 inches bgs.

Additional sample intervals were collected at four soil boring locations based on material characteristics and stratigraphy. Borings JCSP-3, JCSP-12, JCSP-21, and JCSP-24 were advanced to depths of 20, 15, 20, and 25 feet, respectively, based on visual observations at the time of sample collection. In addition, one geotechnical soil boring (GT-2 [0 to 5 feet]) was installed at a location in the spoil material and one geotechnical soil boring (GT-1 [0 to 5 feet]) was installed in an area around the perimeter of the identified spoil material to identify material characteristics. Tier 2 RI soil sample locations are shown on Figure 2-3.

***Tissue***

The biological tissue investigation included collection of 40 tissue samples for use in the HHRA and 70 tissue samples for use in the BERA. Tissue samples were collected under the Texas Parks and Wildlife Department (TPWD) Scientific Research Permit Number SPR-0808-313. The Tier 2 RI biological tissue sampling included collection of 110 fish tissue composite samples from locations across the Site that were accessible by human or watercraft and that represented reasonable habitats for the target species. The biological tissue sample collection activities were completed from April through October 2009.

Fish tissue samples collected for use in the HHRA were collected from the open-channel, fishable portions of Star Lake Canal and Molasses Bayou. Tissue samples collected for use in the BERA were from areas throughout the Site that represented likely habitats for the Receptors of Concerns (ROCs) and their prey.

Approximately half of the pelagic fish tissue samples (PELFISH-01 through PELFISH-05) consisted of spotted gar (*Lepisosteus oculatus)* and were collected from Star Lake Canal

just downstream of the dam. The remaining portion of the pelagic fish tissue samples (PELFISH-11 through PELFISH-13, PELFISH-15, and PELFISH-17) consisted of black drum (*Pogonias cromis*), red drum (*Sciaenops ocellatus*), and spotted sea trout (C*ynoscion nebulosus*) and were collected from the most downstream portion of Star Lake Canal at its confluence with the Neches River. Bottom feeding fish samples were collected primarily from Star Lake Canal and portions of Molasses Bayou at its confluence with Star Lake Canal. The bottom feeding fish samples (BOTFISH-1, BOTFISH-02, BOTFISH-04, and BOTFISH-06 through BOTFISH-10) consisted of hardhead catfish (*Arius felis)*. In addition, bottom feeding fish samples (BOTFISH-03 and BOTFISH-05) consisted of southern flounder (*Paralichthys lethostigma)*. Shellfish samples were collected primarily from Star Lake Canal and portions of Molasses Bayou. Shellfish samples (CRAB-01 TISSUE through CRAB-10 TISSUE) consisted entirely of blue crab (*Callinectes sapidus*). Additional shellfish samples (CRAB-01 HEP through CRAB-10 HEP) collected for analysis of the hepatopancreas tissue were also collected primarily from Star Lake Canal and portions of Molasses Bayou and consisted entirely of blue crab.

Ecological fish tissue samples were collected primarily from Star Lake Canal, Gulf States Utility Canal and Molasses Bayou. Ecological fish were collected in two size ranges (1 to 6 inches) and (6 to 12 inches) to assess potential risk various feeding guilds. Ecological fish tissue samples (ECO-FISH(1-6)-01 through ECO-FISH(1-6)-10) consisted of composites of croaker (*Micropogonias undulatus*), and other species including fathead minnow (*Pimephales promelas)* and gulf menhaden (*Brevoortia patronus*) Ecological fish tissue samples (ECO-FISH[6-12]-01 through ECO-FISH[6-12]-10) consisted primarily of striped mullet *(Mugil cephalus*). Ecological shellfish samples were collected primarily from Star Lake Canal and portions of Molasses Bayou at its confluence with Star Lake Canal. Shellfish samples (ECO-CRAB-01 through ECO-CRAB-10) consisted entirely of whole body blue crab (*Callinectes sapidus*). Blue crab for the ecological evaluation were not subject to the 5 inch width regulation and were collected in the same manner as the HHRA crab tissue samples.

Terrestrial and aquatic emergent insect samples (ECO-INSECT-01 through ECO-INSECT-10) were collected from both upland and wetland areas throughout the Site. The majority of insect samples were collected on the upland areas in and around Star Lake Canal, Molasses Bayou, and downstream Jefferson Canal. Insect samples were collected using light traps. Vegetation samples (ECO-VEG-01 through ECO-VEG-10) included alligator weed (*Alternanthera philoxeroides*) were collected throughout the Site in wetland and fringe areas. Terrestrial invertebrates (ECO-WORM-01 through ECO-WORM-04 and ECO-WORM-06 through ECO-WORM-11) samples were collected primarily from the spoil pile area near the downstream portion of Jefferson Canal. The

terrestrial invertebrate samples consisted entirely of earthworms (*Lumbricus terrestris)*. The ecological amphibian samples (ECO-FROG-01 through ECO-FROG-10) consisted entirely of frogs, with the majority being bullfrogs (*Rana catesbiena*), that were collected primarily from the downstream portion of Jefferson Canal and portions of Molasses Bayou.

Mussels and other mollusks were not available at the Site for sample collection. Several attempts were made to collect these species in their suitable habitats, but no tissue samples were able to be collected.

### 2.2.3 CONCEPTUAL SITE MODEL

This section identifies and discusses the constituent fate and transport mechanisms at the Site and the various potential human and ecological exposure pathways to the constituents. A CSM of constituent fate and transport to ecological receptors is presented on Figure 2-4. A CSM of constituent fate and transport to human receptors is presented on Figure 2-5. As shown on the figures, historical discharges from surrounding industry are the primary source of potential impact at the Site. Constituents were discharged to surface water and sediments in both Jefferson Canal and Star Lake Canal and subsequently to other areas and environmental media within the Site by various transport mechanisms including sediment re-suspension, surface water transport, dredging sediment, and erosion of sediment spoil piles.

The different exposure pathways for general groups of potential receptors chosen for this RI are shown on Figure 2-4 and Figure 2-5**.** Potential ecological receptors include shorebirds, waterfowl, songbirds, mammals, reptiles and amphibians, fish, and terrestrial and aquatic invertebrates. Potential human receptors that may use portions of the Site include recreational users, industrial workers, fishermen/shell fishers, and trespassers.

All the AOIs at the Site are accessible via navigable waterways, with the exception of the upstream portion of Jefferson Canal. Therefore, a recreational user was considered as a potential human receptor in the Star Lake Canal, Former Star Lake, Gulf States Utility Canal, Molasses Bayou Upstream, Downstream, and Wetland, and Jefferson Canal Downstream AOIs. A trespasser was considered as a potential human receptor in the Jefferson Canal Upstream AOI. The Site is not considered public property available for access by the general public; however, because it is potentially accessible for use by the public, a recreational use exposure scenario was considered the most appropriate.

Industrial worker populations that utilize the Site could not be identified. Huntsman personnel confirmed that they do not use the portions of Jefferson Canal Downstream, Star Lake Canal, Former Star Lake, and Gulf States Utility Canal AOI on the Huntsman property. Without an identified industrial worker population, an exposure frequency for an industrial worker in these AOIs could not be estimated and human health risk estimates could not be calculated. An industrial worker exposure scenario was considered for the Jefferson Canal Upstream AOI to account for the portion of the AOI in the stormwater conveyance in the Huntsman PNPP facility. An industrial worker exposure scenario was also considered for the Jefferson Canal Spoil Pile AOI to account for any pipeline or water control maintenance activities that may take place in that area. A recreational user was considered as a conservative potential receptor substitute for any potential industrial workers in the Star Lake Canal, Former Star Lake, Gulf States Utility Canal, Molasses Bayou Upstream, Downstream, and Wetland, and Jefferson Canal Downstream AOIs.

#### 2.2.3.1 BANK SOIL

Bank (upland) soil is restricted to areas where dredged material from Jefferson Canal was deposited and remains.

Ecological exposure pathways include potential uptake by terrestrial plants and insect dietary items and incidental ingestion by some of the ROCs including song birds and mammals.

***Jefferson Canal Spoil Pile AOI***

Impacted sediment was dredged from Jefferson Canal and the spoils were placed in an upland area (bank soil) bordering the western portion of the canal. Erosion of these upland dredged soils is considered a secondary source of potential surface water and canal sediment impact. The lowest of the TCEQ Texas Risk Reduction Program (TRRP) Tier 1 Commercial/Industrial Soil Protective Concentration Levels (PCLs) for a 30 acre source area were used to evaluate surface soil in the Tier 1 and 2 RI. The Tier 1 Commercial/Industrial Soil PCLs include ingestion, dermal contact, inhalation of volatiles and particulates, ingestion of above-ground and below-ground vegetables ($^{Tot}Soil_{Comb}$), and inhalation of volatile emissions from constituents of concern (COCs) in subsurface soil ($^{Air}Soil_{Inh-V}$). The PCLs for soil-to-groundwater leaching to class 1 and 2 groundwater ($^{GW}Soil_{Ing}$), soil-to-groundwater leaching for volatilization ($^{Air}GW\text{-}Soil_{Inh-V}$) were not evaluated during the screening of the soil data. The Huntsman PNPP facility

plans to prohibit the use of groundwater on their property. Huntsman will impose a deed restriction on their property that restricts groundwater use for any purpose. The Huntsman property boundary is shown on Figure 7-3 of the *Tier 2 RI Report*. Subsurface soil data was collected only during the Tier 2 RI. Human exposure pathways for bank soil include potential incidental ingestion, dermal contact, and inhalation by industrial workers at the Site.

#### 2.2.3.2 AIR

Evaporation of volatile constituents and particulates from bank soil is considered a potential route of exposure in the CSM. The potential inhalation of bank soil volatile emissions by recreational users, industrial workers, and trespassers is discussed above. Based on the Tier 1 and 2 RI surface water sample data, the evaporation of volatile constituents from surface water exposure pathway is considered incomplete in the CSM for all AOIs.

The pathway is considered potentially complete, but not evaluated for ecological receptors as inhalation of such constituents by burrowing mammals is not expected to be an ecologically significant exposure pathway. Potential inhalation of dust particles by wildlife has been estimated to contribute less than 0.1% of total risk compared to risk from oral exposures (USEPA 2005).

#### 2.2.3.3 GROUNDWATER

Huntsman is currently conducting a groundwater corrective action monitoring program at the PNPP facility. The objective of the groundwater corrective action monitoring program is to document the existing groundwater plume geometry and monitor the effectiveness and progress of naturally occurring biodegradation processes that are attenuating and degrading the COCs in the groundwater within the two uppermost water-bearing zones beneath the facility.

As part of the Tier 1 and Tier 2 RI, the potential communication between groundwater beneath the Huntsman facility and the surface water in the upstream portions of Star Lake Canal and Jefferson Canal was evaluated to determine if the existing groundwater plume beneath the Huntsman facility represents a continuing source of impairment to sediment and surface water in Star Lake Canal and Jefferson Canal. (Section 10.0 of the *Tier 2 RI Report*)

Groundwater to sediment and surface water exposure pathways are potentially complete as the groundwater impact related to the Huntsman facility is adjacent the Star Lake Canal Superfund Site; however, the related risk assessment of the groundwater exposure pathways (inhalation, ingestion, and dermal contact) is currently being evaluated under TCEQ's Corrective Action Program as part of the Huntsman Site-Wide Groundwater investigation. In addition, the potential groundwater to surface water interaction identified in both Star Lake Canal and Jefferson Canal in the RI has not resulted in identification of constituents in surface water or sediment that pose unacceptable human health or ecological risk. Details regarding the investigation and risk assessment conducted as part of the Huntsman Site-Wide Groundwater Corrective Action Monitoring Program are detailed in Section 10.3 of the *Tier 2 RI Report* and an evaluation of the groundwater, surface water, and sediment constituents is presented in Section 10.4 of the *Tier 2 RI Report*.

#### 2.2.3.4 CANAL SEDIMENT

The historical discharge from surrounding industry was the primary source of impact to the canal sediment in both Star Lake Canal and Jefferson Canal. Sediment is defined in the CSM as a substrate that is partially or permanently inundated with water, including canal and wetland sediment. Canal sediment is considered to be permanently inundated with water as in Star Lake Canal, Jefferson Canal, and Gulf States Utility Canal watercourses.

Potential exposure pathways for ecological receptors include uptake by aquatic invertebrate and fish dietary items and direct ingestion.

***Star Lake Canal***

EPA Region 4 Risk Assessment Guidance for Superfund (RAGS) Human Health Risk Assessment Bulletin states that "in most cases it is unnecessary to evaluate human exposures to sediments covered by surface water" (*USEPA. 2000. Supplemental Guidance to RAGS: Region 4 Bulletins, Human Health Risk Assessment Bulletins. EPA Region 4, originally published November 1995, Website version last updated May 2000*). Canal sediment in the Star Lake Canal watercourse is considered to be covered by surface water at all times, therefore ingestion and dermal contact exposure pathways to all human receptors in this AOI is considered incomplete. However, the Tier 1 and 2 RI sediment data was compared to the TCEQ TRRP sediment Protective Concentration Levels (PCLs) (protective of dermal contact and ingestion by a recreational user) during the human

health screening evaluation, as a conservative measure to identify potential constituents that may require further investigation. The Star Lake Canal Tier 1 and Tier 2 RI sediment data were compared to the sediment PCLs protective of dermal contact and ingestion during the human health screening evaluation, but the pathway will be considered incomplete as identified on the CSM in the risk calculations for the HHRA. Ingestion by fish/shellfish consumption for a fisher/shellfisher in Star Lake Canal is considered complete.

***Gulf States Utility Canal***

Dermal contact exposure to canal sediments by recreational users, industrial workers, and fishermen in Gulf States Utility Canal is considered complete. Incidental ingestion of canal sediment by recreational users and industrial workers is also considered complete in the Gulf States Utility Canal AOI. The sediment exposure pathway was evaluated for dermal contact and ingestion using the Tier 1 Sediment PCLs. The sediment exposure pathway for protection of ingestion of freshwater and saltwater fish/shellfish for Site fishermen in the Gulf States Utility Canal AOI is considered complete and was evaluated based on tissue sample results.

***Molasses Bayou Upstream and Downstream Watercourse AOIs***

Dermal contact exposure to canal sediments by recreational users, industrial workers, and fishermen in Molasses Bayou AOIs is considered complete. Incidental ingestion of canal sediment by recreational users and industrial workers is also considered complete in the Molasses Bayou AOIs. The sediment exposure pathway was evaluated for dermal contact and ingestion using the Tier 1 Sediment PCLs. The sediment exposure pathway for protection of ingestion of freshwater and saltwater fish/shellfish for Site fishermen in Molasses Bayou AOIs is considered complete and was evaluated based on tissue sample results.

***Jefferson Canal Upstream***

Dermal contact and incidental ingestion exposure to canal sediments by industrial workers and trespassers in the Jefferson Canal Upstream AOI is considered complete. Exposure to the recreational user and fisherman/shell fisher receptors was considered incomplete due to the presence of fencing as administrative controls to prevent access by those receptors. The sediment exposure pathway was evaluated for dermal contact and ingestion using the Tier 1 Sediment PCLs. The sediment exposure pathway for protection of ingestion of freshwater and saltwater fish/shellfish for trespassers in the Jefferson Canal Upstream AOI is considered incomplete as there is not a measurable quantity of fish in this portion of the canal available for catching. In addition, the

upstream portion of Jefferson Canal is not hydraulically connected to the downstream portion and fish cannot swim from the downstream to the upstream portion.

***Jefferson Canal Downstream***

Dermal contact exposure to canal sediments by recreational users and fishermen in Jefferson Canal Downstream is considered complete. Incidental ingestion of canal sediment by recreational users is also considered complete in the Jefferson Canal Downstream AOI. The sediment exposure pathway was evaluated for dermal contact and ingestion using the Tier 1 Sediment PCLs. The sediment exposure pathway for protection of ingestion of freshwater and saltwater fish/shellfish for Site fishermen in the Jefferson Canal Downstream AOI is considered complete and was evaluated based on tissue sample results.

#### 2.2.3.5 WETLAND SEDIMENT

Re-suspension of canal sediment into surface water and deposition of the sediments in the surrounding wetland (non-watercourse) areas of the Site was the primary route of impact to the wetland sediment. Sediment is defined in the CSM as a substrate that is partially or permanently inundated with water, including canal and wetland sediment. Wetland sediment is considered to be partially inundated with water as in the Molasses Bayou Wetland and Former Star Lake AOIs.

Potential exposure pathways to wetland sediment for human receptors include dermal contact, ingestion of sediment, and indirect exposure via ingestion of fish/shellfish. Direct contact pathways, i.e., ingestion of sediment and dermal contact with sediment for intermittent waterbodies are evaluated for the sediment not continuously covered by water.

Potential exposure pathways for ecological receptors include uptake by wetland plant and invertebrate dietary items and indirect ingestion.

***Former Star Lake***

Dermal contact and incidental exposure to wetland sediment by recreational users and fishermen in Former Star Lake is considered complete. Incidental ingestion of wetland sediment by recreational users is also considered complete in the Former Star Lake AOI. The sediment exposure pathway was evaluated for dermal contact and ingestion using the Tier 1 Sediment PCLs. The sediment exposure pathway for protection of ingestion

of freshwater and saltwater fish/shellfish for Site fishermen in the Former Star Lake AOI is considered complete and was evaluated based on tissue sample results.

***Molasses Bayou Wetland***

Dermal contact exposure to wetland sediment by recreational users and fishermen in Molasses Bayou Wetland is considered complete. Incidental ingestion of wetland sediment by recreational users is also considered complete in the Molasses Bayou Wetland AOI. The sediment exposure pathway was evaluated for dermal contact and ingestion using the Tier 1 Sediment PCLs. The sediment exposure pathway for protection of ingestion of freshwater and saltwater fish/shellfish for Site fishermen in the Molasses Bayou Wetland AOI is considered complete and was evaluated based on tissue sample results.

#### 2.2.3.6 SURFACE WATER

The primary source of impact to the surface water at the Site is from historical discharge from surrounding industry. Re-suspension of canal sediment and erosion of the upland bank soil, and the potential communication with the existing groundwater plume at the Huntsman facility are secondary sources of impact.

Potential exposure pathways for ecological receptors include uptake by aquatic invertebrates and indirect ingestion.

***Star Lake Canal***

Dermal contact exposure to surface water by recreational users and fishermen in the Star Lake Canal AOI is considered complete. Incidental ingestion of surface water by recreational users is also considered complete in the Star Lake Canal AOI. The surface water exposure pathway was evaluated for dermal contact using the approved Contact Recreation Water PCLs. The surface water exposure pathway for protection of ingestion of freshwater and saltwater fish/shellfish for Site fishermen in the Star Lake Canal AOI is considered complete and was evaluated based on tissue sample results.

***Gulf States Utility Canal***

Dermal contact exposure to surface water by recreational users and fishermen in Gulf States Utility Canal is considered complete. Incidental ingestion of surface water by recreational users is also considered complete in the Gulf States Utility Canal AOI. The surface water exposure pathway was evaluated for dermal contact using the approved Contact Recreation Water PCLs. The surface water exposure pathway for protection of

ingestion of freshwater and saltwater fish/shellfish for Site fishermen in the Gulf States Utility Canal AOI is considered complete and was evaluated based on tissue sample results.

***Molasses Bayou Upstream and Downstream Watercourse AOIs***

Dermal contact exposure to surface water by recreational users and fishermen in Molasses Bayou AOIs is considered complete. Incidental ingestion of surface water by recreational users is also considered complete in the Molasses Bayou AOIs. The surface water exposure pathway was evaluated for dermal contact using the approved Contact Recreation Water PCLs. The surface water exposure pathway for protection of ingestion of freshwater and saltwater fish/shellfish for Site fishermen in Molasses Bayou AOIs is considered complete and was evaluated based on tissue sample results.

***Jefferson Canal Upstream***

Dermal contact and incidental ingestion exposure to surface water by industrial workers and trespassers in the Jefferson Canal Upstream AOI is considered complete. Exposure to the recreational user and fisherman/shell fisher receptors was considered incomplete due to the presence of fencing as administrative controls to prevent access by those receptors. The surface water exposure pathway was evaluated for dermal contact using the approved Contact Recreation Water PCLs. The surface water exposure pathway for protection of ingestion of freshwater and saltwater fish/shellfish for trespassers in the Jefferson Canal Upstream AOI is considered incomplete and was not evaluated further. A representative of the US Fish and Wildlife Service conducted a Site visit during the Tier 2 RI tissue sample collection activities and confirmed that there were no fish available for collection in Jefferson Canal.

***Jefferson Canal Downstream***

Dermal contact exposure to surface water by recreational users and fishermen in Jefferson Canal Downstream is considered complete. Incidental ingestion of surface water by recreational users is also considered complete in the Jefferson Canal Downstream AOI. The surface water exposure pathway will be evaluated for dermal contact using the approved Contact Recreation Water PCLs. The surface water exposure pathway for protection of ingestion of freshwater and saltwater fish/shellfish for Site fishermen in the Jefferson Canal Downstream AOI is considered complete and was evaluated based on tissue sample results.

#### 2.2.3.7 FISH/SHELLFISH

The potential source of impact to the fish/shellfish tissue at the Site is from the ingestion of potentially impacted surface water and canal/wetland sediment by fish and shellfish. The exposure pathway to human receptors is through human consumption (direct ingestion) of the fish and shellfish tissue.

The Tier 2 RI fish/shellfish tissue samples were obtained primarily from Star Lake Canal and portions of Molasses Bayou. The Tier 2 RI fish tissue sample results were used to evaluate potential human health exposure to recreational fishermen in the Star Lake Canal, Former Star Lake, Gulf States Utility Canal, and Jefferson Canal Downstream AOIs. The Jefferson Canal Downstream, Gulf States Utility Canal, Former Star Lake, and portions of Molasses Bayou Wetland AOIs are not expected to yield fish/shellfish of legal size for human consumption.

***Star Lake Canal***

Ingestion of fish/shellfish tissue by a recreational fisher/shellfisher in Star Lake Canal is considered complete. The fish consumption exposure pathway was evaluated using the TCEQ TRRP risk based exposure levels (RBELs) for ingestion of saltwater fish/shellfish tissue.

***Gulf States Utility Canal***

Ingestion of fish/shellfish tissue by a recreational fisher/shellfisher in the Gulf States Utility Canal AOI is considered complete. No human health fish/shellfish tissue samples were collected from this AOI. The fish consumption exposure pathway was evaluated using the TCEQ TRRP RBELs for ingestion of freshwater and/or saltwater fish/shellfish tissue.

***Molasses Bayou Upstream and Downstream Watercourse***

Ingestion of fish/shellfish tissue by a recreational fisher/shellfisher in the Molasses Bayou Upstream and Downstream Watercourse AOIs is considered complete. The fish consumption exposure pathway was evaluated using the TCEQ TRRP RBELs for ingestion of freshwater and/or saltwater fish/shellfish tissue.

***Jefferson Canal Downstream***

Ingestion of fish/shellfish tissue by a recreational fisher/shellfisher in the Jefferson Canal Downstream AOI is considered complete. No human health fish/shellfish tissue samples were collected from this AOI. The fish consumption exposure pathway was evaluated using the TCEQ TRRP RBELs for ingestion of freshwater fish/shellfish tissue.

#### 2.2.3.8 ECOLOGICAL TISSUE

This section provides a summary of the Tier 1 and Tier 2 HHRA results and conclusions.

The potential source of impact to the ecological upper trophic receptors at the Site is from the ingestion of potentially impacted surface water and canal/wetland sediment, soil, and dietary items. The exposure pathway to ecological upper trophic level receptors is through consumption (direct ingestion) of the dietary items at the Site (i.e., insects, vegetation, amphibians, fish, shellfish and invertebrates) and incidental ingestion of constituents through sediments, soil, and surface water.

The Tier 2 RI ecological tissue samples include insects, earthworms, amphibians, fish, shellfish, and vegetation and were obtained from locations throughout the Site. The Tier 2 RI tissue sample results were used to evaluate potential upper trophic level receptor exposure to constituents in Star Lake Canal, Former Star Lake, Gulf States Utility Canal, Molasses Bayou Upstream and Downstream Watercourse, Molasses Bayou Wetland, Jefferson Canal Upstream, Jefferson Canal Downstream, and Jefferson Canal Spoil Pile AOIs.

### 2.2.4 HUMAN HEALTH RISK ASSESSMENT

The Tier 1 RI screening criteria were selected from available sources developed by USEPA and TCEQ using standard default exposure scenarios that may not be applicable to the Site. For example, contact recreation risk based exposure levels (RBELs) for surface water are based on recreational swimming. For many of the AOIs, wading was the appropriate potential recreational activity because of the shallow surface water depth in the AOI. In these cases, the Tier 1 RI screening criteria were overly conservative resulting in detection limits that exceeded the associated RBELs for certain constituents. If Site-specific screening values were used during the Tier 1 RI screening process, there would have been few constituents with detection limits that exceeded screening values.

These surface water and sediment RBELs for protection of fish consumption were obsolete in the Tier 2 RI because fish tissue samples were collected and analyzed in the Tier 2 RI and these tissue analyses were used to develop health based risk estimates for fish consumption. The use of surface water and sediment RBELs derived for the

protection of fish consumption increased the number of constituents with detection limits higher than RBELs.

For constituents with all non-detects in a particular medium, it is unclear whether these constituents (a) are not present at the Site, (b) are present, but at concentrations below the associated limiting human health criteria (LHHC), or (c) are present at concentrations above the associated LHHC, but below the standard quantitation limits (SQLs). USEPA (1989b) indicates that constituents should generally be eliminated from the risk assessment if they are not detected in any sample of a particular medium unless there is evidence they are present. This provision affects the majority of the constituents with detection limits that exceed RBELs, i.e., all analyses were non-detect in a particular medium. The constituents listed in the following sections were not eliminated from evaluation based on percentage frequency of detection. The available analytical data were reviewed and evaluated to determine whether the constituents were likely to be present in a specific medium given (a) results in other AOIs, and (b) results in other media. If the constituents were not detected in other AOIs or in any other medium, then the non-detected constituent was not considered to be an AOI-specific or Site-specific COPC.

***Surface Water***

Tier 1 RI surface water screening criteria were based on the lower of RBELs for fish ingestion or for recreational swimming. Toxaphene and PCB-1260 were not detected in any sample from any of the AOIs. In addition, PCB-1254, PCB 126, and dibenz(a,h)anthracene were not detected in nearly all AOIs. Therefore, consistent with USEPA (1989b), these constituents are unlikely to be Site-specific surface water COPCs. As such, no further evaluation of these constituents in surface water was warranted.

Detection limits for five constituents analyzed in surface water from the Molasses Bayou Downstream Watercourse AOI exceeded screening criteria. These constituents included PCB-1248, bis(2-ethylhexyl)phthalate, hexachlorobenzene, N-nitrosodi-n-propylamine, and pentachlorophenol. The detection limits for only one sample result for each of these constituents exceeded the screening criteria. For the remaining six samples, all detection limits were below screening criteria. As such, none of these constituents are regarded as Site-specific surface water COPCs, and therefore, no further evaluation of these constituents in the Molasses Bayou Downstream Watercourse AOI surface water was warranted.

With respect to PCB-1248 in the Molasses Bayou Downstream Watercourse AOI, the same result is noted, i.e., only one detection limit that exceeded the screening criteria.

Detection limits for the remaining 12 samples were all below the screening level. As such, PCB-1248 is not regarded as a Site-specific surface water COPC in the Molasses Bayou Downstream Watercourse AOI, and therefore, no further evaluation of PCB-1248 in the Molasses Bayou Downstream Watercourse AOI surface water was warranted.

The detection limits for arsenic in the Molasses Bayou Wetland AOI surface water exceeded the screening criteria. However, the Tier 1 RI screening criteria for arsenic was based on protection of fish ingestion by humans. Arsenic was included in the analytical test program for fish tissue and therefore, the Tier 1 RI screening criteria is not applicable for identifying constituents for inclusion in quantitative risk estimates with respect to fish ingestion. All detection limits for arsenic in the Molasses Bayou Wetland AOI were below the recreational swimming RBEL. As such, no further evaluation of arsenic in the Molasses Bayou Wetland AOI surface water was warranted.

***Sediment***

As noted above for surface water, Tier 1 sediment criteria were based on the lower of RBELs for fish ingestion or for recreational swimming. For certain AOIs (Star Lake Canal), contact with sediments was considered an incomplete exposure pathway because of surface water depth.

The Tier 1 screening criterion for PCB 126 was based on protection of fish ingestion by humans. PCB 126 was included in the analytical test program for fish tissue and therefore, the Tier 1 RI screening criterion is not applicable for identifying constituents for inclusion in quantitative risk estimates with respect to fish ingestion. All detection limits for PCB-126 in these AOIs were below the recreational swimming RBEL. As such, no further evaluation of non-detected PCB 126 was warranted.

For dieldrin in the Former Star Lake AOI sediment samples, only one detection limit exceeded associated screening criteria in surface sediment (0-6 inches). Detection limits in the remaining nine samples were all below screening criteria. As such, dieldrin is not regarded as a Site-specific sediment COPC in the Former Star Lake AOI, and therefore, no further evaluation of this constituent in the Former Star Lake AOI sediment was warranted.

One non-detect result for PCB-1016, PCB-1221, and PCB-1232 exceeded associated screening criteria in surface sediment (0-6 inches) samples from the Jefferson Canal Upstream AOI. Detection limits in the remaining nine samples were all below screening criteria. As such, these constituents are not regarded as Site-specific sediment COPCs in

the Jefferson Canal Upstream AOI, and therefore, no further evaluation of these constituents in the Jefferson Canal Upstream AOI sediment was warranted.

***Soil***

No constituents in soil samples collected from the Jefferson Canal Spoil Pile AOI had detection limits that were higher than the screening criteria.

***Tissue***

There were 7 non-detected constituents in fish tissue samples that had detection limits that were higher than screening criteria. These constituents included 4 semi-volatile organic compounds (SVOCs), 2 PAHs, and 1 pesticide. Because detection limits in more than one composite tissue sample exceeded the fish ingestion RBEL, concentrations of these seven constituents in surface water, sediment, and ecological tissue samples were evaluated. If the constituent was not detected in any of these samples, no further evaluation was completed. If these constituents were detected in any sample, further evaluation with respect to (a) detection limits and RBELs and (b) estimated potential risks assuming concentrations of ½ the detection limit was completed.

Table 8-25 of the *Tier 2 RI Report* shows that neither 3,3'-dichlorobenzidine or bis(2-chloroethyl)ether was detected in surface water, sediment, or ecological tissue samples (3,3'-dichlorobenzidine was not analyzed in ecological tissue samples). As such, these constituents are not regarded as Site-specific COPCs in fish tissue. For hexachlorobenzene, pentachlorophenol, and toxaphene, 100% or nearly 100% of detection limits were below RBELs for freshwater and all ½ detection limit values were below RBELs for tidal saltwater. As such, these constituents are regarded as unlikely to pose an unacceptable risk to human health, even if present. Finally, carcinogen risk estimates for benzo(a)pyrene and dibenz(a,h)anthracene using the maximum ½ detection limit value ranged from 1.46E-05 for tidal freshwater to 3.21E-05 for tidal saltwater sources. These risk estimates are well below the target level of 1.00E-04 and therefore no further evaluation was warranted.

Based on the information presented in the HHRA, the following conclusions were made:

i) The HHRA evaluated potential human health impacts associated with exposure to COPCs identified in surface water, sediment, soil, and biological tissue collected at the Site.

ii) The potential exposure scenarios evaluated at the Site considering the current and potential future use of the Site included: recreational fishing, recreational

swimming/wading, trespass wading, industrial (maintenance) worker, and industrial (outdoor) worker.

iii) The calculated central tendency (CT) and reasonable maximum exposure (RME) carcinogen risks and non-carcinogen hazard indexes (HIs) for all exposure scenarios for all receptors were below $1.00 \times 10^{-5}$ for cancer risk and less than 1.0 for hazard index. All RME estimates for all scenarios, with the exception of recreational wading in Molasses Bayou Downstream, fall within the $1 \times 10^{-4}$ to $1 \times 10^{-6}$ cancer risk range (Tables 8-14, 8-16, 8-18, 8-19, 8-20, and 8-21 of the *Tier 2 RI Report*). In addition, several of the CT estimates fall within the $1 \times 10^{-4}$ to $1 \times 10^{-6}$ cancer risk range (Tables 8-15, 8-17, 8-19, and 8-20 of the *Tier 2 RI Report*).

### 2.2.5 BASELINE ECOLOGICAL RISK ASSESSMENT

This section provides a summary of the BERA results and conclusions completed during the Tier 2 RI.

In the BERA, declines in health and viability of avian, reptilian, terrestrial mammal, fish, and terrestrial, aquatic and benthic invertebrate receptor populations were identified as the assessment endpoints. These assessment endpoints were evaluated with information obtained from measurement endpoints to determine if reduced survival, impaired reproduction, or growth inhibition in local ROC populations was likely a result of exposure to COPECs at the Site. For this phase of the assessment, multiple lines of evidence were evaluated for selected receptors to reduce some of the uncertainties associated with making decisions based on a single line of evidence. Table 9-25 of the *Tier 2 RI Report* details each line of evidence used for sediment samples at the Site and the risk management decision concerning risk to benthic receptors. Table 9-26 of the *Tier 2 RI Report* shows the risk level for each COPEC-upper level trophic receptor pair.

The specific measurement endpoints used in this BERA include data quantifying the occurrence and magnitude of concentrations of COPECs in surface sediments (including wetland sediments), soils, surface water, and selected biological tissues within the study area. These data permit the evaluation of ecological risks to ecological receptors exposed to COPECs in abiotic media and via the food chain. More realistic exposures of upper trophic level ROCs to COPECs were assessed by using measured tissue concentrations in dietary prey items (e.g., blue crab, forage fish) in the exposure models.

Potential risks from COPECs were evaluated for terrestrial, aquatic and benthic invertebrates through Hazard Ratio (H)-values for both terrestrial and aquatic invertebrates, and through Effects Range-Median (ERM)-Quotient (Q)/ Probable Effects Level (PEL)-Q), Toxic Units (TUs), first effects levels and midpoint H-values, and Simultaneously Extractable Metals (SEM)/Acid-Volatile Sulfide (AVS) ratios for benthic invertebrates.

#### 2.2.5.1 BENTHIC INVERTEBRATES

A total of 19 freshwater sediment and 94 estuarine or saltwater sediment samples were collected during the RI. The following analyses/comparisons were made as part of the evaluation of multiple lines of evidence:

- Utilization of Sediment Quality Guidelines (ERM and PEL)
- Comparisons of concentrations to State and Federal Benchmarks (H values)
- Determination of the SEM/AVS ratio
- Calculation of Toxic Units (PAHs and five non-ionic organics)

***Lines of Evidence Analysis***

A preferential line of evidence analysis was used to form a decision regarding whether the sediment sample would be addressed in the FS or the sediment sample required no further action. This method for decision making was as follows: a sediment sample will be addressed in the FS if the sample has high or medium-high ERM-Q/PEL-Q priority status or if the sample has medium-low ERM-Q/PEL-Q priority status with an additional Line of Evidence exceedance (Midpoint H > 1, TU >1, SEM/AVS >1); a sediment sample will require no further action if the sample has medium-low ERM-Q/PEL-Q priority status with no additional line of evidence exceedance or if the sample has low ERM-Q/PEL-Q priority status. A detailed discussion of the lines of evidence analysis is included in the Section 9.4 of the *April 2011 Tier 2 RI Report* and Section 2.2.1 of the *June 2011 Alignment Document*. The results for each line of evidence at each sediment sample location and the resulting risk management decision based on the preferential line of evidence analysis are provided in Table 9-25 of the Tier 2 RI Report.

***Freshwater Sediment***

The results of the preferential lines of evidence assessment indicated that all samples in Jefferson Canal and one sample in Star Lake Canal (SLC-8) will need to be addressed in the FS for potential remedial action. The samples in the highest PEL-Q risk category

were found to have risk mostly driven by pesticides (4'4-DDE and dieldrin), PCBs, and PAHs. While these COPECs analyzed with the PEL-Q method did not have detected concentrations high enough to meet the criteria for a high or med-high priority status in the remaining Jefferson Canal samples, several other COPECs did exceed midpoint benchmarks. The COPECs that were elevated beyond midpoint benchmark levels in the samples with med-low PEL-Q risk priority status included several metals (iron, manganese, silver) and pesticides (aldrin, lindane, heptachlor epoxide, and toxaphene). Based on PELs, total PAH benchmarks, and TUs, PAHs appear to be posing risk at only those samples that are in the high PEL-Q risk priority category (JC-2, JC-7, JC-13, JC-18, and JC-19).

***Saltwater Sediment***

The results of the preferential lines of evidence assessment indicated that the majority of the Molasses Bayou Downstream Watercourse AOI sample locations, with the exception of MB-34, MB-44, and MB-42, do not pose unacceptable risk and therefore, do not require further action. Conversely, a large percentage of the Molasses Bayou Upstream Watercourse AOI sediment samples will be addressed in the FS due to potential risk to benthic receptors. Based on the preferential lines of evidence analysis, the COPECs that appear to be driving this potential risk in the Molasses Bayou upstream watercourse are 4'4-DDT, lead, mercury, Dieldrin, PAHs, and gamma-BHC. Of the 94 saltwater sediment sample locations within the Site, only six sample locations, all within Molasses Bayou (MB-10, MB-14, MB-21, MB-24, MB-56 and MB-63), had concentrations that exceeded the second effects level benchmark for total PAHs, representing concentrations that will cause adverse effects to benthic invertebrates. Of those six locations, two of them (MB-10 and MB-21) had TU values that also exceeded 1.0, denoting risk posed to benthic invertebrates due to the additive narcotic toxicity of PAHs and non-ionic organics. Gulf States Utility Canal, Former Star Lake, and Star Lake Canal did not have risk confined to certain geographical areas of each respective AOI; the sediment samples that will be addressed in the FS were found in variable locations within these AOIs.

#### 2.2.5.2 TERRESTRIAL INVERTEBRATES

Within soil, each constituent at each sample location was compared to the ecological benchmark where benchmarks were available. Results indicate that within the Jefferson Canal Spoil Pile Area, each of the 30 sampling locations had exceedances of ecological benchmarks for at least one of the following: dieldrin, barium, chromium (total), cobalt, lead, manganese, mercury, selenium, silver, vanadium, and zinc. Total chromium, vanadium, and dieldrin were found to have the highest hazard ratios when comparing benchmarks to Site Reasonable Maximum Exposures (RMEs) and sample means. Since

all benchmarks found in TCEQ (2006) for soil exposure to terrestrial invertebrates are first effects levels, these very conservative benchmarks were used for comparison to soil sample concentrations at the Site. It is likely that risk to terrestrial invertebrates is overestimated due to these conservative benchmarks; nevertheless, all samples will be addressed in the FS to further evaluate this potential risk.

#### 2.2.5.3 AQUATIC INVERTEBRATES AND FISH

***Comparison to Aqueous Benchmarks***

When comparing reasonable maximum exposure concentrations in freshwaters with appropriate ecological benchmarks, data indicated that aquatic invertebrates and fish would be exposed to concentrations that could pose risk and therefore, will be addressed in the FS. Data indicate that some metals, pesticides, PCBs and volatiles exceeded their applicable benchmark. It is important to note that for many of the COPECs with H>1, the constituents were not detected at or above the SQL. Non-detected constituents with H>1 include some metals, Aroclors, volatile organic compounds (VOCs) and pesticides. Twelve of the 100 COPECs with applicable ecological benchmarks had detected concentrations that resulted in H>1. Detected constituents collected in 2006 with H>1 include aluminum (total), copper (dissolved), iron (total), magnesium (total), manganese (total), vanadium (total), dieldrin, endosulfan II and pentachlorophenol. Detected constituents collected in 2009 with H>1 include aluminum (total), calcium, iron (total), magnesium (total), manganese (total), endosulfan I, heptachlor epoxide and pentachlorophenol.

When comparing reasonable maximum exposure concentrations in saltwater with appropriate ecological benchmarks, data indicated that aquatic invertebrates and fish would be exposed to concentrations that might indicate some risk. Data indicate that some metals, pesticides and volatiles exceeded their applicable benchmark. Risk is likely overestimated for many of the COPECs with H>1, as most of those constituents were not detected at or above the sample quantitation limit. Non-detected constituents with H>1 include several pesticides and VOCs.

***Sediment to Fish Pathway***

A comparison of concentrations of COPECs in tissues to literature-derived tissue residue data was made in an attempt to further determine if effects on fish would be expected at the Site. In general, there were few exceedances of COPECs above literature-derived tissue residue values. The constituents that were found at levels determined to be a potential risk to fish include: aluminum, barium, iron, copper, lead, manganese,

chromium, zinc, endosulfan II and total PAHs. Although data indicate that some metals, endosulfan II and total PAHs might exceed concentrations where effects could be expected, most fish are very transient and it is likely that exposure to metals does not come solely from the Site.

#### 2.2.5.4 UPPER TROPHIC LEVEL RECEPTORS

Risk to Upper Trophic Level (UTL) ROCs from exposure to each COPEC was assessed in the Tier 2 RI Report through exposure modeling using Site-specific dietary and media COPEC concentrations. Exposure factors, such as body weight, food ingestion rate, soil/sediment ingestion rate, water ingestion rate, dietary items, and home range, were used in estimating the dose of each constituent to which the ROC is exposed. Estimates of total daily dose were calculated for each ROC-COPEC pair and divided by an effects concentration to equal the Hazard Quotient (HQ). The HQs were determined for each COPEC-receptor pair using the Site-wide RME concentrations in sediment, soil, surface water, and dietary items. An HQ≤1.0 indicated that risk is acceptable (EPA 1998). Alternatively, an HQ>1.0 indicated an unacceptable risk and resulted in the decision to address the sample in the FS. The calculated HQs for each COPEC-receptor pair are provided in Table 9-23 of the Tier 2 RI Report.

Risk was further defined as low (or acceptable) if the $HQ_{[NOAEL]}$, $HQ_{(GMATC)}$, or $HQ_{(LOAEL)}$ values are less than one. Risk was considered to be indeterminate if the $HQ_{[NOAEL]}$ >1 while the $HQ_{(GMATC)}$ and $HQ_{(LOAEL)}$ <1. Risk was considered probable if the $HQ_{(GMATC)}$ >1 and the $HQ_{(LOAEL)}$ <1. Risk was considered high if the $HQ_{(LOAEL)}$ >1 or if a threatened and endangered species has a $HQ_{(NOAEL)}$, $HQ_{(GMATC)}$, or $HQ_{(LOAEL)}$ >1. The COPEC exposures that are addressed in the FS are those that resulted in an indeterminate, probable, or high risk. Identification of these COPECs that are causing potential risk to the ROCs allows for identification of specific geographic areas in the Site that have COPEC concentrations at or above levels that result in an Hazard Quotient (HQ)>1. Additionally, any COPEC-ROC pair showing risk due to ingestion of mollusks or mammals could potentially be an overly conservative risk estimate. These prey items were not collected at the Site, so mollusk and mammal concentrations used in the exposure models were based on sediment and soil concentrations and a literature-derived bioaccumulation factors (BAF). An evaluation of these conservative risk estimates was recommended for the FS.

Two VOCs, ethylbenzene and carbon disulfide, indicated indeterminate and probable risk to the spotted sandpiper and the marsh wren, respectively. Exposure levels in the

remaining thirteen receptor models had acceptable risk for VOCs. Exposure models indicate high exposure risks from hexachlorobenzene to the bullfrog, painted turtle, mallard, marsh wren, spotted sandpiper, raccoon and the short-tailed shrew. Pentachlorophenol had indeterminate exposure risks to the spotted sandpiper and high exposure risks to the painted turtle, raccoon, and short-tailed shrew. Benzaldehyde showed indeterminate exposure risk in the belted kingfisher model. PCBs evaluated as PCB congeners ($\sum TEQ_{PCB}$) had indeterminate exposure risk to the short-tailed shrew and the raccoon. Total PAHs were determined to be a high risk to the short-tailed shrew and an indeterminate risk to the raccoon and muskrat. Endosulfan II and endrin pose probable risk to the raccoon and indeterminate risk to the American robin, respectively. Risks to all upper trophic level receptors with the exception of the brown pelican, green heron, and reddish egret, indicated general risk from exposure to metals Site-wide. The results of the exposure model assessment indicated that no COPEC exposure posed unacceptable risk to the state endangered brown pelican, state threatened reddish egret, and green heron. The state threatened wood stork, white-faced ibis, and alligator snapping turtle (painted turtle as surrogate) were found to be at potential risk from exposure to several COPECs.

The dietary item (daily dose) that contributed the majority of risk for ROC-COPEC pairs with HQ > 1 was identified to determine if risk was being driven by a particular environmental medium (i.e. soil, sediment, surface water) or by a combination of lower trophic dietary items and ingestion of COPECs directly from the environment. Each ROC-COPEC pair with a HQ > 1 is discussed in the *Tier 2 RI Report* . Table 9-27 of the *Tier 2 RI Report* provides a summary of the dietary or environmental media that is driving risk.

### 2.2.6 REMEDIAL INVESTIGATION CONCLUSIONS

The Tier 1 RI Report objectives were met with the presentation of the results of the Tier 1 RI including the determination of the preliminary nature and extent of impact at the Site and the identification of potential ecological and human health risk. The Tier 1 HHRA screening process and the Screening Level Ecological Risk Assessment (SLERA) indicated that COPCs and COPECs are present at the Site at concentrations that may pose human health or ecological risk. The Tier 1 RI sample locations are shown on Figure 2-1.

The Site characterization and sampling plan was based on a source and pathway approach to data collection. The source of the impact was defined as the historical

discharge of upstream industries. Constituents were discharged into the surface water bodies of Jefferson Canal and Star Lake Canal. Subsequently the constituents were transported to other areas of the Site and other environmental media within the Site via mechanisms including deposition, sediment re-suspension, surface water transport, dredging, and erosion. Therefore, Tier 1 and 2 RI sample locations were placed at locations along, and adjacent to, the potential transport pathways. Constituents were detected in sample media including soil, surface water, and sediment at various locations throughout the transport pathways. Sufficient data was collected in order to adequately identify the horizontal and vertical extent of COPCs and COPECs in sediment, soil, and surface water at the Site.

To assess the potential for risk to human receptors from exposure to these constituents by way of the various media, a human health risk assessment (HHRA) was completed. The HHRA established screening level human health criteria for constituents based on existing guidance documents and identified environmental media in certain areas of the Site in which specific constituent concentrations exceeded the screening level human health criteria for different exposure pathways. The HHRA included an exposure assessment, toxicity assessment, and risk characterization, using conservative assumptions, with the COPCs identified in the screening level HHRA. Calculated risk estimates for all receptors evaluated were either below or within the acceptable cancer risk range of $1x10^{-6}$ to $1x10^{-4}$ and below the noncancer hazard index of 1.0 defined by USEPA for Superfund sites. The acceptable cancer risk range established in CERCLA states that the upper end of the risk range usually applies to residential areas and sensitive populations, and the lower end of the risk range typically applies to commercial/industrial uses. Groundwater was not addressed in this HHRA and is being evaluated under the TCEQ Corrective Action Program; this is discussed briefly in Section 2.2.3.3 and in detail in Section 10.0 of the Tier 2 RI Report.

To assess the potential for risk to ecological receptors from exposure to constituents at the Site, a BERA was completed. In the BERA, declines in health and viability of avian, reptilian, terrestrial mammal, fish, and terrestrial, aquatic and benthic invertebrate receptor populations were identified as the assessment endpoints. These assessment endpoints were evaluated with information obtained from measurement endpoints to determine if reduced survival, impaired reproduction, or growth inhibition in local ROC populations was likely a result of exposure to COPECs. For this phase of the assessment, multiple lines of evidence were evaluated for selected receptors to reduce the uncertainties associated with making decisions based on a single line of evidence.

The specific measurement endpoints used in the BERA include data quantifying the occurrence and magnitude of concentrations of COPECs in surface sediment (including wetland sediment), soil, surface water, and selected biological tissue within the study area. The results of these data were evaluated to estimate ecological risks to ecological receptors exposed to COPECs in abiotic media and via the food chain. Exposures of upper trophic level ROCs to COPECs were assessed using measured tissue concentrations in dietary prey items (e.g., blue crab, forage fish) in the exposure models. Potential risks from COPECs were evaluated for terrestrial, aquatic, and benthic invertebrates with H ratios for both terrestrial and aquatic invertebrates, and with H ratios, ERM-Q/PEL-Q, and TUs for benthic invertebrates. The BERA determined that potential widespread ecological risk exists for benthic invertebrates, terrestrial invertebrates, aquatic invertebrates, fish, and some upper trophic level ROCs due to exposure to certain constituents at the Site.

Based on the various lines of evidence evaluated at the Site, the results indicate that concentrations of metals in sediment, surface water, soil, and tissue samples and concentrations of several pesticides in sediment, surface water, and fish tissue samples appear to influence the majority of risk potential to the ROCs at the Site. While there are multiple soil and sediment sample locations that have constituent concentrations that were addressed in the FS, in general, there is a subset of locations in either freshwater or saltwater areas that appear to be influencing much of the risk estimated to upper trophic level receptors. These locations, which will be further evaluated in the FS for their risk contribution, generally consist of soil sample locations in the Jefferson Canal spoil pile area and sediment sample locations in the Jefferson Canal area, the Former Star Lake area, and locations typically confined to the Molasses Bayou upstream watercourse. Evaluations on COPEC exposure levels in three state-threatened upper trophic level receptors, the white-faced ibis, wood stork, and alligator snapping turtle (painted turtle used as surrogate) resulted in some risk potential from several metals and SVOCs. The information contained in this BERA is intended to support decisions regarding the evaluation of potential future remedial actions within the Site.

## 2.3 ALIGNMENT DOCUMENT

CEMC and Huntsman submitted the Alignment Document on June 17, 2011. The purpose of the Alignment Document was to provide a bridge between the Tier 2 RI and the FS for the Site. In the Tier 2 RI and the BERA, risks to benthic invertebrates were quantified on a sample location basis while risks to UTL ROCs were determined on a Site-wide basis. The Alignment Document helped to define those areas of the Site that

might contribute the most significant amount of risk to UTL ROCs instead of referring to risk across the Site.

**DEVELOPMENT OF THIESSEN POLYGONS**

The Site was delineated into decision units surrounding each sediment and soil sample location using a Thiessen polygon approach (See Figures 1 and 2 of the *Alignment Document*). Thiessen polygons are used to mathematically define individual areas around each of a set of points. The boundaries of each of these polygons define areas that are statistically closest to each point relative to all other points. So, if a particular point is found to contribute significantly to risk, then the boundary represented by the polygon surrounding that point would be considered to contribute significantly to that risk.

**BENTHIC INVERTEBRATE RISK APPLIED TO THIESSEN POLYGONS**

Four lines of evidence were used in the BERA to evaluate risk to benthic and epibenthic organisms: Hs, ERM-Qs/PEL-Qs, SEM/AVS, and TUs. A preferential line of evidence analysis was used to form a decision regarding whether the sediment sample location would be addressed in the FS or the sediment sample location required no further action. Results of the preferential lines of evidence analysis were applied to the Thiessen polygons in Figure 3 of the *Alignment Document*.

**UPPER TROPHIC LEVEL RISK APPLIED TO THIESSEN POLYGONS**

To define those areas that might be considered drivers of upper trophic level risk, sediment and soil protective concentration levels (PCLs) were calculated for the ROCs that were determined to have unacceptable risk from a particular COPEC. Unacceptable risk was defined by an indeterminate, probable, or high risk. Risk was considered to be indeterminate if the $HQ_{[NOAEL]}$ >1 while the $HQ_{(GMATC)}$ and $HQ_{(LOAEL)}$ <1. Risk was considered probable if the $HQ_{(GMATC)}$ >1 and the $HQ_{(LOAEL)}$ <1. Risk was considered high if the $HQ_{(LOAEL)}$ >1 or if a threatened and endangered species has a $HQ_{(NOAEL)}$, $HQ_{(GMATC)}$, or $HQ_{(LOAEL)}$ >1.

PCLs were determined using the dose equation method (see Equations 1 and 2 of the *Alignment Document*) outlined in the Texas Natural Resource Conservation Commission (TNRCC) Guidance for Conducting Risk Assessments at Remediation Sites in Texas (2001). The ecological PCL is the concentration of a COPEC within an exposure medium which is protective of the more wide-ranging receptors that may frequent the Site and

utilize the less mobile receptors as a food source (TNRRC 2001). In the dose equation method, a single media-specific PCL is calculated while COPEC concentrations in other media are held constant. As such, the sediment PCL was calculated as the COPEC concentration in sediment that would result in a HQ = 1 while soil and water COPEC concentrations are held at constant concentrations. Conversely, the soil PCL was calculated as the COPEC concentration in soil that results in a HQ = 1 while sediment and water COPEC concentrations are held at constant concentrations. Soil PCLs were only calculated for those receptors with greater than 1% of soil in their diet (raccoon, short-tailed shrew, and American robin) and a HQ>1.

A large percentage of the total daily dose for most receptors was due to ingestion of dietary items. Because the constituent concentrations in dietary items were dynamically linked to sediment or soil concentrations, the revised dose equations utilized Site-specific BAFs to model tissue concentrations given a decrease in soil and sediment constituent concentration. The BAF value is calculated as the ratio of the concentration of a constituent in an organism's tissue to the concentration in an environmental medium to which the organism is exposed (see Equation 3 in the *Alignment Document*). The Site-specific BAF was calculated for each receptor and then used in place of the RME concentrations of the dietary items that were used in the Tier 2 RI exposure models.

For those COPECs with a GMATC HQ>1 or a NOAEL HQ>1 for T&E species, the sediment and soil PCLs for each ROC were compared to the COPEC concentrations in each polygon. Figures 4 through 20 in the *Alignment Document* show the number of ROCs (out of the 15 total ROCs at the Site) with PCL exceedances at each sediment polygon. Figures 21 through 27 in the *Alignment Document* show the number of ROCs (out of the 15 total ROCs at the Site) with PCL exceedances at each soil polygons. PCL exceedances were used to identify the hot spot locations that are driving risk to upper trophic level ROCs.

While performing the PCL analysis, it was determined that there were overly conservative measures used in the hexachlorobenzene risk calculation. Re-evaluation of the hexachlorobenzene risk levels determined that a number of the hexachlorobenzene PCLs did not need to be calculated due to an overly conservative mollusk BAF. This nonempirically-derived BAF was replaced with a field-measured mollusk BAF resulting in acceptable risk levels for the short-tailed shrew, raccoon, mallard, bullfrog, and painted turtle. Therefore, calculations of hexachlorobenzene PCLs were not necessary for those ROCs.

**CONCLUSIONS**

By applying the Thiessen polygons to the Site and showing the areas that are contributing to upper trophic level risk, remedial alternatives can be evaluated or interpreted on a sediment or soil sample area basis instead of a Site-wide basis. Upper trophic level PCL values and PCL exceedance values at each polygon location were presented in the *Alignment Document* and were further used during the *Sensitivity Analysis* to determine the areas that contributed a majority of the risk to UTL ROCs and to establish PRGs. In addition, showing the benthic risk decisions as Thiessen polygons allows the remedial alternatives to be evaluated or interpreted for benthic invertebrates on an area basis instead of a point to point basis.

## 2.4 SENSITIVITY ANALYSIS

The Sensitivity Analysis was completed to assess the reduction in Site-wide risk to UTL ROCs that would occur given a variety of remediation scenarios in sediment and soil. These remediation scenarios evaluated PRGs in sediment and soil, as well as the sediment and soil locations that need to be addressed in the FS.

### 2.4.1 EVALUATION OF UPPER TROPHIC LEVEL RISK

Risk to UTL ROCs from exposure to each COPEC was assessed in the *Tier 2 RI Report* through exposure modeling using Site-specific dietary and media COPEC concentrations. The HQ characterized UTL risk in which HQs ≤ 1 indicated no risk for adverse ecological effects and HQs > 1 indicated some potential for adverse effects. Each ROC-COPEC pair determined to have an HQ > 1 was retained for further evaluation in the Sensitivity Analysis (Table 2-1).

### 2.4.2 DEVELOPMENT OF REMEDIATION SCENARIOS

In the Alignment Document, PCLs for UTL receptors were developed and compared to Site concentrations in sediment and soil (see Section 2.3). The ROCs with PCL exceedances within each polygon was evaluated and presented in the Alignment Document. While this evaluation did present the frequency of PCL exceedances it did not address the magnitude of the exceedance. The magnitude of a PCL exceedance can help identify the hot spot areas that will be most successful in reducing risk to UTL

ROCs given a remediation of that area. Sediment and soil sample locations with UTL PCL exceedances were assessed for their individual contributions to overall Site-risk by comparing the magnitudes of all PCL exceedances among samples, which aided in a determination of UTL risk hot spots. These hot spot locations were identified by first dividing the COPEC concentration at a sample location by the UTL PCL of the corresponding COPEC, as follows:

$$PCL\ Exceedance\ Ratio_{sed} = \frac{C_{sed}}{PCL_{sed}}$$

*or*

$$PCL\ Exceedance\ Ratio_{soil} = \frac{C_{soil}}{PCL_{soil}}$$

Where:

*PCL Exceedance Ratio* $_{sed}$ = PCL Exceedance for a UTL ROC-COPEC pair at a sediment sample location (unitless)

*PCL Exceedance Ratio* $_{soil}$ = PCL Exceedance for a UTL ROC-COPEC pair at a soil sample location (unitless)

$C_{sed}$ = COPEC concentration at the corresponding sediment sample location (mg/kg dry weight)

$C_{soil}$ = COPEC concentration at the corresponding soil sample location (mg/kg dry weight)

$PCL_{sed}$ = PCL in sediment for a UTL ROC-COPEC pair (mg/kg dry weight)

$PCL_{soil}$ = PCL in soil for a UTL ROC-COPEC pair (mg/kg dry weight)

The PCL exceedance ratios were then summed for all of the COPECs at each sample location, as follows:

$$Total\ PCL\ Exceedance\ Ratio_{sediment} = \sum PCL\ Exceedance\ Ratio_{sediment}$$

or

$$Total\ PCL\ Exceedance\ Ratio_{soil} = \sum PCL\ Exceedance\ Ratio_{soil}$$

Where:

*PCL Exceedance Ratio* $_{sediment}$ = PCL Exceedance for a UTL ROC-COPEC pair at a sediment sample location (unitless)

*PCL Exceedance Ratio* $_{soil}$ = PCL Exceedance for a UTL ROC-COPEC pair at a soil sample location (unitless)

*Total PCL Exceedance Ratio* $_{sediment}$ = Sum of all PCL Exceedance Ratios in sediment for all UTL ROC-COPEC pairs at the corresponding sample location (unitless)

*Total PCL Exceedance Ratio* $_{soil}$ = Sum of all PCL Exceedance Ratios in soil for all UTL ROC-COPEC pairs at the corresponding sample location (unitless)

The sample locations that are significantly contributing to the Site-wide risk to UTL ROCs are those sample locations with the highest Total PCL Exceedance Ratios. Sediment and soil sample locations were grouped according to their total ratio number and then illustrated on Thiessen polygon maps (Figures 2-6 and 2-7). The Total PCL Exceedance Ratios were used during the Sensitivity Analysis to evaluate the areas that contributed a majority of the risk to UTL receptors and to evaluate various PRGs for their potential to reduce risk to UTL ROCs to an acceptable level (HQ ≤ 1).

The EPA also requested for an evaluation of scenarios that remediate areas showing risk to benthic invertebrates. Benthic invertebrate risk was assessed with several lines of evidence in the Tier 2 RI. The ERM-Q and PEL-Q was the primary line of evidence to confer risk to benthic invertebrates because this method evaluates notable metals, PAHs, PCBs, and pesticides using 2nd effects level benchmarks to assess the toxicological significance of the mixture. Using this line of evidence as the risk management strategy, several remediation scenarios were developed that evaluated remediation of any sediment sample with an ERM-Q and PEL-Q Priority Categories Score of three or four, corresponding to medium-high and high risk categories, respectively (Scenarios 10 and 11).

Description of the remediation scenarios that were evaluated in the Sensitivity Analysis are provided in Table 2-2.

### 2.4.3 REFINEMENT OF COPEC LIST FOR SENSITIVITY ANALYSIS

For all remediation scenarios, HQs were calculated for each effects level (NOAEL, GMATC, and LOAEL). To further refine the risk characterization and COPEC list for which PRGs should be established in the FS, the EPA recommended that acceptable risk to UTL receptors could be defined as any COPEC in which the $HQ_{[NOAEL]} < 1$ for T&E

receptors and the $HQ_{[GMATC]} < 1$ for all other non-T&E receptors. Based on this approach, benzaldehyde, hexachlorobenzene, nitrobenzene, PCB congeners, endrin, and zinc were not carried forward into the FS. These COPECs were determined to result in acceptable UTL risk levels at the Site under the current Site conditions. See Table 2-3 for a list of the COPECs retained and the COPECs not carried forward into the FS.

### 2.4.4 THIESSEN POLYGONS

Thiessen polygons were developed in the *Alignment Document* using sediment and soil sample locations to establish areas to be used as decision units in the FS. During the Sensitivity Analysis phase of the FS, the EPA recommended a revision to the polygon boundaries based on geographical features and recommended using the AOI boundaries from the RI investigation as boundaries for the revised Thiessen polygons. The reason for this request was to reduce the number of habitat types included in each polygon, thereby reducing the types of remedial actions to be considered within each polygon. The Thiessen polygons are illustrated in Figure 2-8 and were reviewed by the EPA and trustees during the FS.

### 2.4.5 EXPOSURE MODELING FOR EACH REMEDIATION SCENARIO

For each remediation scenario in the Sensitivity Analysis, Site-wide risk to UTL receptors was calculated based on a remediation of sediment and soil polygons to PRGs, as outlined in Table 2-2. Three different sediment PRGs were evaluated in the remediation scenarios: the first effects benchmark for benthic invertebrates, half of the first effects benchmark for benthic invertebrates, and the analytical detection limit. A soil background concentration was evaluated as the soil PRG for each scenario. If a background concentration was not found in TCEQ (2006), then a soil concentration that was protective of terrestrial plants or invertebrates was used as the PRG. Sediment and soil remediation goals that were evaluated in the Sensitivity Analysis are provided in Table 2-4.

All concentrations were converted to a wet weight concentration based on the percent water of the remediated sample. The remediated samples were only changed to the PRG value if the actual Site concentration for the sample was higher than the PRG.

For each scenario, Site-wide exposure following remediation was predicted by determining the RME for each COPEC in sediment and soil. The RME was calculated as

the 95% upper confidence limit (UCL) of the PRG concentrations in the remediated areas and the sample concentrations in the non-remediated areas. ProUCL version 4.00.02 was used to calculate 95% UCL values for sediment and soil (see Appendix I of the Tier 2 RI Report for a flowchart on the RME process).

For each scenario, UTL receptor exposure to COPECs through ingestion of dietary items was predicted by multiplying the remediation scenario sediment or soil RME by the Site-specific BAF (see Alignment Document for a description of all Site-specific BAFs). A sediment RME and BAF was used for dietary items that likely accumulate COPEC concentrations from sediment exposure. A soil RME and BAF was used for dietary items that likely accumulate COPEC concentrations from soil exposure.

Using these modeled concentrations in sediment, soil, and dietary items following a remediation according to each specified scenario, HQs were generated for all UTL ROC-COPEC pairs that were retained for the Sensitivity Analysis. See Tier 2 RI for a description of the HQ calculation.

### 2.4.6 EVALUATION OF REMEDIATION SCENARIO RESULTS

Remediation scenario HQ results were evaluated for reduction in risk to UTL ROCs by measuring the HQs that dropped below one. For each scenario, the percentage of HQs that dropped below one following remediation is listed in Table 2-5 along with the total amount of remediated acres. In addition, the number of HQs that dropped below one, the number of HQs that fell between one and ten, and the number of HQs that were above 10 were compared for each remediation scenario (Table 2-6). The percentage of risk reduction ranged from 0% in the scenario that modeled no remediation (Scenario 1) to 72.06% in the scenario that modeled remediation of the benthic invertebrate risk areas and all of the Jefferson Canal Spoil Pile (Scenario 10b). The scenario that evaluated complete remediation of the Site (Scenarios 8a, 8b, and 8c) only resulted in a risk reduction of 36.76 – 67.60%, depending on the PRG used in the exposure modeling. The lower risk reduction in Scenarios 8a, 8b, and 8c, compared to the risk reduction in Scenario 10b, occurred because of dietary item concentrations used in the Scenario 10a, 10b, and 10c exposure models. At the request of the EPA, Scenarios 10a, 10b, and 10c, were evaluated with the assumption that remediation of the entire Jefferson Canal Spoil Pile would result in a zero concentration for any dietary item linked to soil exposure (e.g. terrestrial plants, terrestrial insects, and earthworms). This method is in contrast to all other scenario evaluations in which the soil-linked dietary items were calculated with a Site-specific BAF multiplied by the soil RME. Evaluating these dietary items in this

manner resulted in a marked increase in risk reduction, as reflected in Table 2-5 and Table 2-6.

The sediment PRG evaluation between first effects benchmarks, ½ first effects benchmarks, and detection limits generally resulted in a higher risk reduction for sediment remediated to ½ first effects benchmarks. This can be seen in Tables 2-5 and 2-6 by comparing the "b" scenarios (½ first effects benchmarks), to the "a" scenarios (first effects benchmarks) and "c" scenarios (detection limits).

### 2.4.7 SELECTION OF REMEDIATION SCENARIO

The EPA recommended that risk to benthic invertebrates be the priority when identifying polygons to be addressed in the Sensitivity Analysis. After these polygons were chosen for remediation then exposure to UTL receptors was evaluated based on remediation of those polygons. Remediation scenarios 10a, 10b, 10c, 11a, 11b, and 11c follow this approach, where all sediment samples with an ERM-Q or PEL-Q Category Score > 2 are remediated to a PRG (Table 2-2). Based on this recommendation, the EPA determined that Scenario 10b is the most acceptable scenario moving forward into the FS as this scenario addresses both benthic invertebrate and upper trophic level risk at a PRG that is acceptable. Figure 2-9 shows the Thiessen polygons that are remediated in Scenario 10b.

Scenario 10b is focused on remediating sediment sample areas that likely pose unacceptable risk to benthic invertebrates and also remediating all areas of the Jefferson Canal Spoil Pile. Sediment sample areas with an ERM/PEL-Q category score of 3 (Medium High Priority) or 4 (High Priority) are assumed to be remediated to concentrations at or below half of the first effects sediment benchmarks listed in Table 2-4. Soil is assumed to be remediated to the Soil PRG listed in Table 2-4. Dietary items that were assumed to accumulate COPEC concentrations as a result of contaminated sediment exposure were calculated by multiplying the sediment BAF by the sediment RME. At the request of the EPA, dietary items that were assumed to accumulate COPEC concentrations through soil exposure were set to a zero concentration in the exposure models as an assumption that these items will pose no risk after all of the Jefferson Canal Spoil Pile is remediated to background levels.

### 2.4.8 SCENARIO 10B RISK ANALYSIS MODIFICATIONS

Results from Scenario 10b indicated acceptable risk levels for most of the COPECs that were evaluated in the Sensitivity Analysis. The following COPECs, pentachlorophenol, aluminum, hexavalent chromium, copper, and manganese, were found to still pose risk to UTL receptors in Remediation Scenario 10b (Table 2-7). EPA recommended that an evaluation be performed on each COPEC found to have unacceptable risk levels with Scenario 10b. These COPECs were assessed for conservative measures that could be contributing to an HQ>1 (source of the highest dose, prey item concentrations calculated with BAFs that are not Site-specific, TRV uncertainty) as well as issues that can help better define the risk to UTL receptors such as bioavailability due to soil chemistry. This assessment was necessary because a remediation of all sediment to detection limits and all soil to background levels (Scenario 8c) resulted in continued risk at the Site (Tables 2-5 and 2-6), indicating that there were a number of conservative measures incorporated into the exposure modeling.

Overly conservative measures in the exposure models can result in unrealistic risk estimates that are then used to develop PCLs and PRGs for ecological receptors. The TCEQ (2005) recommends the use of a LOAEL-based PCL in situations where only conservative exposure assumptions have been used. While TCEQ (2006) has developed some guidelines to follow in determining the most appropriate PCL, the TRRP rule is intentionally silent on how to select a comparative ecological PCL that is bounded by the NOAEL and LOAEL to allow one the flexibility of making this determination. Additionally, if a combination of less conservative and conservative assumptions have been used, it may be appropriate to use a PCL value that is bounded by the upper and lower effect levels but is biased toward the LOAEL bound (TCEQ 2006). An exception to using the average of the NOAEL and LOAEL-based PCLs can also be made in some cases where there is TRV uncertainty. Development of a PCL for consideration as a PRG should take into account the uncertainty of the conservative measures used in the exposure models (TCEQ 2005).

After conservative measures were identified, modifications were made to the exposure models to better define the risk posed by these COPECs. Modifications to these COPEC risk analyses were made according to the recommendations received by the EPA and TCEQ. These modifications included adjustments to the dietary components of the alligator snapping turtle surrogate species (painted turtle), using the $HQ_{[LOAEL]}$ to measure risk, using soil pH levels and AVS/SEM ratios to determine bioavailability, setting non-detect sample concentrations at half detection limits, and using a more appropriate manganese TRV for avian and mammals. COPECs found to have

unacceptable risk in Remediation Scenario 10b are described in detail below along with a description of the modifications.

#### 2.4.8.1 PENTACHLOROPHENOL

Pentachlorophenol was found to have unacceptable risk levels in the raccoon and the painted turtle in Remediation Scenario 10b (raccoon $HQ_{[GMATC]}$ = 1.57, painted turtle $HQ_{[NOAEL]}$ = 2.10).

A large majority of the pentachlorophenol total daily dose (TDD) in raccoons was from ingestion of prey items, specifically mollusks (97.44% of TDD). The mollusk BAF was calculated with a literature-derived sediment-to-mollusk BAF, therefore not representative of realistic bioaccumulation at the Site. A Site-specific BAF value was not included in the exposure models because mollusk samples were not collected at the Site. This mollusk BAF (3308.8) was based on a recommended bioconcentration factor (BCF) value from USEPA (1999) multiplied by the food chain multiplier (FCM). The recommended BCF was calculated using a regression equation (log BCF = 0.819 x log $K_{ow}$ - 1.146) due to the lack of available empirical data (USEPA 1999). According to USEPA (1995), a measured baseline BAF for an organic or inorganic chemical derived from a field study of acceptable quality is the most preferred method for deriving baseline BAFs. Conversely, deriving a baseline BAF from a predicted baseline BAF for an organic chemical derived from a $K_{ow}$ of acceptable quality and a FCM is the least preferred method. There is concern that the TDD of the raccoon is overly conservative due to the mollusk concentration being calculated with a non-empirically derived BAF. Using a non-empirically derived BAF to calculate concentrations that contribute the largest exposure source to the raccoon can be considered an overly conservative exposure assumption. This assumption supports the use of a LOAEL-based HQ for the raccoon (TCEQ 2005), which has a value less than one ($HQ_{[LOAEL]}$ = 0.70) and indicates acceptable risk levels for the raccoon in Scenario 10b.

The painted turtle was selected as a surrogate species for the state-threatened alligator snapping turtle due to the exposure information that is available for the surrogate species. However, there is considerable difference in the diet of these two species, with a majority carnivorous diet occurring in the alligator snapping turtle and a majority herbivorous diet occurring in the painted turtle. As dietary dose in the alligator snapping turtle is most likely to be attributable to fish, the dietary proportions were modified in the painted turtle exposure model to 100% fish. This change in dietary

exposure source resulted in an $HQ_{[NOAEL]}$ = 0.06, indicating acceptable risk levels for the alligator snapping turtle (painted turtle as surrogate) in Scenario 10b.

#### 2.4.8.2 ALUMINUM

Aluminum exposure resulted in unacceptable risk levels following a remediation according to Scenario 10b. The following HQs indicated unacceptable risk: american robin $HQ_{[GMATC}$ = 3.04, short-tailed shrew $HQ_{[GMATC]}$ = 1.11, belted kingfisher $HQ_{[GMATC]}$ = 32.78, marsh wren $HQ_{[GMATC]}$ = 11.39, spotted sandpiper $HQ_{[GMATC]}$ = 29.15, wood stork $HQ_{[NOAEL]}$ = 1.51, bullfrog $HQ_{[GMATC]}$ = 1.54, painted turtle $HQ_{[NOAEL]}$ = 1.28. While ingesting these concentrations did result in a HQ>1, it can be assumed that aluminum is not bioavailable to the receptors as most pH readings in the soil samples were above 7.0. This is based on the Eco-SSL for Aluminum (USEPA 2003) that states the following:

> *Because the measurement of total aluminum in soils is not considered suitable or reliable for the prediction of potential toxicity and bioaccumulation, an alternative procedure is recommended for screening aluminum in soils. The procedure is intended as a practical approach for determining if aluminum in Site soils could pose a potential risk to ecological receptors. This alternative procedure replaces the derivation of numeric Eco-SSL values for aluminum. Potential ecological risks associated with aluminum are identified based on the measured soil pH. Aluminum is identified as a COPC only at sites where the soil pH is less than 5.5 (EPA 2003).*

Soil pH levels at the Site indicate aluminum is not bioavailable to the receptors (USEPA 2003), therefore this COPEC is assumed to pose acceptable risk levels to the UTL receptors in Scenario 10b and under Site conditions. Based on these bioavailability factors, it was determined that aluminum did need to be carried forward in the FS.

#### 2.4.8.3 HEXAVALENT CHROMIUM

Exposure to hexavalent chromium resulted in unacceptable risk levels in Remediation Scenario 10b. The following HQs indicated unacceptable risk: belted kingfisher $HQ_{[GMATC]}$ = 4.23, spotted sandpiper $HQ_{[GMATC]}$ = 1.01, bullfrog $HQ_{[GMATC]}$ = 2.69, painted turtle $HQ_{[NOAEL]}$ = 1.04.

All receptors found to be at risk from hexavalent chromium exposure in Scenario 10b were receiving the largest source of risk from dietary items. Risk drivers to the belted kingfisher were consumption of fish (96.12% of TDD) and crustaceans (3.81% of TDD). Risk drivers to the spotted sandpiper were also consumption of fish (45.59% of TDD) and crustaceans (45.59% of TDD). The bullfrog was getting the largest daily dose from fish (78.64% of TDD) and insects (11.01% of TDD). Risk drivers to the painted turtle were consumption of fish (9.35% of TDD), insects (64.48% of TDD), vegetation (16.03% of TDD) and crustaceans (9.35% of TDD).

Site-specific BAFs were not able to be calculated for fish, crustaceans, or mollusk dietary items due to analytical rejections of the tissue. Due to this lack of Site-specific data, the dietary items RMEs were calculated with a literature-derived BAF. By not using a Site-specific BAF for these dietary items, it is likely the RMEs are not accurately predicting bioaccumulation of chromium VI in dietary items at the Site. This could lead to an overestimation of the predicted concentration in fish, crustaceans, and mollusks.

Additionally, UTL receptors that consume aquatic species may have an overestimated risk as biomagnification of chromium in aquatic food webs is reported to be insignificant (Agency for Toxic Substances and Disease Registry [ATSDR], 1993). The toxic effects of chromium are primarily found at the lower trophic levels. Chromium has been found to bioaccumulate in algae, other aquatic vegetation, and invertebrates, but it does not biomagnify. Further, hexavalent chromium is readily converted to trivalent chromium in animals, which appears to protect higher organisms from the effects of low level exposures (Eisler 1986).

TRV uncertainty and conservatism were found to be potentially an overly conservative factor in the HQ calculations. As no data were found regarding songbirds and passerines, the chicken TRV was used to extrapolate the TRV for the belted kingfisher and the spotted sandpiper by dividing by 5 to account for inter-taxon variability. The chicken TRV was also used to extrapolate the TRV for the bullfrog and painted turtle due to lack of exposure data. The chicken TRV was divided by an uncertainty factor of 10 to account for interclass variation. Using an uncertainty factor due to extrapolation between species and classes can result in an overly conservative TRV.

In addition to the use of literature-derived BAFs, the dietary item concentrations could also be inaccurate due to the sediment RME used in the calculation. The sediment RME used in the Sensitivity Analysis was not based on all sediment samples at the Site because 19 of the sediment samples (17% of the total) collected at the Site were rejected for analytical testing. Of the samples that were not rejected, only 12 percent had

detectable concentrations. Therefore, there is concern that the sediment RME is based not only on insufficient data but also on a large majority of detection limits. Sediment RMEs were calculated using half detection limits for the samples with non-detectable concentrations at the recommendation of the EPA due to the concern of high detection limits driving the sediment RME. The modified sediment RME did result in acceptable risk levels at the Site. Risk calculations were as follows: belted kingfisher $HQ_{[GMATC]}$ = 0.85, spotted sandpiper $HQ_{[GMATC]}$ = 0.98, and bullfrog $HQ_{[GMATC]}$ = 0.64. As dietary dose in the alligator snapping turtle is most likely to be attributable to fish, the dietary proportions were modified in the painted turtle exposure model to 100% fish. This change in dietary exposure source resulted in acceptable risk levels ($HQ_{[NOAEL]}$ = 0.62).

The modified exposure factors (diet in the painted turtle model and half detection limits for sediment non-detects in the spotted sandpiper, belted kingfisher, and bullfrog models) resulted in risk calculations that indicate acceptable risk levels at the Site for these receptors following remediation according to Scenario 10b. A lack of significant biomagnification in the UTL receptors consuming aquatic species indicates acceptable risk levels for these receptors as well.

#### 2.4.8.4 COPPER

Exposure to copper resulted in unacceptable risk levels following remediation according to scenario 10b. The following HQs indicate unacceptable risk: belted kingfisher $HQ_{[GMATC]}$ = 1.39 and spotted sandpiper $HQ_{[GMATC]}$ = 1.39. Risk drivers in the belted kingfisher were mainly from food ingestion (37.98% of TDD from fish, 4.98% of TDD from amphibians, and 56.99% of TDD from crustaceans). Risk drivers in the spotted sandpiper were due to ingestion of fish (15.01% of TDD), crustaceans (72.90% of TDD), and sediment (12.02% of TDD).

Of the 113 surface sediment samples evaluated, 12 had total SEM/AVS concentrations greater than 1.0. The freshwater samples included one location in Jefferson Canal (JC-13). The saltwater samples included one location in the Gulf States Utility Canal (GSUC-10), six locations in Molasses Bayou (MB-2, MB-12, MB-13, MB-23, MB-59, MB-63), three locations in Former Star Lake (SL-6, SL-7, SL-9), and one location in Star Lake Canal (SLC-6). Seven of these sediment samples have an ERM/PEL-Q Score >2, therefore will be remediated in Scenario 10b. The remaining 101 samples had total SEM values less than their AVS concentrations indicating that these metals in the sediment pore water are precipitated as a metal sulfide and are not likely to be bioavailable. It

can be assumed that metal concentrations will decrease in the remediated sample areas, leaving only five sediment samples at the Site with bioavailable copper concentrations.

Risk calculations that do not take into account the presence of metal sulfides at the Site likely overestimate risk to the receptors as copper concentrations are not largely bioavailable. This conservatism in the exposure models warrants the use of a LOAEL-based HQ for risk determination. The $HQ_{[LOAEL]}$ for the belted kingfisher and spotted sandpiper ($HQ_{[LOAEL]}$ = 0.622 for both species) indicates acceptable risk levels for these species exposed to Site-wide concentrations of copper following remediation according to Scenario 10b.

#### 2.4.8.5 MANGANESE

Exposure to manganese resulted in unacceptable risk in Remediation Scenario 10b. The following HQs indicated unacceptable risk: muskrat $HQ_{[GMATC]}$ = 2.97, belted kingfisher $HQ_{[GMATC]}$ = 1.49, painted turtle $HQ_{[NOAEL]}$ = 8.02. Risk to the muskrat was largely driven by vegetation in the diet (99.98% of TDD). Risk from manganese exposure in the belted kingfisher was also due to dietary items, but drivers were crustaceans (90.25%) and fish (8.43% of TDD). The painted turtle was determined to be at risk due to ingestion of vegetation (43.12% of TDD) and crustaceans (50.49% of TDD).

As dietary dose in the alligator snapping turtle is likely to come mostly from fish, the dietary proportions were modified in the painted turtle exposure model to 100% fish. This change in dietary exposure source resulted in acceptable risk levels ($HQ_{[NOAEL]}$ = 0.34).

TRV uncertainty was found to be a possible contributor to the risk calculations for manganese. The avian TRV was based on a 6-week (approximate test duration) value of 7.3 mg/kg-bw/day for guinea fowl exposed to manganese sulfate (Offiong and Abed 1980). This study was designed to assess the nutritional deficiencies of manganese and the maximum dose examined significantly improved the fertility, hatchability, and embryos of guinea fowl compared to controls. Therefore, the maximum dose examined (70 mg/kg feed; 7.3 mg/kg-bw/day) represents a required dose for successful reproduction and is likely considerably lower than a true NOAEL. As such, this value should be considered extremely conservative. For small mammals, the TRV was based on a 224 day NOAEL of 44 mg/kg-bw/day for rats exposed to manganese oxide in feed (Laskey et al. 1982). The 44 mg/kg-bw/day TRV was a no-effect concentration based on fertility (percent pregnant). However, a NOAEL based on litter size, ovulations,

resorptions, preimplantation deaths, and fetal weights was reported as 158-316 mg/kg-bw/day. No data were found on a medium mammal TRV. Therefore, the small mammal TRV was divided by 5 to account for inter-taxon variability to represent a conservative medium mammal TRV. No data were found on reptile or amphibian exposure to manganese, therefore the avian TRV was used for extrapolation by dividing by an uncertainty factor of 10 to account for interclass variation, resulting in a TRV of 0.73 mg/kg-bw/day. As the avian TRV is likely an overly conservative value, adding an additional uncertainty factor for extrapolation to reptiles and amphibians is also very likely to be an overly conservative measure of risk.

Because TRV uncertainty was found to be a likely contributor of risk in the Scenario 10b calculations, the Scenario 10b exposure models were recalculated with TRVs that were developed according to the U.S. Ecological Soil Screening Levels (Eco-SSL) guidance (USEPA 2003) and provided in Eco-SSLs for Manganese (USEPA 2007). These values were developed by a multi-stakeholder group led by the U.S. EPA Office of Solid Waste and Emergency Response (OSWER) and are derived to be protective of the conservative end of the exposure and effects species distribution (USEPA 2007). TRVs previously used in the Scenario 10b exposure models for the muskrat and belted kingfisher were replaced by TRVs for mammalian and avian species, respectively, found in the Eco-SSL for Manganese (EPA 2007). The Eco-SSL avian TRV (179 mg manganese/kg bw/day) is based on the geometric mean of the reported NOAELs for growth and reproduction in 21 studies approved according to Eco-SSL guidance. The Eco-SSL mammal TRV (51.5 mg manganese/ kg bw/day) is based on the geometric mean of the reported NOAELs for reproduction and growth in 58 studies approved according to Eco-SSL guidance. Using these less conservative TRVs in the Scenario 10b risk evaluation, manganese exposure to the muskrat and belted kingfisher was determined to be at acceptable risk levels following the Scenario 10b remediation (muskrat $HQ_{[GMACT]}$ = 0.51, belted kingfisher $HQ_{[GMACT]}$ = 0.061).

It was then determined that all of the exposure models that calculated risk at the Site for the BERA should also be reevaluated using the Eco-SSL TRVs because an EPA-derived and recommended TRV is preferable to the overly conservative TRVs used in the Tier 2 RI BERA. Therefore, all avian exposure models from the Tier 2 RI BERA were recalculated with the avian Eco-SSL TRV. All mammal exposure models from the Tier 2 RI BERA were also recalculated with the Eco-SSL mammal TRV. Reptile and amphibian exposure models from the Tier 2 RI BERA were recalculated using a TRV that was extrapolated from the Eco-SSL avian TRV by dividing by an uncertainty factor of 10 to account for interclass variation (NOAEL TRV = 17.9 mg manganese/ kg bw/ day). This

extrapolation was necessary because reptile and amphibian TRVs are not provided in the Eco-SSLs for Manganese (USEPA 2007).

The revised HQs that were calculated with Eco-SSL TRVs were compared to the HQs reported in the Tier 2 RI BERA. Eight of the 15 receptors showed risk from manganese exposure when calculated with the Tier 2 RI BERA TRVs. In contrast, none of the receptors showed risk from manganese exposure when calculated with the Eco-SSL TRVs. The risk characterization of UTL ROCs at the Site was determined to be more realistic when exposure models used the EPA-derived Eco-SSL TRVs. These revised HQs that were calculated with the Eco-SSL TRVs showed that manganese does not pose risk to UTL ROCs at the Site and therefore, this COPEC was not carried forward in the FS.

### 2.4.9 CONCLUSIONS

Remediation scenarios in the Sensitivity Analysis were chosen for their potential contribution to a reduction in risk to UTL receptors and/or benthic invertebrates. Risk calculations for COPECs showing unacceptable risk as a result of conservative measures were modified to provide a more realistic prediction of risk to UTL receptors following remediation. These modifications included adjustments to the dietary components of the alligator snapping turtle surrogate species (painted turtle), using the $HQ_{[LOAEL]}$ to measure risk, using soil pH levels and AVS/SEM ratios to determine bioavailability, setting non-detect sample concentrations at half detection limits, and using a more appropriate manganese TRV for avian and mammals. With these modifications, all COPECs were found to pose acceptable risk levels following remediation based on Scenario 10b (Table 2-8). Aluminum and manganese were determined to pose acceptable risk levels at the Site for all ROCs based on bioavailability and Eco-SSL TRVs, respectively. Therefore, aluminum and manganese were not carried forward in the FS. Scenario 10b was recommended by the EPA, TCEQ, and trustees as the remediation scenario to be evaluated in the FS.

## 3.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

The following sections present the RAOs, Applicable or Relevant and Appropriate Requirements (ARARs), COCs, and PRG, and general response actions for the FS. This section also includes the screening of potential technology types and process options against effectiveness, implementability, and cost.

### 3.1 REMEDIAL ACTION OBJECTIVES

Identification of RAOs is the first step in the CERCLA FS process following the RI. RAOs specify the COCs, medium where COCs were found, exposure pathways, and goals that will take into account a myriad of scenarios to achieve the final objective. The RAOs were developed based on a conglomeration of information presented in the Tier 1 and Tier 2 RI documents and the Alignment document. In addition to these documents, the RAOs were written in accordance with the Site chemical-, location-, and action-specific ARARs that are discussed in Section 3.1.1. In the BERA, data and modeling validated the risk to benthic organisms and upper trophic level receptors while eliminating or invalidating the risk to human receptors as it pertains to this Site. The conclusion and focus of the remediation activity was determined to be concentrated on the ecological exposure risk to benthic organisms and upper trophic level receptors as it was deemed to be an unacceptable risk of exposure to toxic chemicals and metals found in the sediment and soil in which these organisms live.

The RAOs for the Site follow:

Ecological

- Protect benthic invertebrates by reducing direct contact exposure with COCs (Table 3-4A) in areas where sediment is designated as medium-high or high using the ERM-Q/PEL-Q method (A detailed discussion of the COCs is provided in Section 3.1.2 below.)
- Protect UTL receptors by reducing ingestion/direct contact with sediment concentrations in excess of PRGs (Table 3-4A) in areas where sediment is designated as medium-high or high using the ERM-Q/PEL-Q method. (A detailed discussion of the COCs is provided in Section 3.1.2 below.)
- Protect UTL receptors by reducing or eliminating exposure to COCs (Table 3-4B) in soil from the Jefferson Canal Spoil Pile. (A detailed discussion of the COCs is provided in Section 3.1.2 below.)

Human Health

- The HHRA identified human health risk that was not sufficient to require establishment of a human health RAO.

### 3.1.1 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS)

As defined by CERCLA Section 121, specified remedial actions shall be protective of human health and the environment. ARARs and to-be-considered materials (TBC) have been used to specify the level of protection of human health and the environment.

ARARs are requirements established under Federal or State environmental laws that are either "applicable" or "relevant and appropriate".

Applicable requirements are remediation standards, standards of control, and other substantive environmental protection requirements, criteria, or restrictions that address the specific situation at a CERCLA site regarding the hazardous substance, chemical, remedial actions, location, or other characteristics of the site.

Relevant and appropriate requirements address problems or situations sufficiently similar although not specific to the characteristics at the Site. In situations that a requirement is relevant but not appropriate due to specific characteristics of the Site, the requirement is not an ARAR for the Site.

A two-step process is used to identify ARARs on a Site-specific basis. The first step in the process is determining whether the requirement is applicable. If the requirement is not applicable, then the second step in the process is to determine whether the requirement is both relevant and appropriate.

TBCs are guidance, criteria, and advisories issued by the Federal or State government that are not publicized or legally binding. Although TBCs do not have the status of potential ARARs, TBCs may be useful in determining the required level of cleanup for protection of human health and the environment.

Based on CERCLA guidance, ARARs were classified into three types during the FS.

- Chemical-specific requirements – These requirements define acceptable concentrations of a chemical that may be present in the environment or released to the environment (Table 3-1).
- Location-specific requirements – These requirements restrict concentrations of hazardous material and remediation activities based on the specific site location. These locations include sensitive or hazard-prone areas such as active fault zones, wildlife habitat and flood plains (Table 3-2).
- Action-specific requirements – These requirements control activities and technologies selected relative to remediating the Site (Table 3-3).

ARARs will be one of the nine criteria that are used to evaluate remedial alternatives at the Site. Section 121(d) of CERCLA stipulates that remedial actions instituted under the Superfund program comply with ARARs. Consideration must also be given to relevant information that, while not legally binding, is collectively referred to as to be considered (TBC) information. TBCs may or may not be promulgated standards and not legally enforceable but may contribute to the development and implementation of effective and protective remedial alternatives.

The ARARs that were identified as being applicable for the Site RI/FS include CERCLA, Texas Commission on Environmental Quality, the Toxic Substances Control Act (TSCA), the Resource Conservation Recovery Act (RCRA), the Occupational Safety and Health Administration (OSHA), Hazardous Materials Transportation Act, Floodplain Management, Protection of Wetlands, National Historical Preservation Act, Endangered Species Act of 1973, Rivers and Harbors Act of 1899, and the Fish and Wildlife Coordination Act requirements.

As summarized in Table 3-1, Table 3-2, and Table 3-3, the ARARs are defined and classified into categories based on chemical-specific, location-specific, and action-specific requirements.

### 3.1.2 CONSTITUENTS OF CONCERN

Physical and chemical properties, environmental fate and transport, as well as toxicity, differ among the COCs for which PRGs have been developed. The purpose of this section is to summarize the characteristics of these COCs and their general toxicity concerns.

## POLYCYCLIC AROMATIC HYDROCARBONS (PAHs)

The compounds 2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, and pyrene belong to the group of compounds known as PAHs and are defined as hydrocarbons containing two or more aromatic rings. PAHs are released into the environment from both natural and manmade sources and are common constituents of petroleum hydrocarbon mixtures such as diesel, motor oil, and asphalt.

In general, PAHs have low water solubility and may increasingly adsorb to soil, sediment, or suspended solid particles within water with increasing organic carbon content. Adsorption is also directly dependent on particle size. Smaller particles with higher surface area to volume ratios are more efficient at adsorbing PAHs. PAH compounds are more mobile in systems with small amounts of organic carbon. Adsorption to soil particles is the primary process responsible for the removal of PAHs from aqueous systems. The Henry's Law constant ($K_H$) ranges from $10^{-4}$ to $10^{-8}$ atmospheres per cubic meter per mole (atm-$m^3$/mol) for individual PAHs. The soil organic carbon water partition coefficient $K_{oc}$ values for the high molecular weight PAHs are in the range of $10^5$ to $10^6$, which indicates a strong tendency to adsorb to organic carbon present in soil and sediment. The high adsorption potential of PAHs to soil and sediment explains the frequency with which PAHs were detected in soil and sediment samples at the Site.

### *Toxicity*

The toxicity of PAHs is generally expressed relative to the toxicity of benzo(a)pyrene. In addition to benzo(a)pyrene, six other PAHs, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenzo(a,h)anthracene, chrysene, and ideno(1,2,3-cd)pyrene are classified by the EPA as probable human carcinogens. These other compounds have been estimated to be approximately 1 to 1,000 times less carcinogenic than benzo(a)pyrene, therefore the toxicological information for benzo(a)pyrene is discussed herein.

Benzo(a)pyrene is readily absorbed after inhalation, oral, and dermal routes of exposure. The metabolism of benzo(a)pyrene is complex and includes the formation of benzo(a)pyrene-7,8-diol-9,10-epoxide which is classified as a proposed carcinogen by the EPA. No data is available on the noncarcinogenic effects of benzo(a)pyrene in humans.

Numerous epidemiologic studies have shown a clear association between exposures to various mixtures (e.g., coke oven emissions, roofing tar emissions, and cigarette smoke) of PAHs containing benzo(a)pyrene and an increased risk of lung cancer and other tumors. However, each of the mixtures also contained other potentially carcinogenic PAHs, therefore, it is not possible to evaluate the contribution of benzo(a)pyrene alone to the carcinogenity of these mixtures.

## POLYCHLORINATED BIPHENYLS (PCBS)

PCBs are a class of organic compounds with 1 to 10 chlorine atoms attached to biphenyl, which is a molecule composed of two benzene rings. PCBs are, in general, highly resistant to chemical or biological transformation. They exhibit a relatively high degree of persistence in the environment and biomagnification in aquatic and terrestrial food chains and are thus treated as a special class of compounds. PCBs are insoluble in water and will partition from the water column and adsorb strongly to sediments and suspended matter. The solubility of PCBs decreases with increases in chlorination. The organic carbon partition coefficient is higher for the higher chlorinated isomers, which indicates they will sorb more strongly. PCBs volatilize from water. PCBs of the higher chlorinated biphenyl groups (e.g., higher than the tetrachlorinated biphenyls) do not significantly biodegrade in soils, especially those with high organic carbon content. In sediment, there appears to be a potential for anaerobic biodegradation, which is determined by congener reactivity. Biomagnification via impacted food is the principle route of uptake for low water-soluble compounds like PCBs. The major source to plant vegetation is through contact with volatilized PCBs in the air.

### *Toxicity*

PCBs have been classified by the EPA as probable human carcinogens. The toxicity of PCBs increases with length of exposure and position of the exposed species in the food chain. PCBs can affect mortality, can have adverse effects on reproduction, and can cause behavioral changes in terrestrial wildlife. In aquatic systems, PCBs can affect reproduction and endocrine function in fish and semi-aquatic birds and mammals, primarily through interference of the aryl hydrocarbon receptor (AHR). The primary effects of PCBs in aquatic systems occur at the higher trophic levels of the food web through uptake by benthic invertebrates and bioconcentration because benthic invertebrates lack the AHR.

The toxicity of the various PCB mixtures is also dependent on their composition. The coplanar PCBs are known as non-ortho PCBs because they are not substituted at the ring

positions ortho to (next to) the other ring, (i.e., PCB congeners 77, 126, 169, etc.). The non-ortho PCBs tend to have dioxin-like properties, and generally are considered among the most toxic congeners. Because of this property, the toxicity of these congeners is related to that of 2,3,7,8-tetrachlorodibenzo[p]dioxin (TCDD) through the use of toxic equivalency factors (TEFs), where the more toxic PCB congeners are assigned higher TEF values. TCDD is assigned a TEF of 1.

## METALS

### ANTIMONY

Antimony is a silvery-white metal that is found in the earth's crust. Antimony ores are mined and then mixed with other metals to form antimony alloys or combined with oxygen to form antimony oxide. The United States currently mines very little antimony, and therefore it is brought in from other countries for processing. However, there are companies in the United States that produce antimony as a by-product of smelting lead and other metals. Antimony is not used alone because it breaks easily, but when mixed into alloys, it is used in lead storage batteries, solder, sheet and pipe metal, bearings, castings, and pewter. Antimony oxide is added to textiles and plastics to prevent them from catching fire. It is also used in paints, ceramics, and fireworks, and as enamels for plastics, metal, and glass. Antimony is released to the environment from natural sources and from industry. Antimony also enters the environment during the mining and processing of its ores and in the production of antimony metal, alloys, antimony oxide, and combinations of antimony with other substances. Small amounts of antimony are also released into the environment by incinerators and coal-burning power plants. The antimony that comes out of the smoke stacks of coal-burning power plants is attached to very small particles that settle to the ground or are washed out of the air by rain. Antimony cannot be destroyed in the environment; it can only change its form or become attached to or separated from particles. Most antimony will end up in the soil or sediment, where it attaches strongly to particles that contain iron, manganese, or aluminum (ATSDR 1992).

#### *Toxicity*

Exposure to antimony at high levels can result in a variety of adverse health effects. Breathing high levels for a long time can irritate your eyes and lungs, and cause heart and lung problems, stomach pain, diarrhea, vomiting, and stomach ulcers. In short-term studies, animals that breathed very high levels of antimony died. Animals that breathed high levels of antimony had lung, heart, liver, and kidney damage. In long-term studies, animals that breathed very low levels of antimony had eye irritation, hair loss, lung damage, and heart problems. In addition, problems with fertility were also noted. In

animal studies, problems with fertility have been seen when rats breathed very high levels of antimony for a few months. Long-term animal studies have reported liver damage and blood changes when animals ingested antimony. Antimony can irritate the skin if it is left on it (ATSDR 1992). It is known that ingesting large doses of antimony can cause vomiting, but other effects are unknown.

Antimony does not appear to bioconcentrated appreciably in fish and aquatic organisms. Uptake from soil is minor and appears to be correlated with the amount of available antimony (that which is soluble or easily exchangeable). Antimony does not biomagnify from lower to higher trophic levels in the food chain (ATSDR 1992).

**ARSENIC**

Arsenic is a naturally occurring element that is widely distributed in the earth's crust. Arsenic is classified chemically as a metalloid, having both properties of metals and nonmetals. It has oxidation states of +1, +2, +3, +5, and -3. Elemental arsenic is a steel grey solid material; however, arsenic is usually found in the environment combined with other elements such as oxygen, chlorine, and sulfur. Arsenic combined with carbon and hydrogen is referred to as organic arsenic.

Until December 31, 2003, inorganic arsenic compounds were primarily used to preserve wood. Copper chromated arsenic (CCA) was used to make "pressure-treated" lumber. CCA is no longer used in the U.S. for residential purposes. In the past, inorganic arsenic compounds were predominantly used as pesticides, primarily on cotton fields and in orchards. Inorganic arsenic compounds are no longer used in agriculture. However, some organic arsenic compounds are still used in pesticides.

Arsenic cannot be destroyed in the environment; itt can only change its form or become attached to or separated from particles. Arsenic may be transported by wind or in runoff or may leach into subsurface soil. Arsenic is largely immobile in soil; therefore, it tends to concentrate and remain in the upper soil layers. Transport and partitioning of arsenic in water depends upon the chemical form. Soluble forms move with the water and may be carried long distances. Arsenic may be adsorbed from water onto sediment or soil particles.

***Toxicity***

The Department of Health and Human Services (DHHS) and the EPA have determined that inorganic arsenic is a known human carcinogen. Inhalation is the predominant occupational exposure route. For the general population, diet is the largest source of exposure. Dermal uptake is a minor route of exposure.

Inhalation of inorganic arsenic may cause respiratory irritation, nausea, skin effects, and increased risk of lung cancer. Acute oral exposure to inorganic arsenic may cause nausea, vomiting, diarrhea, cardiovascular effects, and encephalopathy. Long-term exposure to low levels of arsenic may cause dermal effects and a peripheral neuropathy characterized by numbness in the hands and feet. There may also be increased risk of skin, bladder, and lung cancer. In most species, including humans, ingested organic arsenic compounds undergo limited metabolism, do not readily enter the cell, and are primarily excreted unchanged in urine.

**CADMIUM**

Cadmium is a natural metal in the earth's crust and is usually found as a mineral combined with other elements such as oxygen (cadmium oxide), chlorine (cadmium chloride), or sulfur (cadmium sulfate, cadmium sulfide). Soils and rocks, including coal and mineral fertilizers, usually contain some cadmium. Most cadmium used in the United States is extracted during the production of other metals like zinc, lead, and copper. Cadmium does not corrode easily and has many uses, including batteries, pigments, metal coatings, electroplating and plastics. Cadmium is also found in some industrial paints and may represent a hazard when sprayed. Cadmium emits a characteristic brown fume (CdO) upon heating, which is relatively non-irritating, and thus does not alarm the exposed individual. Several deaths from acute exposure have occurred among welders who have unsuspectingly welded on cadmium-containing alloys or worked with silver solders (ATSDR 2008).

In the environment, cadmium enters soil, water, and air from mining, industry, and burning coal and household wastes. Cadmium can change forms in the environment, but does not break down and airborne particles can enter the ground and water. In the ground cadmium binds strongly to soil particles and some forms can dissolve. Thus, fish, plants, and animals can take up cadmium from their environments (ATSDR 2008).

***Toxicity***

Cadmium is an extremely toxic metal commonly found in industrial workplaces, particularly where any ore is being processed or smelted. In addition to industrial exposure, low levels of cadmium are found in many foods (particularly shellfish, liver and kidney meats) as well as cigarette smoke. Breathing high levels of cadmium can severely damage the lungs. Eating food or drinking water with very high levels severely irritates the stomach, leading to vomiting and diarrhea. Long-term exposure to lower levels of cadmium in air, food, or water leads to a buildup of cadmium in the kidneys and possibly lead to kidney disease. Other long-term effects are lung damage and

fragile bones. DHHS has determined that cadmium and cadmium compounds are known human carcinogens (ATSDR 2008).

A few studies in animals indicate that younger animals absorb more cadmium than adults and that the young are more susceptible than adults to a loss of bone and decreased bone strength from exposure to cadmium. It is unknown whether cadmium causes birth defects in humans, however offspring of animals exposed to high levels of cadmium during pregnancy had changes in behavior and learning ability. There is also some information from animal studies that high enough exposures to cadmium before birth can reduce body weight and affect the skeleton in the developing young (ATSDR 2008).

**CHROMIUM**

Environmental concentrations of chromium are attributable to both natural and anthropogenic sources, with the largest contribution coming from industrial releases. The primary contributing industries include metal processing, tannery facilities, chromate production, stainless steel welding, and ferrochrome and chrome pigment production. The estimated atmospheric chromium levels in the United States urban and nonurban areas typically reflect mean total chromium concentrations ranging from 5 to 525 nanograms per cubic meter ($ng/m^3$). Chromium concentrations in United States fresh waters typically range from <1 to 30 micrograms per liter (µg/L), with a median value of 10 µg/L.

Chromium concentrations in typical United States drinking water supplies range from 0.2 to 35 µg/L; however, most supplies in the United States contain less than 5 µg/L. Specifically related to chromium VI, recent monitoring data from California, indicated that 86 percent of drinking water supplies tested had chromium VI levels below 10 µg/L. Total chromium in U.S. soils ranges from 1 to 2,000 milligrams per kilogram (mg/kg), with a mean concentration of 37 mg/kg. The mean total chromium level in ocean water is 0.3 µg/L (ATSDR 2008).

***Toxicity***

The primary adverse health effects associated with chromium VI exposure are respiratory, gastrointestinal, immunological, hematological, reproductive, and developmental in nature. In addition, direct contact with chromium VI may result in dermal and ocular irritation. Available dose-response data in humans and animals suggest that the most sensitive noncancer effects of chromium VI compounds are respiratory (nasal and lung irritation, altered pulmonary function), gastrointestinal (irritation, ulceration and non-neoplastic lesions of the stomach and small intestine),

hematological (microcytic, hypochromic anemia), and reproductive (effects on male reproductive organs, including decreased sperm count and histopathological change to the epididymis) (ATSDR 2008).

The primary effects of chromium III compounds are respiratory and immunological in nature. Respiratory effects appear to be portal-of-entry effects for inhalation exposure. Similarly, chromium allergic dermatitis, which is the major immunological effect of chromium III, typically results from dermal contact in sensitized individuals. The initial sensitization, however, may result from one or more of the following exposure routes alone or in combination: inhalation, oral, or dermal exposure. Conflicting results have been reported from developmental and reproductive animal studies of chromium III compounds. These results do, however, provide evidence of adverse effects on the developing and adult reproductive system. No evidence of developmental or reproductive effects of chromium III in humans has been identified. Based on results of chronic-duration oral studies in animals, chromium III compounds (chromium acetate, chromium chloride, chromium nicotinate, chromium oxide, chromium picolinate) do not appear to produce gastrointestinal, hematological, hepatic, renal, cardiovascular, endocrine, or musculoskeletal effects (ATSDR 2008).

**COPPER**

Copper occurs naturally throughout the environment, in rocks, soil, water, and air and is an essential element in plants, animals, and humans. Copper is used to treat plant diseases, for water treatment and as a preservative in wood, leather, and fabrics. Copper is also used to make products like wire, plumbing pipes, and sheet metal. United States pennies made before 1982 are made of copper while those after 1982 are only coated with copper.

Copper is released into the environment by mining, farming, and manufacturing operations and through wastewater releases into lakes and rivers. Natural sources of copper releases include windblown dusts, decaying vegetation, forest fires, and volcanoes. Once in the environment, copper usually attaches to particles made of organic matter, clay, soil, or sand, and it does not breakdown (ATSDR 2004).

***Toxicity***

Copper exposure can occur through breathing air, drinking water, or eating foods containing copper. Drinking water in homes can contain high levels of copper if the home has copper pipes and acidic water. In addition, lakes and rivers that have been treated with copper compounds to control algae or receive cooling water from power plants can have high levels of copper. Exposure through the soil typically occurs in

areas near copper smelting plants. Copper is primarily ingested via copper-containing fungicides or in areas near copper mines or copper processing plants (ATSDR 2004).

While small amounts of copper are ingested daily and are essential for good health, high levels can be harmful. Breathing high levels of copper can cause irritation of your nose and throat and ingesting high levels of copper can cause nausea, vomiting, and diarrhea. Very-high doses of copper can cause damage to your liver and kidneys, and can even cause death. It is unknown whether copper can cause cancer in humans and the EPA has determined that copper is not classifiable as to human carcinogenicity. Further, it is unknown if copper causes birth defects or other developmental defects though studies in animals suggest a potential decrease in fetal growth. There is a small percentage of infants and children who are unusually sensitive to copper and studies in animals indicate that young children may have more severe, albeit the same, effects than adults but this is unproven in humans (ATSDR 2004).

**LEAD**

Lead is a naturally occurring metal found in the earth's crust, typically in the range of 15–20 mg/kg. In comparison to aluminum and iron, the two most abundant metals in the earth, lead is relatively uncommon. Lead is rarely found in its elemental state and most commonly occurs in the form of its +2 oxidation state in various ores. The most important lead containing ores include the following: galena (PbS), anglesite ($PbSO_4$), and cerussite ($PbCO_3$). The world's lead reserves, over one third of which are located in North America, are estimated at $7.1 \times 10^7$ tons. An observed increase in environmental lead levels, not associated with ore deposits, over the past three centuries is attributable to human activity. Lead exposure is common in humans as a result of the widespread use of this metal. The largest ongoing industrial use of lead is the production of lead batteries, which are largely used in the automobile industry. Other uses include the production of lead alloys, soldering materials, shielding for x-ray machines, and in the manufacture of corrosion and acid resistant building materials (ATSDR 2007).

***Toxicity***

The health effects of lead on human health are well documented. The toxicity of lead to humans has been known for centuries. Only during the past few decades, however, has it been established that exposure resulting in relatively low levels of lead in blood (e.g., <20 micrograms per deciliter (µg/dL) is associated with adverse effects in the developing organism. Most modern data regarding lead toxicity originates from occupational studies covering a variety of industries and also from studies of the general population, encompassing both adults and children. The most sensitive targets for lead toxicity include: the developing nervous system, the hematological and cardiovascular

systems, and the kidneys. Due to the multi-modes of action of lead in biological systems, however, lead has the potential to affect any system or organ in the body (ATSDR 2007).

**MERCURY**

Mercury is a naturally occurring element and exists in the environment in several forms: metallic or elemental mercury, inorganic mercury, and organic mercury. Mercury is naturally released into the environment as a by-product of erosion of rocks and soil, and from volcanic activity. Human industrial activities such as mining and burning of fossil fuels have resulted in additional environmental releases of mercury. Metallic mercury in its pure form is a shiny, silver-white liquid metal at room temperature, often used in thermometers and some electrical switches. Even at room temperature a certain amount of the metallic mercury will evaporate and form colorless, odorless vapors. Liquid metallic mercury releases more vapors at increasingly higher temperatures. Some people have reported a metallic taste in their mouths after breathing mercury vapors. Metallic mercury has been found at numerous hazardous waste sites across the United States. Inorganic mercury compounds (mercury salts) occur when the element combines with others such as chlorine, sulfur, or oxygen. Most of these mercury salts appear as white powders or crystals, except for mercuric sulfide (also known as cinnabar) which is red and turns black after exposure to light. When mercury combines with carbon it forms compounds called organomercurials, the most common of which is methylmercury (also known as monomethylmercury). In their pure form methylmercury and phenylmercury appear as white crystalline solids, whereas dimethylmercury is a colorless liquid. The most commonly occurring natural forms of mercury in the environment include metallic mercury, mercuric sulfide (cinnabar ore), mercuric chloride, and methylmercury. Methylmercury is produced primarily by microorganisms (bacteria and fungi) in the environment, rather than by human activity. Concern surrounding methylmercury is due to its tendency to bioaccumulate in various edible freshwater and saltwater fish and marine mammals (ATSDR 1999).

***Toxicity***

Most of the studies concerning inhalation exposure to mercury focus on metallic mercury vapor since other forms of inorganic mercury do not pose a risk by the inhalation pathway. Systemic toxicity in both humans and animals has been reported in association with inhalation of metallic mercury vapor, with the kidneys and the central nervous system as major target organs. Respiratory, cardiovascular, and gastrointestinal effects have also been reported in relation to high-exposure levels. Death from respiratory failure in humans has been reported following accidental acute exposure to high, but unspecified, metallic mercury vapor concentrations. Deaths in humans have

also been reported in case studies of occupational exposure to alkyl mercury compounds; while the cause of death was not reported, most subjects died following development of profound neurotoxicity (ATSDR 1999).

**SELENIUM**

Selenium is an essential micronutrient for humans and animals that is found ubiquitously in the environment, being released from both natural and anthropogenic sources. The principal release of selenium into the environment from anthropogenic sources is from coal combustion. Natural sources of selenium include the weathering of selenium-containing rocks and soils, and volcanic eruptions. Selenium is found in most rocks and soils, and naturally occurs at low concentrations in surface waters and groundwaters of the United States. Accumulation of selenium in agricultural drainage waters has been documented in basins in the western United States, particularly in California. Ambient background concentrations of selenium in the air are very low, generally in the $ng/m^3$ range. Exposure of the general population to selenium is primarily by ingestion of its organic and inorganic forms, both of which occur naturally in the diet. Other exposure pathways for selenium, which are of lesser importance, are water and air. Various estimates of the selenium intake for Americans have ranged from 0.071 to 0.152 mg selenium/day (approximately 1 to 2 microagrams per kilogram per day [µg/kg/day] in adults). Some people living in areas with high soil concentrations of selenium (as in areas of the western United States) might have higher exposure because of the natural selenium levels found locally, particularly if they consume crops primarily grown in that area. Metal industry workers, health service professionals, mechanics, and painters may be exposed to higher levels of selenium than the general population or workers employed in other trades (ATSDR 2003).

***Toxicity***

Depending upon the level of intake, selenium can have both nutritional and potentially toxic effects. While excessive intake of selenium can result in adverse health effects, such toxicity is generally observed at doses over 5 times greater than the Recommended Dietary Allowance (RDA) established by the Food and Nutrition Board of the National Research Council (National Academy of Sciences). The current RDA for selenium is 55 µg/day for male and female adults (approximately 0.8 µg/kg/day). Chronic oral intake of selenium at 10 to 20 times higher than normal levels can produce selenosis in humans, with major health effects being dermal and neurological in nature. Intermediate and chronic oral exposure of livestock to high levels of dietary selenium compounds has been reported to produce dermal and neurological effects. Studies in rats and other laboratory animals with high selenium tissue concentrations demonstrate that many organ systems retain selenium and are affected. The primary adverse effects

reported in laboratory animals exposed to inorganic selenium salts or to selenium-containing amino acids are cardiovascular, gastrointestinal, hematological, hepatic, dermal, immunological, neurological, and reproductive in nature. Doses required to cause these effects, however, are generally at least 5 times higher than normal daily selenium intake. Acute oral exposure to extremely high levels of selenium (e.g., several thousand times more than normal daily intake) produces nausea, vomiting, and diarrhea in both humans and laboratory animals and has occasionally caused cardiovascular symptoms, such as tachycardia. Acute- and intermediate-duration oral exposure to very large amounts of selenium (approximately 100 times normal human intake) has produced myocardial degeneration in laboratory animals (ATSDR 2003).

Cases of acute, high-level inhalation exposure of humans and laboratory animals to selenium dusts or fumes have resulted in toxicity to the lung, with cardiovascular, hepatic, nervous, and renal involvement as well. There are reports of acute occupational exposures to high concentrations of elemental selenium dust resulting stomach pain and headaches; also workers acutely exposed to elevated levels of selenium dioxide dust reported respiratory symptoms such as pulmonary edema, bronchial spasms, symptoms of asphyxiation and persistent bronchitis, elevated pulse rates, lowered blood pressure, vomiting, nausea, and irritability. No health effects data is available for humans or laboratory animals in relation to intermediate-duration (up to 1 year) inhalation exposure to selenium or selenium compounds. Several occupational studies are available regarding chronic inhalation exposure, reporting respiratory effects such as irritation of the nose, respiratory tract, and lungs, bronchial spasms, and coughing following exposure to selenium dioxide or elemental selenium as dust. Similar respiratory symptoms have also been reported in animal studies following inhalation exposures to high doses of elemental selenium fumes or dust (ATSDR 2003).

**SILVER**

Silver is a rare metal and one of the basic elements that make up the earth's crust. While silver occurs naturally in the environment as a soft, "silver" colored metal, it also occurs in compounds with either a powdery white (silver nitrate and silver chloride) or dark-gray to black (silver sulfide and silver oxide) color. Silver in its metallic form is commonly used to make jewelry, silverware, electronic equipment, and dental fillings. Silver compounds may be found at various environmental media at hazardous waste sites across the United States. Historically, photographers have used silver compounds to make photographs, with photographic materials being the major source of the silver that is released into the environment. Another source of environmental releases of silver is mining of silver and also other metals. Natural erosion and wearing down of

silver-bearing rocks and soil by the wind and rain also releases large amounts of silver into the environment (ATSDR 1990).

***Toxicity***

Published human studies regarding inhalation of silver are predominantly based on exposure to elemental silver, silver nitrate, and silver oxide. Human data for oral exposures come from information on medicines containing silver, such as silver acetate-containing antismoking lozenges, breath mints coated with silver, and silver nitrate solutions for treating gum disease. Animal studies are usually based on exposure to silver nitrate and silver chloride in drinking water (ATSDR 1990).

Respiratory effects have been observed infrequently in humans following inhalation of silver compounds. Reported effects include respiratory irritation and abnormal lung function. Workers have also reported abdominal pain following exposure to silver nitrate and oxide in the workplace, with exposure levels estimated to be between 0.039 and 0.378 milligram per cubic meter ($mg/m^{3)}$ silver. Occupational exposure to silver metal dust has been associated with increased excretion of a particular renal enzyme, and with decreased creatinine clearance, both effects being diagnostic of marginally impaired renal function. Workers have also reported skin and ocular burns caused by contact with silver nitrate. Gray or blue-gray discoloration of the skin has been observed in individuals that have ingested both metallic silver and silver compounds in small doses over periods of months to years. Several reports describe the deposition of silver containing granules in central nervous system tissues. Several medical case histories indicate that extended dermal exposure to silver or silver compounds can lead to localized skin discoloration similar in nature to the pigmentation reported after repeated oral exposure. Decreased body weight gain was observed in guinea pigs following dermal application of 81 mg silver nitrate (2 milliliter [mL] of a 0.239 Molar [M] solution) to 3.1 square centimeter ($cm^{2)}$ of skin. Medical case histories describe mild allergic responses attributed to repeated dermal contact with silver and silver compounds (ATSDR 1990).

**VANADIUM**

Vanadium is the 22nd most abundant element in the earth's crust and is widely distributed. It occurs in nature as a white-to-gray metal, and is often found in the form of crystals. Vanadium usually combines with other elements such as oxygen, sodium, sulfur, or chloride. It has oxidation states of +2, +3, +4, and +5. Because of its high melting point, it is referred to as a refractory metal. Most of the vanadium used in the United States is used to make steel.

Vanadium cannot be destroyed in the environment. It can only change its form or become attached to or separated from particles. Vanadium particles in the air settle to the ground or are washed out of the air by rain. Smaller particles, such as those emitted from oil-fueled power plants, may stay in the air for longer periods of time and are more likely to be transported farther away from the site of release. The transport and partitioning of vanadium in water and soil is influenced by many factors including acidity of the water or soil and the presence of particulates. Vanadium can either be dissolved in water as dissolved ions or may become adsorbed to particulate matter.

***Toxicity***

The DHHS and the EPA have not classified vanadium as to its human carcinogenicity. Exposure to vanadium may cause harmful health effects. The major effects from breathing high levels of vanadium are on the lungs, throat, and eyes. Breathing air with vanadium pentoxide can result in coughing which can last for a number of days after exposure. Vanadium is not readily absorbed by the body from the stomach, gut, or contact with the skin. However, nausea, mild diarrhea, and stomach cramps have been reported in people taking sodium metavanadate or vanadyl sulfate for experimental treatment of diabetes.

**ZINC**

Zinc is one of the most common elements in the Earth's crust. Zinc is found in the air, soil, and water and is present in all foods. In its pure elemental (or metallic) form, zinc is a bluish-white, shiny metal. Powdered zinc is explosive and may burst into flames if stored in damp places. Metallic zinc has many uses in industry. A common use for zinc is to coat steel and iron as well as other metals to prevent rust and corrosion; this process is called galvanization. Metallic zinc is also mixed with other metals to form alloys such as brass and bronze. A zinc and copper alloy is used to make pennies in the United States. Metallic zinc is also used to make dry cell batteries (ATSDR 2005).

Zinc enters the air, water, and soil as a result of both natural processes and human activities. Most zinc enters the environment as the result of mining, purifying of zinc, lead, and cadmium ores, steel production, coal burning, and burning of wastes. These activities can increase zinc levels in the atmosphere. Waste streams from zinc and other metal manufacturing and zinc chemical industries, domestic waste water, and run-off from soil containing zinc can discharge zinc into waterways. The level of zinc in soil increases mainly from disposal of zinc wastes from metal manufacturing industries and coal ash from electric utilities. Sludge and fertilizer also contribute to increased levels of zinc in the soil. In air, zinc is present mostly as fine dust particles. Most of the zinc in lakes or rivers settles on the bottom. However, a small amount may remain either

dissolved in water or as fine suspended particles. The level of dissolved zinc in water may increase as the acidity of water increases. Most of the zinc in soil is bound to the soil and does not dissolve in water. Zinc in aerobic waters is partitioned into sediments through sorption onto hydrous iron and manganese oxides, clay minerals, and organic material. Precipitation of soluble zinc compounds appears to be significant only under reducing conditions in highly polluted water. Generally, at lower pH values, zinc remains as the free ion. In anaerobic environments and in the presence of sulfide ions, precipitation of zinc sulfide limits the mobility of zinc. Zinc sorbs strongly onto soil particulates. Zinc in a soluble form (e.g., zinc sulfate) is moderately mobile in most soils. However, relatively little land-disposed zinc at waste sites is in the soluble form. Thus, mobility is limited by a slow rate of dissolution (ATSDR 2005).

***Toxicity***

Inhaling large amounts of zinc (as zinc dust or fumes from smelting or welding) can cause a specific short-term disease called metal fume fever, which is generally reversible once exposure to zinc ceases. However, very little is known about the long-term effects of breathing zinc dust or fumes. Eating food containing very large amounts of zinc (1,000 times higher than the RDA) for several months caused many health effects in rats, mice, and ferrets, including anemia and injury to the pancreas and kidney. Rats that ate very large amounts of zinc became infertile. Rats that ate very large amounts of zinc after becoming pregnant had smaller babies. Putting low levels of certain zinc compounds, such as zinc acetate and zinc chloride, on the skin of rabbits, guinea pigs, and mice caused skin irritation. Skin irritation from exposure to these chemicals would probably occur in humans. EPA has determined that because of lack of information, zinc is not classifiable as to its human carcinogenicity (ATSDR 2005).

## PESTICIDES

**Dichloro Diphenyl Ethylene (DDE) and Dichloro Diphenyl Trichloroethane (DDT)**

DDT is a synthetic organochlorine pesticide. Technical grade DDT is a mixture of three isomers: p,p'-DDT (85 percent), o,p'-DDT (15 percent), and o,o'-DDT (trace amounts). DDT, DDE, and dichloro diphenyl dichloroethane (DDD) are white crystalline solids. DDT is a pesticide once widely used to control insects in agriculture and insects that carry diseases such as malaria. Its use in the U.S. was banned in 1972, but is still used in some countries. DDD was also used to kill pests, but its use has also been banned. Both DDE and DDD are degradation products of DDT (ATSDR 2002).

Before it was banned, DDT entered the air, water, and soil during its production and use as an insecticide. DDT still enters the environment because of its current use in other

areas of the world. DDE is only found in the environment as a result of contamination or breakdown of DDT. DDT, DDE and DDD may also enter the air when they evaporate from contaminated water and soil. DDT, DDE, and DDD in the air will then be deposited on land or surface water. This cycle of evaporation and deposition may be repeated many times. As a result, DDT, DDE, and DDD can be carried long distances in the atmosphere. DDT, DDE, and DDD may occur in the atmosphere as a vapor or be attached to solids in air. Vapor phase DDT, DDE, and DDD may break down in the atmosphere due to reactions caused by the sun. Most DDT breaks down slowly into DDE and DDD in soil, generally by the action of microorganisms. They stick strongly to soil, and therefore generally remain in the surface layers of soil. Some soil particles with attached DDT, DDE, or DDD may get into rivers and lakes in runoff. Only a very small amount, if any, will seep into the ground and get into groundwater. The length of time that DDT will last in soil depends on many factors including temperature, type of soil, and whether the soil is wet. DDT disappears faster when the soil is flooded or wet than when it is dry. DDT disappears faster when it initially enters the soil. Later on, evaporation slows down and some DDT moves into spaces in the soil that are so small that microorganisms cannot reach the DDT to break it down efficiently. In temperate areas, half of the ΣDDT initially present usually disappears in about 5 years. However, in some cases, half of the ΣDDT initially present will remain for 20, 30, or more years. In surface water, DDT will bind to particles in the water, settle, and be deposited in the sediment. DDT is taken up by small organisms and fish in the water (ATSDR 2002).

***Toxicity***

The predominant route of exposure of the general population to DDT and its metabolites is through the diet. The main sources of DDT in food are meat, fish, poultry, and dairy products. The amount in food has greatly decreased since DDT was banned in the United States in 1972. Residues are more likely to occur in food imported from countries where DDT is still used (ATSDR 2002).

Acute-duration exposure to high concentrations of DDT can induce tremors and seizures which usually disappear after the exposure ceases. Several studies in humans suggest that high DDT/DDE burdens may be associated with alterations in end points controlled by hormonal action, such as duration of lactation, maintenance of pregnancy, and fertility. In animals, short-term exposure to large amounts of DDT in food affected the nervous system, while long-term exposure to smaller amounts affected the liver. Also in animals, short-term oral exposure to small amounts of DDT or its breakdown products may also have harmful effects on reproduction. Long-term exposure to DDT, DDE, or DDD has induced liver cancer in mice. The DHHS determined that DDT may reasonable be anticipated to be a human carcinogen. The International Agency for

Research on Cancer (IARC) determined that DDT may possibly cause cancer in humans. The EPA determined that DDT, DDE, and DDD are probable human carcinogens (ATSDR 2002).

**DIELDRIN**

Aldrin and dieldrin are insecticides with similar chemical structures. They are discussed together because aldrin quickly breaks down to dieldrin in the body and in the environment. Neither substance occurs naturally in the environment and they are no longer produced or used. From the 1950s until 1970, aldrin and dieldrin were used extensively as insecticides on crops such as corn and cotton. The United States Department of Agriculture canceled all uses of aldrin and dieldrin in 1970. In 1972, however, EPA approved aldrin and dieldrin for killing termites. Use of aldrin and dieldrin to control termites continued until 1987. In 1987, the manufacturer voluntarily canceled the registration for use in controlling termites (ATSDR 2002).

The Henry's law constants of aldrin and dieldrin indicate that volatilization from moist soil surfaces will occur. Both compounds also bind strongly to soil particles and are often associated with dust particles in the atmosphere. Dieldrin in soil or water breaks down very slowly. Dieldrin sticks to soil and may stay there unchanged for many years. Water does not easily wash dieldrin off soil. Dieldrin does not dissolve in water very well and is therefore not found in water at high concentrations. Most dieldrin in the environment attaches to soil and to sediments at the bottoms of lakes, ponds, and streams. In the air, dieldrin changes to photodieldrin within a few days (ATSDR 2002).

***Toxicity***

Exposure of the general population to aldrin and dieldrin may occur through ingestion of contaminated food (including fish and shellfish) or water, through inhalation of contaminated air, especially in homes that have been treated with either pesticide, and through dermal contact with contaminated soil or water. The dietary contribution is likely the most significant route of human exposure. Dieldrin tends to be stored in high-fat tissues within the body, but can be mobilized during lactation or starvation (ATSDR 2002).

Aldrin and dieldrin are carcinogenic in animals, but this effect appears to be specific to the mouse liver. The IARC has categorized aldrin and dieldrin as Group 3 (unclassifiable as to human carcinogenic potential) chemicals. Based on the finding of liver tumors in mice, EPA classified both aldrin and dieldrin as B2, probable human carcinogens; however, current mechanistic data suggest that the mouse carcinogenicity data may not be highly relevant to humans. The preponderance of evidence appears to

indicate that aldrin and dieldrin induce a carcinogenic response through nongenotoxic mechanisms. The major target organs that are affected from dieldrin exposure are the liver and central nervous system (ATSDR 2002).

**ENDOSULFAN II (β-Endosulfan**)

Technical-grade endosulfan contains at least 94 percent of two pure isomers, α- and β-endosulfan. The α- and β-isomers of endosulfan are present in the ratio of 7:3, respectively. Technical-grade endosulfan may also contain up to 2 percent endosulfan alcohol and 1 percent endosulfan ether. Endosulfan sulfate is a reaction product found in the environment due to photolysis and in organisms as a result of oxidation by biotransformation (ATSDR 2000).

Endosulfan enters air, water, and soil when it is manufactured or used as a pesticide. Endosulfan is often applied to crops using sprayers. Some endosulfan in the air may travel long distances before it lands on crops, soil, or water. Endosulfan on crops usually breaks down within a few weeks. Endosulfan released to soil attaches to soil particles. Endosulfan found near hazardous waste sites is usually found in soil. Some endosulfan in soil evaporates into air, and some endosulfan in soil breaks down. However, it may stay in soil for several years before it all breaks down. Rain water can wash endosulfan that is attached to soil particles into surface water. Endosulfan does not dissolve easily in water. Most endosulfan in surface water is attached to soil particles floating in the water or attached to soil at the bottom. The small amounts of endosulfan that dissolve in water break down over time. Depending on the conditions in the water, endosulfan may break down within 1 day or it may take several months. Because it does not dissolve easily in water, only very small amounts of endosulfan are found in groundwater (ATSDR 2000).

***Toxicity***

There is very little difference in toxicity between endosulfan and its metabolite, endosulfan sulfate. However, the α-isomer has been shown to be about three times as toxic as the β-isomer of endosulfan (ATSDR 2000). The DHHS, IARC, and EPA have not classified endosulfan as to its carcinogenicity. Results from animal studies show that exposure to very large amounts of endosulfan for short periods of time can cause adverse nervous system effects (such as hyper excitability, tremors, and convulsions) and death. Because the brain controls the activity of the lungs and heart, lethal or near lethal exposures in animals have also resulted in failure of these organs. Other effects seen in animals after short-term, high-level exposures include harmful effects on the stomach, blood, liver, and kidney. After somewhat longer exposures, the ability of animals to fight infection was also impaired. The kidney, testes, and possibly the liver

are the only organs in laboratory animals affected by longer-term exposure to low levels of endosulfan. The seriousness of these effects is increased when animals are exposed to higher concentrations of endosulfan (ATSDR 2000).

**PENTACHLOROPHENOL**

Pentachlorophenol is a synthetic substance, made from other chemicals, and does not occur naturally in the environment. Since 1984, the purchase and use of pentachlorophenol has been restricted to certified applicators. Before use restrictions, pentachlorophenol was widely used as a wood preservative. It is now used industrially as a wood preservative for power line poles, cross arms, fence posts, and the like (ATSDR 2001).

Pentachlorophenol released into the atmosphere from treated wood can be transported back to surface waters and soils via wet and dry deposition. Atmospheric pentachlorophenol is transformed via photolysis; the compound may slowly undergo free radical oxidation with an estimated half-life of approximately 2 months. In surface waters, pentachlorophenol undergoes biotransformation and photolysis, and is adsorbed to sediments. Hydrolysis, oxidation, and volatilization do not significantly affect surface water concentrations. In soils and sediments, pentachlorophenol is metabolized by acclimated microbes, under both aerobic and anaerobic conditions, or is adsorbed. Pentachlorophenol may also be methylated to form pentachloroanisole, a more lipid soluble compound. Adsorption of pentachlorophenol in soils is pH dependent. Adsorption decreases in neutral and basic soils and is strongest in acidic soils. Therefore, the compound is most mobile in neutral-to-basic mineral soils and least mobile in acidic organic soils. Volatilization and photolysis do not appear to be important transport and transformation processes for pentachlorophenol in soils. A Henry's law constant of $2.75 \times 10^{-6}$ atm $m^3$/mol has been reported for pentachlorophenol; the value for the salt or ionic form of this compound is expected to be much less. Therefore, volatilization of the solvated anionic form from an aqueous system is not considered to be a significant transport mechanism under ambient conditions. Photolysis and biodegradation are believed to be the dominant transformation processes for pentachlorophenol in aquatic systems. Pentachlorophenol is degraded under anaerobic conditions in sewage sludge and sediments (ATSDR 2001).

***Toxicity***

Short exposures to large amounts of pentachlorophenol in the workplace or through the misuse of products that contain it can cause harmful effects on the liver, kidneys, blood, lungs, nervous system, immune system, and gastrointestinal tract. Contact with pentachlorophenol (particularly in the form of a hot vapor) can irritate the skin, eyes,

and mouth. If large enough amounts enter the body, heat is produced by the cells in the body, causing an increase in body temperature. The body temperature can increase to dangerous levels, causing injury to various organs and tissues and even death. An increased risk of cancer has been shown in some laboratory animals given large amounts of pentachlorophenol orally for a long time. There is weak evidence that pentachlorophenol causes cancer in humans. The IARC has determined that pentachlorophenol is possibly carcinogenic to humans, and the EPA has classified pentachlorophenol as a probable human carcinogen. The compound has been found to bioaccumulate to modest levels (e.g., bioconcentration factors of <1,000), but food chain biomagnification has not been observed (ATSDR 2001).

## SEMI-VOLATILE ORGANIC COMPOUNDS (SVOCs)

### DIBENZOFURAN

Dibenzofuran is a white crystal-like solid that is created from the production of coal tar. Dibenzofuran is used as an insecticide and to make other chemicals. It is made from coal tar and has been found in coke dust, grate ash, fly ash, and flame soot. Dibenzofuran is released to the ambient air from combustion sources. It may be found in coke dust, grate ash, fly ash, and flame soot. The general public may be exposed to dibenzofuran through the inhalation of contaminated air or through the consumption of contaminated drinking water or food.

Dibenzofuran is a polynuclear aromatic compound with a molecular weight of 168.20 grams per mole (g/mol). Dibenzofuran occurs as white crystals or crystalline solid that has a solubility in water of about 3 mg/L at 25 °C. The odor threshold for dibenzofuran is about 1 milligram per cubic meter ($mg/m^3$). The vapor pressure for dibenzofuran is 0.0175 millimeter of mercury (mm Hg) at 25 °C, and its log octanol/water partition coefficient (log Kow) varies between 3.18 and 4.12. Dibenzofuran can enter your body when you breathe contaminated air. It can also be absorbed into your body when it comes into contact with your skin.

#### *Toxicity*

Little to no information is available on the health effects of dibenzofuran exposure. However, the information that does exist shows that short-term exposure to dibenzofuran can cause skin, eye, nose, and throat irritation. No information is available on the acute (short-term), chronic (long-term), reproductive, developmental, and carcinogenic effects of dibenzofuran in humans or animals. Health effects information is available on the polychlorinated dibenzofurans; however, the EPA has noted that the biological activity of various chlorinated dibenzofurans varies greatly, thus, risk

assessment by analogy to any of these more widely studied compounds would not be recommended.

In a comparison of Toxic Equivalency Factor (TEF) values for chlorinated dibenzofurans, mono-, di- and tri-chlorinated dibenzofuran had TEF values of 0 (U.S. EPA, 1989). Based on these results and the fact that toxicity of polychlorinated dibenzofurans (PCDF) depends on the number of chlorine substituents and their position (U.S. EPA, 1986), the TEF for dibenzofuran, with no chlorine substituents, is set equal to 0.

The EPA has determined that there is not enough information available to classify dibenzofuran as a cancer causing substance.

## VOLATILE ORGANIC COMPOUNDS

### CARBON DISULFIDE

In nature, small amounts of carbon disulfide are found in gases released to the earth's surface, for example, in volcanic eruptions or over marshes. Microorganisms in the soil can also produce gas containing carbon disulfide. Commercial carbon disulfide is made by combining carbon and sulfur at very high temperatures. Several industries use carbon disulfide as a raw material to make such things as rayon, cellophane, and carbon tetrachloride. Currently, the largest user of this chemical is the viscose rayon industry. Carbon disulfide is also used to dissolve rubber to produce tires and as a raw material to make some pesticides (ATSDR 1996).

Carbon disulfide evaporates rapidly when released to the environment. The amount of carbon disulfide released into the air through natural processes is difficult to judge because it is in such small amounts in nature. This also makes it hard to monitor carbon disulfide and to explain how it behaves when it comes into contact with other compounds. Most carbon disulfide in the air and in surface water is from manufacturing and processing activities. However, it is found naturally in coastal and ocean waters.

Once released to the environment, carbon disulfide moves quickly to the air. Once in the air, it stays close to the ground because it is heavier than the surrounding air. It is estimated that carbon disulfide will break down into simpler components after approximately 12 days. Carbon disulfide moves through soils fairly quickly and normally evaporates rapidly. However, since carbon disulfide does not bind tightly to soils, the amount that does not evaporate can easily move down through the soil into groundwater. Since it is very mobile, it is not likely to stay in the soil long enough to be broken down. It does not remain very long in water either because it evaporates within

minutes. However, if dissolved in water, it is relatively stable and is not easily broken down. It is estimated that carbon disulfide is not taken up in significant amounts by the organisms living in water (ATSDR 1996).

***Toxicity***

At very high levels (10,000 parts of carbon disulfide per million parts [ppm] of air), carbon disulfide may be life threatening because of its effects on the nervous system. Studies in animals indicate that carbon disulfide can affect the normal functions of the brain, liver, and heart. However, the amount of carbon disulfide in the air to which animals in these studies were exposed was much higher than the amounts in the air that the general public usually breathes. The brains, livers, and hearts of the animals were affected only after breathing air that contained carbon disulfide for days, months, or years. There is no information on health effects in people who eat food or drink water contaminated with carbon disulfide. No EPA, DHHS, or IARC cancer classifications were reported for carbon disulfide (ATSDR 1996).

**ETHYLBENZENE**

Ethylbenzene is a colorless liquid that smells like gasoline. It evaporates at room temperature and burns easily. Ethylbenzene is found naturally in oil. Large amounts of ethylbenzene are produced in the United States; most of it is used to make styrene. It is also used in fuels. Consumer products containing ethylbenzene include: gasoline, paints and inks, pesticides, carpet glues, varnishes and paints, tobacco products, automobile products. This compound is most commonly found in air. It moves easily into the air from water and soil. Ethylbenzene in soil can also contaminate groundwater. It is rapidly broken down in air, less than 3 days with the aid of sunlight. In surface water such as rivers and harbors, it breaks down by reacting with other compounds naturally present in water. In the soil, ethylbenzene is broken down by soil bacteria (ATSDR 2010).

***Toxicity***

Exposure to high levels of ethylbenzene in air for short periods can cause eye and throat irritation. Exposure to higher levels can result in dizziness. Irreversible damage to the inner ear and hearing has been observed in animals exposed to relatively low concentrations of ethylbenzene for several days to weeks. Exposure to relatively low concentrations of ethylbenzene in air for several months to years causes kidney damage in animals. The IARC has determined that ethylbenzene is a possible human carcinogen (ATSDR 2010).

## 3.2 DEVELOPMENT OF REMEDIATION GOALS

Preliminary remediation goals (PRGs) for the protection of upper trophic level (UTL) receptors of concern (ROCs) and benthic invertebrates were evaluated in the Sensitivity Analysis (Section 2.3). Various remediation scenarios involving sediment and soil PRGs were assessed for their predicted reduction in risk to UTL ROCs.

### 3.2.1 PRELIMINARY REMEDIATION GOALS FOR PROTECTION OF UPPER TROPHIC LEVEL RECEPTORS IN SEDIMENT

At the conclusion of the Sensitivity Analysis (Section 2.4), Remediation Scenario 10b was recommended by the EPA. This scenario involves a remediation of all sediment sample areas with an ERM-Q or PEL-Q Category Score greater than two to a PRG equal to one-half of the TCEQ-recommended first effects level benchmark for benthic invertebrates (TCEQ 2005). This sediment PRG resulted in acceptable Site-wide risk levels for UTL ROCs given the assumptions outlined in Section 2.4.7.

For several COPECs, the TCEQ did not provide a first effects sediment benchmark. In these cases, a value, such as a federal screening benchmark in sediment was used as a substitute. PRGs for UTL ROCs and their sources are documented in Table 3-4A.

### 3.2.2 PRELIMINARY REMEDIATION GOALS FOR PROTECTION OF BENTHIC INVERTEBRATES IN SEDIMENT

The final Remediation Scenario (10b) modeled risk to UTL ROCs based on remediation of sediment sample areas determined to be a risk to benthic invertebrates. Protection of benthic invertebrates was addressed with an EPA-recommended risk management strategy that involved addressing all sediment sample areas with an ERM-Q or PEL-Q Priority Category Score of three or four, corresponding to medium-high risk and high risk, respectively. Based on this evaluation method, benthic invertebrate PRGs were developed for those COPECs that are used in the ERM/PEL-Q Category Score calculation. For these COPECs, a TCEQ-recommended first effect benchmark was determined to be the most appropriate PRG for protection of benthic invertebrate because it can be viewed as the NOAEL concentration (TCEQ 2006).

While the ERM/PEL-Q method used in the Tier 2 RI was calculated using individual PAHs, a PRG for benthic invertebrates was developed for total PAHs. COPECs in this

class of compounds demonstrate the same narcotic effect mechanism. Therefore, a PRG that evaluates impacts from all COPECs in the class is an appropriate value.

PRGs for benthic invertebrates and their sources are documented in Table 3-4A.

### 3.2.3 ECOLOGICAL PRELIMINARY REMEDIATION GOALS IN SEDIMENT

Sediment PRGs were developed for the protection of UTL ROCs and benthic invertebrates. The ecological PRG, which is protective of both of these receptor groups, is the lowest concentration of the UTL sediment PRG and the benthic invertebrate sediment PRG for each COPEC. According to 30 TAC §350.77, protective concentration levels for ecological receptors are primarily intended to be protective for more mobile or wide-ranging ecological receptors and, where appropriate, benthic invertebrate communities. Therefore, a PRG that protects UTL ROCs and benthic invertebrates in sediment is considered a protective concentration for ecological receptors in sediment and is equal to the ecological sediment PRG. Ecological sediment PRGs and their sources are documented in Table 3-4A.

### 3.2.4 PRELIMINARY REMEDIATION GOALS FOR PROTECTION OF UPPER TROPHIC LEVEL RECEPTORS IN SOIL

Remediation Scenario 10b was the final remediation scenario recommended by the EPA (see Sensitivity Analysis Section 2.4). This scenario involves a remediation of all soil sample areas (the Jefferson Canal Spoil Pile) to a PRG equal to the Texas-median background concentration provided by TCEQ (2005). This soil PRG resulted in acceptable Site-wide risk levels for UTL ROCs given the assumptions outlined in Section 2.4.7.

For several COPECs, the TCEQ did not provide a Texas-median background concentration. In these cases, a value, such as a soil ecological benchmark or federal background concentration, was used as a substitute. PRGs for UTL ROCs and their sources are documented in Table 3-4B.

### 3.2.5 ECOLOGICAL PRELIMINARY REMEDIATION GOALS IN SOIL

Soil PRGs were developed for the protection of UTL ROCs. According to 30 TAC §350.77, protective concentration levels for ecological receptors are primarily intended to be protective for more mobile or wide-ranging ecological receptors and, where appropriate, benthic invertebrate communities. Therefore, the UTL soil PRG is considered a protective concentration for ecological receptors and is equal to the ecological soil PRG. Ecological soil PRGs and their sources are documented in Table 3-4B.

### 3.2.6 HUMAN HEALTH PRELIMINARY REMEDIATION GOALS

The HHRA identified human health risk that was not sufficient to require establishment of human health PRGs for sediment or soil.

## 3.3 GENERAL RESPONSE ACTIONS

General response actions were developed for sediment and soil that define containment, treatment, removal, or other actions, individually or in combination that may be completed to satisfy the RAOs for the Site. Areas of sediment impairment and corresponding volumes and soil impact were identified at which the general response actions may be applied. The areas or volumes to which the general response actions may be applied were based on the potential exposure routes, the nature and extent of impact, the preliminary remediation goals, and the preliminary list of action-specific ARARs. In addition, the requirements for protectiveness identified in the RAOs and the chemical and physical characteristics of the Site were considered during development of the general response actions.

The general response actions identified to meet the RAOs were selected from six primary remediation strategy categories. Table 3-5 identifies the general response actions that are relevant for consideration at the Star Lake Canal Superfund Site.

## 3.4 IDENTIFICATION AND SCREENING OF TECHNOLOGY TYPES AND PROCESS OPTIONS

The potential remedial technologies and process options identified in the FS address the impacted sediment and soil at the Site and are summarized in this section. Various types

of remedial technologies and process options were identified to achieve the goals of the general response actions. Remedial technologies are general categories of technologies and process options are the specific processes included within a remedial technology category.

### 3.4.1 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

A list of potentially acceptable technologies and technology process options, corresponding to the identified general response actions, were developed and screened by evaluation of the process options with respect to technical implementability. Each proposed potential technology was further evaluated during the FS for technical implementability, cost, and effectiveness in meeting the RAOs. This section describes methods and procedures used to identify and screen remedial technologies for the Star Lake Canal Superfund Site**.** The following procedure was used:

1. Identify general response actions that can achieve the remedial action objectives as defined in Section 3.1
2. Determine the method to initially screen the potential remedial technologies and establish the evaluation criteria
3. Based on the evaluation criteria, identify and screen the potential remedial technologies with respect to the characteristics of the impact and other Site-specific characteristics

The potential technologies were identified based on their estimated ability to reduce constituent concentrations in Site sediment and/or soil or to eliminate potential exposure pathways. Existing information on technologies and Site characterization data were used to screen process options that could not be effectively implemented at the Site. Table 3-6 includes a list of potential remedial technologies to address the identified sediment and soil impact at the Site including containment, removal, treatment, monitored natural recovery, and institutional controls. The physical and chemical methods for isolation or removal of impacted sediment and/or soil are described briefly in Table 3-6. Each potential technology was further evaluated during the FS for effectiveness, implementability, and cost in meeting the RAOs.

The ranking system used to screen the remedial technologies is described below and summarized in Table 3-7.

**Effectiveness** – Remedial technologies were rated for effectiveness using a numerical scale of 1 to 4. Remedial technologies that were determined not effective were given a ranking of 1. If the remedial technologies were slightly effective or the effectiveness could not be determined, the technologies were given a ranking of 2. Innovative technologies that have the potential to be effective based on results of previous applications were ranked with a 3. Remedial technologies that have a high probability of effectiveness and were effective in other applications were ranked with a 4.

**Implementability –** Remedial technologies were rated on a scale of 1 to 4 regarding implementability. Technologies that cause a high degree of disruption in the project area and require a significant amount of specialized equipment, technical knowledge, and/or permits were ranked with a 1. A ranking of 2 indicates that the technology may cause a medium amount of disruption in the project area and require a moderate amount of specialized equipment, technical knowledge, and/or permits. Technologies causing a minimal amount of disruption in the project area and do not require specialized equipment, technical knowledge, and or permits were ranked with a 3. If no disruption of the project area and a minimal amount of equipment is required, the technology was ranked with a 4.

**Cost –** The costs of remedial technologies were rated on a scale of 1 to 4. The most costly remedial technologies were ranked with a 1. Remedial technologies that have moderate costs were ranked with a 2. Low cost remedial technologies were ranked with a 3. Rankings of 4 were given to those technologies that have no costs associated with them.

Potential remedial technologies screened included No Action, containment, removal, treatment, monitored natural recovery, and institutional controls. Table 3-8 includes the screening results of the potential remedial technologies. Specific remedial technologies were retained based on the screening results.

### 3.4.2 EVALUATION OF TECHNOLOGIES AND SELECTION OF REPRESENTATIVE TECHNOLOGIES

The selection of representative process options is intended to simplify the development and evaluation of alternatives. The specific process options were selected in order to develop and evaluate remedial alternatives and represent the broader range of process options with each general technology type. Additional or alternative process options may be selected during the remedial design, if they are found to be more advantageous. The initial screening evaluated each technology type for effectiveness, implementability,

and cost. Remedial technologies and process options that do not have the capability to effectively isolate, reduce, or eliminate soil/sediment impact were eliminated. Remedial technologies and process options that were retained and carried forward to develop remedial alternatives are presented in Table 3-9. These remedial technologies and process options shall be implemented individually or in combination, and are discussed in detail in Section 5.0 of this submittal.

As noted in Table 3-8, various process options within a remedial technology type may achieve the remedial action objectives as defined in Section 3.1. When possible, one representative process option was selected for use in establishing remedial alternatives and cost estimates. Additional or alternative process options may be identified and used during the remedial design if such process options are determined to be more successful with respect to achieving the RAO while meeting the aforementioned criteria.

The remedial technologies retained after screening include No Action, MNR, in-situ capping, dredging or excavation, and off-Site disposal. The following provides a summary of the technologies retained after screening.

**No Action -** No Action does not reduce the risk to benthic invertebrates and the environment but is retained to serve as a baseline for comparing the effectiveness of the remedial alternatives applicable to the Site.

**MNR -** The remedial technology types included in the evaluation of MNR are chemical/physical transport and degradation, biological degradation, and the physical burial process. The long-term effectiveness is heavily related to Site specific conditions. Chemical/Physical Transport may dilute and remove affected sediments from an implementation area, while having the negative effect of dispersal of COCs to a larger area downstream. Degradation may result in breakdown of PCBs, pesticide, PAHs, SVOCs, and VOCs while leaving metals in place. All MNR process options have low short-term effectiveness because of dependence upon the optimization of natural processes over time. Implementability of all process options are high because minimal action is taken, and all implementation can be performed using commercially available materials, equipment, and personnel. MNR is conditionally feasible, when multiple processes may be used to effectively reduce risk.

**Containment –** An in-situ cap is highly effective since COCs are isolated from the environment by the cap. Typical estimated breakthrough of organic COCs for most composite caps, armored caps, or containment pipes is on the order of hundreds of years. Impacted sediments may be temporarily re-suspended during the installation of

the cap thus reducing the short-term effectiveness. The implementability of an in-situ cap will cause a medium degree of disruption in the project area and a moderate amount of specialized equipment, technical knowledge, and permits will be required. Maintenance dredging may affect the stability of the cap. An evaluation of the final cap elevation and the depth of maintenance dredging is critical to minimize the possibility of structural degradation resulting from maintenance dredging. An in-situ cap is considered feasible for the remediation of the COCs.

**Removal/Disposal –** Removal by dredging or excavation has high long-term effectiveness for permanent elimination of the pathway between COC-affected sediment or soil and the environment. During dredging or underwater excavation, impacted sediments may be temporarily re-suspended in the water column thus reducing the short-term effectiveness of dredging or excavation. Regarding implementability, dredging or excavation will cause a medium degree of disruption in the area. A moderate amount of equipment, technical knowledge, and permits will be required. Dredging or excavation is considered feasible for the remediation of the Site. Removed sediment or soil will be transported for disposal at an approved waste treatment facility.

## 4.0 EVALUATION OF GENERAL RESPONSE ACTIONS AND DEVELOPMENT OF REMEDIAL ACTION ALTERNATIVES

This section describes methods and procedures used to assemble the selected general response actions and prepare remedial action alternatives. These alternatives represent a range of treatment activities and combinations of several technologies. General response actions assembled as alternatives for the screening process only include those options that have a significant potential for implementation at the Site. General response actions are described as classifications of remedial techniques (monitored natural recovery, containment, removal and disposal, etc.), while technology process options are individual remedial techniques (armor cap, composite cap, hydraulic dredge, etc.) considered for implementation at the Site. The application of the technology process options to each AOI is addressed further in Section 5.0.

The following sections screen the four retained general response actions from Section 3.4.2 of No Action, MNR, containment, and removal/disposal for effectiveness, implementability, and cost.

### 4.1 GENERAL REPONSE ACTION SCREENING CRITERIA

General response actions are screened to evaluate use for remediation of COC-affected media, addressing Site settings as applicable. Examples of Site settings include areas beside or under water, limited access, limited staging areas, and large treatment volumes. Additionally some of the areas are under additional guidelines such as Section 10 of the Rivers and Harbors Act of 1899 for navigable waters of the United States. The basic criteria for evaluation of each technology process option in this section are effectiveness, implementability, and cost.

***Effectiveness***

Effectiveness addresses the ability of the remedial technology to meet the RAOs given the present conditions and limitations of the AOI. Effectiveness is evaluated based on the reduction of toxicity, mobility, or volume of COC-affected sediments or soils. Short-term effectiveness considers how promptly risk is reduced; whereas long-term effectiveness considers the permanent nature of the technology and the ability to sustain the reduction of risk and exposure to COCs detected at the AOI. Remedial technologies with potentially low levels of effectiveness have been eliminated through this evaluation process.

***Implementability***

Implementability is evaluated based on Site-specific technical and administrative feasibility factors associated with the application of the remedial technology considered.

Technical feasibility addresses the ease of construction and availability of necessary resources for implementation of the technology. Damage or disruption to the area and long-term maintenance and monitoring requirements following the implementation of the remedial action are also considered.

Administrative feasibility addresses the capability to fulfill legal and regulatory requirements, and submit necessary permits in order to apply a given remedial technology. Administrative feasibility also incorporates the ability to overcome physical obstructions, proximity of treatment and disposal facilities, and the coordination of Site operations.

Remedial technologies with potentially low levels of implementability for a given AOI are eliminated through this evaluation process.

***Cost***

Cost is considered based on general cost estimates for implementation of each remedial technology, and evaluated as low, moderate, or high. The cost for each technology is estimated in more detail in Section 6.0.

## 4.2 EVALUATION OF GENERAL RESPONSE ACTIONS

Alternatives are screened to evaluate use within the two media, sediment and soil. Each general response action is also screened for appropriate use with the Site-specific settings under consideration. Examples of Site settings include areas beside or under water, limited access, limited staging areas, and large treatment volumes. Additionally, some of the areas are under additional guidelines such as Section 10 for navigable waters of the United States.

The following sections provide brief descriptions of the retained general response actions from Section 3.4.2 and an assessment of the general response actions based on the screening criteria described in Section 4.1.

### 4.2.1 GENERAL RESPONSE ACTION 1 – NO ACTION

Consideration of a No Action response is required by the *EPA Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA, 1988). The No Action response has been included to provide a basis for the comparison of the remaining general response actions. Under this response, No Action would be taken to isolate, remove, treat, or contain COCs in the sediment or soil at the Site. COC-affected media would remain in place and the potential for continued migration of constituents would not be mitigated. Additionally, no controls would be implemented to prevent intrusive activities, such as benthic invertebrate burrowing into the affected sediment.

***Assessment***

The No Action response does not reduce the toxicity, volume, or mobility of the constituent affected media. Since it does not result in any significant change in the risks associated with the COC-affected sediment or soil, the effectiveness on a long- and short- term basis is considered very low. The No Action response is minimally disruptive, has a low cost, and is highly implementable as no actions are taken, but due to its lack of risk reduction, it is considered not feasible or acceptable for the remediation of COCs within any of the areas to be addressed in the AOIs for this FS.

### 4.2.2 GENERAL RESPONSE ACTION 2 – MONITORED NATURAL RECOVERY (MNR)

MNR is a response for COC-affected sediment that uses natural processes (i.e., degradation, transport of sediments) to contain, destroy, or reduce toxicity or the bioavailability of constituents. Multiple natural occurring processes may be optimized to isolate, degrade, and remove COCs from the benthic environment. MNR is a gradual process, with a recovery time of years to decades. MNR types include chemical/physical processes, biological processes, and physical processes.

The chemical/physical transport process option optimizes the natural activities of sorption, desorption, dispersion, diffusion, dilution, volatilization, re-suspension, and transport. The timeframe for this process option varies with each activity, COC, and Site condition.

The biological degradation process option optimizes the natural attenuation of COCs by native aerobic or anaerobic bacteria. PCBs and pesticides may be dechlorinated, and PAHs, SVOCs, and VOCs may be partially or completely degraded.

The physical burial process option optimizes natural sedimentation and deposition to bury the affected materials in place. Additional deposition of clean sediment into the environment may lead to natural placement of an isolation layer between COC-affected sediments and the water column.

**Assessment**

The MNR response has low to high long-term effectiveness depending on the process option selected and the Site conditions. Chemical/physical transport may dilute and remove affected sediments from an implementation area, while having the negative effect of dispersal of COCs to a larger area downstream. Degradation may result in the breakdown of PCBs, pesticides, PAHs, SVOCs, and VOCs while leaving metals in place. All MNR process options have low short-term effectiveness because of the dependence upon the optimization of natural processes over time.

Implementability of all process options is high because minimal action is taken, and all implementation can be performed using commercially available materials, equipment, and personnel. MNR is conditionally feasible, when multiple processes are used to effectively reduce risk.

Cost of all process options within MNR is moderate, and depends on long-term sampling requirements.

If MNR is selected as a remedial alternative, the effectiveness of MNR will be evaluated during the Remedial Design and subsequent monitoring phases. Historical anecdotal information indicates that the Site has been generally recovering over time; however, scientific evidence of the success or enhancement of MNR cannot be provided at this time. A proposed plan to monitor the effectiveness of MNR will be included in the Remedial Design phase, if appropriate. The monitoring and sampling program will be established during the Remedial Design phase and will contain elements designed to reflect reductions in bioavailability and, hence, toxicity of contaminated sediments in Molasses Bayou. Risk reduction through natural attenuation should focus on all mechanisms that reduce contaminant concentration, exposure and bioavailability by mineralization or transformation of organic compounds as well as through purely physical processes such as physical-chemical weathering in the biologically active surface sediment layer. An additional remedial alternative that includes both active remediation and Monitored Natural Recovery (MNR) will be considered for both the Molasses Bayou Wetland and Molasses Bayou Waterway AOIs. The Final FS Report will include development and evaluation of the additional recommended remedial

alternative. If MNR is selected as a remedial alternative in Molasses Bayou, the effectiveness of MNR will be evaluated during the Remedial Design and subsequent monitoring phases. Following the Record of Decision (ROD), monitoring data will be reviewed to evaluate the effectiveness of the selected remedy. Pilot tests will be considered to enhance MNR during the 5-year review process, if needed.

Within the Star Lake Canal Superfund Site, the conditions present within the Molasses Bayou may allow for optimization of multiple natural recovery processes. Low velocity water movement minimizes erosion and bioturbation, while allowing some physical and biological processes to occur within the sediment.

### 4.2.3 GENERAL RESPONSE ACTION 3 – CONTAINMENT

Containment includes a range of options by which the pathway between constituents and the environment is interrupted by a physical barrier. This barrier eliminates direct contact between benthic invertebrates and constituent affected sediment and soil, and discourages constituent migration; or prevents erosion of affected sediments and soil. Examples of containment techniques potentially appropriate for the Site include: soil caps, clay caps, composite caps, armored caps, and erosion control mats.

The soil cap process option is implemented by covering affected sediment or soil with clean top soil to isolate COCs from the surrounding environment. Soil caps are not impermeable, making them better suited for containment of COC affected soils in non-aquatic environments than for use in aquatic environments where migration of COCs to the water column, and benthic invertebrate burrowing, may not be sufficiently inhibited.

The impermeable clay cap process option is implemented by covering affected sediment or soil with clean clay material to isolate COCs from the surrounding environment. When saturated, the impermeable caps form a continuous, impermeable barrier between constituent affected sediments and the water column. This option provides long-term protection of benthic invertebrates and the environment, and produces a new benthic habitat. In high water velocity settings, impermeable clay caps are resistant to erosion, and can additionally be reinforced by an armored cap. Impermeable clay caps can also be used for containment of soils in non-aquatic environments.

Both armored caps and erosion control mats serve to reduce erosion and bioturbation. An armored cap consists of a layer of cobbles, pebbles, or other large material and

prohibits disturbance by its ability to prevent burrowing by organisms, stabilize materials, and prevent erosion. An erosion control mat consists of a lightweight aggregate contained within a polymesh exterior, and can both prevent erosion and provide stable marsh habitat, where applicable.

The composite cap process option consists of some combination of soil, clay, and optional stabilizing media or geotextile (synthetic fabric for additional stabilization) placed over sediments or soils to inhibit migration of impaired pore water and to discourage bioturbators such as burrowing invertebrates. Composite cap mixtures include the use of a variety of materials to form the stabilizing aggregate; bentonite clay, other clay particles, or polymers are used frequently. When compared to sand caps, composite caps may reduce the necessary cap thickness by more than 90 percent.

The soil cap and pipe process option encloses the channel flow within a pipe designed to meet necessary hydraulic capacity. The impacted sediments no longer have contact with the flowing water and may be capped in place with a layer of soil or clay.

**Assessment**

The containment response action has high effectiveness because COCs are isolated from the environment on a long-term basis. Typical estimated breakthrough of organic COCs for most clay caps, composite caps, or containment pipes, is on the order of hundreds of years. The isolation provided by the containment response action is also effective on a short-term basis, though during implementation COC-affected sediments may be temporarily re-suspended in the water column.

Implementability of the containment response action is low to high depending on Site conditions and the potential to damage portions of Molasses Bayou Waterway and Wetlands AOIs. All of the containment technologies described above can be implemented using commercially available materials, equipment, and personnel. Administrative responsibilities would include rental of appropriate equipment, and coordination with multiple vendors for containment material delivery.

The cost of the containment response action is moderate to high, depending upon Site conditions and includes materials, transportation, and monitoring. In general, materials for a clay cap have the lowest cost and are locally available; materials for a composite cap will include some clay and other materials which may be produced and transported by specific non-local suppliers.

A containment response could be engineered to meet the Site conditions of any of the seven AOIs. Combinations of process options may be necessary to adjust for the degree

of necessary resistance against erosion, COC migration, and penetrability by invertebrates. In the Jefferson Canal AOI, where certain portions require a very specific hydraulic capacity, a pipe could maintain that requirement. The Jefferson Canal Spoil Pile AOI, where the soil is not saturated, a clay or composite cap could be used to prevent rainwater penetration. In Star Lake Canal AOI, where the water velocity may cause erosion, an armored cap could act as a protective layer. In Former Star Lake AOI, Gulf States Utility Canal AOI, Molasses Bayou Waterway AOI, Molasses Bayou Wetland AOI, and the upper portion of Jefferson Canal AOI, where the water velocity is low, soil, clay or composite caps should remain stable.

### 4.2.4 GENERAL RESPONSE ACTION 4 – REMOVAL AND DISPOSAL

The removal and disposal alternative involves extraction of the affected sediments or soils by excavation or dredge, followed by permanent disposal of those materials at an appropriate off-Site facility. Several remedial alternatives include removal of approximately twelve inches of impacted soil or sediment in applicable polygons in each AOI. Twelve inches is considered the biologically active zone for the purpose of eliminating ecological risk to potential receptors.

The excavation process option involves the removal of affected sediments using standard heavy equipment, excavation attachments on a marsh buggy, or similar amphibious heavy equipment. Following excavation, constituent affected sediments can be disposed at an approved off-Site landfill. The current assumption is that heavy equipment will not be used for removal of material in the pipeline servitude areas in any AOI.

The hydraulic dredge process option is an appropriate removal alternative for sites involving underwater sediments with low accessibility. During hydraulic dredging a pump provides suction to move the sediment slurry through a pipeline to a land-based dewatering area. The dredged material can be disposed at an approved off-Site landfill, or contained on-Site.

**Assessment**

The removal and disposal general response action has high long-term effectiveness because by removal of the COC-affected material, pathways for exposure are permanently eliminated. Short-term effectiveness of this alternative corresponds to the time required for implementation. Though during dredging or underwater excavation COC-affected sediments may be temporarily re-suspended in the water column,

sediment dispersion can be mitigated by the use of curtains or other suspended barriers within the waterway.

Implementability of the removal and disposal response is low to high depending on Site conditions and the potential to damage portions of Molasses Bayou Waterway and Wetlands AOIs. Excavation or dredging can be performed using commercially available materials, equipment, and personnel; however, removal causes disruption and suspension of sediments in the water column. Administrative responsibilities would include rental of appropriate equipment, submittal of waste profiles, and coordination of transportation with disposal facilities.

The cost of the removal and disposal response is moderate to high depending on Site conditions, quantities, accessibility, and transportation. The costs include heavy equipment (for excavation or dredge), waste transportation and disposal, waste permits, and cost of backfill materials and transportation if applicable.

A removal and disposal response could be engineered to meet the Site conditions of any of the seven AOIs. The process option selection depends upon the accessibility of each AOI. Jefferson Canal AOI and Jefferson Canal Spoil Pile AOI are directly accessible by road and the material from both AOIs could be excavated directly into transportation trucks. Portions of other AOIs are accessible by either excavator or marsh buggy, however, due to its marsh surroundings some portions in Molasses Bayou AOI may necessitate the use of a hydraulic excavator.

## 4.3 DEVELOPMENT OF ALTERNATIVES

Potential interaction between each alternative and media has been considered during development and selection of alternatives. In addition, consideration has been given to suitability of the general response for the Site setting. The range of alternatives developed for sediment and soil includes combinations of No Action, MNR, containment, and removal and disposal. The alternative development process focused on the most viable options for remediation of the Site sediment and soil, as appropriate. Alternatives formed for each AOI are as follows:

**Jefferson Canal AOI**

Alternative 1: No Action

Alternative 2a: Containment: Soil Cap and Pipe Containment of JC-7, Partial 12-inch Removal/Disposal, and Partial Containment: 12-inch soil cap

Alternative 2b: Containment: Soil Cap and Pipe Containment of JC-7, Partial 12-inch Removal/Disposal, and Containment: 12-inch soil cap on area outside the pipeline servitude and 12-inch Erosion Control Mat on the pipeline servitude

Alternative 2c: Containment: Soil Cap and Pipe Containment of JC-7, Partial 12-inch Removal/Disposal, and Partial Containment: 12-inch Armored Cap

Alternative 2d: Containment: Soil Cap and Pipe Containment of JC-7, Partial 12-inch Removal/Disposal, and Containment: 12-inch Armored Cap on area outside the pipeline servitude and 12-inch Erosion Control Mat on the pipeline servitude

Alternative 3a: Partial 12-inch Removal/Disposal and Partial Containment: 12-inch soil cap

Alternative 3b: Partial 12-inch Removal/Disposal and Containment: 12-inch soil cap on area outside the pipeline servitude and 12-inch Erosion Control Mat on the pipeline servitude

Alternative 3c: Partial 12-inch Removal/Disposal and Partial Containment: 12-inch Armored Cap

Alternative 3d: Partial 12-inch Removal/Disposal and Containment: 12-inch Armored Cap on area outside the pipeline servitude and 12-inch Erosion Control Mat on the pipeline servitude

**Jefferson Canal Spoil Pile AOI**

Alternative 1: No Action

Alternative 2a: Containment: 2-foot Composite Cap

Alternative 2b: Removal/Disposal of mounds to grade and Containment: 2-foot Composite Cap

Alternative 2c: Partial Containment: 2-foot Composite Cap

Alternative 3a: Partial 12-inch Removal/Disposal, Removal/Disposal of mounds to grade, and Containment: 2-foot Composite Cap

Alternative 3b: Partial 12-inch Removal/Disposal, Removal/Disposal of mounds to grade, and Partial Containment: 2-foot Composite Cap

**Former Star Lake AOI**

Alternative 1: No Action

Alternative 2a: Partial 12-inch Removal/Disposal and Partial Containment: 12-inch Impermeable Cap (minimizes erosion)

Alternative 2b: Partial 12-inch Removal/Disposal and Containment: 12-inch Impermeable Cap (minimizes erosion) on area outside the pipeline

servitude and 12-inch Erosion Control Mat and 12-inch Composite Cap on the pipeline servitude

Alternative 3a: Partial 12-inch Removal/Disposal and Partial Containment: 12-inch Composite Cap

Alternative 3b: Partial 12-inch Removal/Disposal and Containment: 12-inch Composite Cap on area outside the pipeline servitude and 12-inch Erosion Control Mat and 12-inch Composite Cap on the pipeline servitude

**Star Lake Canal AOI**

Alternative 1: No Action

Alternative 2: 12-inch Removal/Disposal and Containment: 12-inch Impermeable Cap (minimizes erosion)

Alternative 3: 12-inch Removal/Disposal and Containment: 12-inch Armored Cap

**Gulf States Utility Canal AOI**

Alternative 1: No Action

Alternative 2: Containment: 12-inch Composite Cap

Alternative 3: 12-inch Removal/Disposal and Containment: 12-inch Armored Cap

Alternative 4: 12-inch Removal/Disposal

**Molasses Bayou Waterway AOI**

Alternative 1: No Action

Alternative 2a: Monitored Natural Recovery

Alternative 2b: Monitored Natural Recovery and 12-inch Removal/Disposal and Containment: 12-inch Armored Cap

Alternative 3: 12-inch Removal/Disposal and Containment: 12-inch Armored Cap

**Molasses Bayou Wetland AOI**

Alternative 1: No Action

Alternative 2a: Monitored Natural Recovery

Alternative 2b: Monitored Natural Recovery and Containment: 12-inch Composite Cap

Alternative 2c: Monitored Natural Recovery and 12-inch Removal/Disposal and Containment: 12-inch Armored Cap

Alternative 2d: Monitored Natural Recovery and 12-inch Removal/Disposal

Alternative 3: Containment: 12-inch Composite Cap

Alternative 4: Partial 12-inch Removal/Disposal and Partial Containment: 12-inch Armored Cap

Alternative 5: Partial 12-inch Removal/Disposal

## 4.4 PIPELINES

All pipelines at or near the Star Lake Canal Superfund Site will be taken into consideration for all remedial alternatives developed for this FS. Through evaluation of pipeline easements, coordination with pipeline owners and/or completion of a geophysical survey, the operational status and location of all applicable pipelines will be determined during the Remedial Design prior to implementation of any remedial alternative in each of the AOIs. A set-back or servitude will not be disturbed within 25 feet of the pipelines extending through Scenario 10b Thiessen Polygons unless specifically noted in Section 5.0. The terms "partial removal" and/or "partial containment" in the remedial alternatives for each AOI refers to the area outside the pipeline servitude. In addition, a plan for any potential future access to the pipelines will be considered during the Remedial Design phase. The plan would include procedures to minimize potential erosion and run-off and re-installation of any containment cap following completion of the pipeline work.

Figures 5-1 through 5-7 show the Thiessen polygons and given the currently available information, the approximate location of the pipeline servitudes in the areas of Jefferson Canal, Jefferson Canal Spoil Pile, Former Star Lake, Star Lake Canal, Gulf States Utility Canal, Molasses Bayou Waterway, and Molasses Bayou Wetland AOIs, respectively. In addition, refer to Appendix B for more information regarding the pipelines in and around the Site. It should be noted that the currently available pipeline information provides conflicting locations for several pipelines in the Former Star Lake and Star Lake Canal AOIs. Both potential locations are shown on the figures and the remedial alternatives are developed for the locations that more adversely affect the AOIs. Based on the available information regarding the pipeline servitude areas in each AOI, the pipeline servitudes account for the following approximate percentages of total polygons to be remediated: 6 percent for Jefferson Canal AOI, 24 percent for the Jefferson Canal Spoil Pile AOI, 13 percent for the Former Star Lake AOI, 32 percent for the Star Lake Canal AOI, and 1 percent for the Molasses Bayou Wetland AOI. Due to the minimal pipeline servitude area in each AOI, there will be no significant impact to potential upper trophic level ecological risk if the pipeline servitude areas are not addressed. However, all the recommended remedial alternatives will address the pipeline servitude areas.

## 5.0 DETAILED ANALYSIS OF REMEDIAL ACTION ALTERNATIVES

This section describes the process that will be used to further refine the remedial action alternatives and conduct a detailed analysis of the alternatives with respect to the evaluation criteria. The objective of the detailed analysis is to provide EPA with adequate information to select an appropriate remedy for the Site. The results of the detailed analysis of remedial action alternatives provide the basis for identification of a preferred alternative and preparation of a proposed plan.

### 5.1 REGULATORY REQUIREMENTS

The detailed analysis should address the statutory requirements for each remedial action. Remedial actions are required to:

- Be protective of human health and the environment
- Attain ARARs or provide justification for a waiver
- Be cost-effective
- Utilize permanent solutions and alternative treatment technologies, or resource recovery technologies, to the maximum extent practical
- Satisfy the preference that reduces toxicity, mobility, or volume of the constituents as a principal element or provide an explanation as to why it does not

In addition, CERCLA requires consideration of long-term effectiveness of each of the alternative remedial actions including:

- The long-term uncertainty associated with land disposal
- The goals, objectives, and requirements of the Solid Waste Disposal Act
- The persistence, toxicity, and mobility of hazardous substances and their constituents, and their propensity to bioaccumulate
- Short- and long-term potential for adverse health effects from human exposure
- Long-term maintenance costs
- The potential for future remedial action costs if the alternative remedial action implemented were to fail
- The potential threat to human health and the environment associated with excavation, transportation, and redisposal or containment

## 5.2 EVALUATION CRITERIA

The nine criteria used in the FS process during the evaluation of remedial alternatives provide the framework for conducting a detailed analysis for selection of appropriate remedial actions. The individual analysis of alternatives includes an evaluation of the performance of each alternative with the evaluation criteria, highlighting the performance of each alternative relative to specified criteria. The threshold criteria relate directly to statutory findings that must ultimately be met and, therefore, each remedial alternative must meet the overall protection of human health and the environment and compliance with the ARARs at the Site. The balancing criteria represent the primary criteria upon which the technical analysis of remedial alternatives are based. These criteria are characterized by the role of the criteria during the remedy selection process. There are threshold, balancing, and modifying criteria to be considered in this evaluation process.

The threshold criteria are:

- Overall protection of human health and the environment
- Compliance with the ARARs

The balancing criteria are:

- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume
- Short-term effectiveness
- Implementability
- Cost

The modifying criteria are:

- State acceptance
- Community acceptance

These are further explained in the following paragraphs.

***Overall Protection of the Environment***

This is the first of two threshold factors used to screen alternatives. Threshold factors must be met for an alternative to be eligible for selection. Evaluation of the overall protectiveness of an alternative focuses on how well the alternative will achieve

protection over time and how well it will reduce risk. This evaluation is intended to determine how well the risk posed by each pathway associated with each media is eliminated, reduced, or controlled through treatment and engineered controls. For the Site, protection is accomplished through interruption of the exposure pathway between COC-affected sediments and benthic invertebrates.

***Compliance with ARARs***

This is the second of the two threshold factors used to screen alternatives. The alternatives must conform to the effects of federal, state, and local requirements, regulations, and other institutional considerations relative to the design, operation, and timing of each option evaluated. The ARARs for the Site are identified and described in Section 3.1.1 and Tables 3-1 through 3-3.

***Long-term effectiveness and permanence***

This is the first of the primary balancing factors used to assess the qualitative reduction of risk to the environment. The evaluation of long-term effectiveness addresses the ability of a given alternative to maintain or continue reduction of risk for an extended period of time following implementation.

***Reduction of toxicity, mobility, or volume***

Reduction of toxicity, mobility, or volume is a primary balancing factor that addresses the method by which risk is reduced. For example, alternatives causing reaction or sorption of constituents reduce the toxicity of constituent affected sediments or soils, while barriers reduce mobility, and removal methods reduce volume present.

***Short-term effectiveness***

This primary balancing factor addresses the immediacy with which an alternative has affect on risk reduction. Alternatives that reduce risk upon implementation are considered to have high, short-term effectiveness; alternatives that reduce risk gradually are considered to have low, short-term effectiveness.

***Implementability***

Implementability is a primary balancing factor used to evaluate the characteristics that would prevent or enable the commencement of an alternative. Technical operations, disruption of the project area, administrative requirements, and long-term maintenance and testing requirements are all taken into account.

***Cost***

Cost is a primary balancing criterion addressed based on specific estimates for each technology process option and AOI. This evaluation is discussed in detail in Section 6.0.

***State and Community acceptance***

The final two criteria, state acceptance and community acceptance, are considered modifying considerations. These will be addressed once the ROD is released and presented for public comment. This evaluation will address any technical and administrative issues or concerns that the state and/or community may have with a proposed remedial alternative. Based on the comments received from the state and community, the EPA may modify components of the preferred alternative or decide that another alternative is more appropriate.

These threshold and balancing criteria were used to evaluate each remedial alternative for each AOI and are presented in the following sections.

## 5.3 INDIVIDUAL ANALYSIS OF ALTERNATIVES

As part of the screening process, general response actions have been analyzed to address the removal of the COCs for reduction of risk to the benthic organisms and the environment. Using these refined response actions, more detailed information pertinent to each of the technology process options is documented.

Remedial action alternatives retained through the screening process include those options that have a significant potential for implementation at the Site. An evaluation of the developed remedial action alternatives is conducted in this section based not only on screening for effectiveness and implementability, but taking into account the nine screening criteria and AOI specific conditions. Technology process options with insufficient degree of effectiveness or implementability have been eliminated from subsequent consideration within the FS.

For the Site, COCs include PCBs, PAHs, and metals; few remedial alternatives have capabilities to treat this range of constituents. The following remedial alternatives have been eliminated in prior stages of the FS because they do not isolate, remove or treat the organic COCs: physical burial process MNR, in situ chemical treatment, in situ physical treatment, ex situ chemical treatment, and ex situ chemical/physical treatment. The following remedial alternatives have been eliminated because they do not isolate,

remove, or treat the metal COCs: biological degradation MNR, in situ biological degradation, and ex situ biological treatment.

The remaining remedial alternatives are considered potential options, and are evaluated for each AOI in this section. The following analysis refines applicable alternatives with respect to the physical setting and accessibility of each area of investigation.

### 5.3.1 JEFFERSON CANAL

Access to this section of the canal is limited to the public by a secure 8-foot-tall chain link fence within the Huntsman Chemical Plant. The canal is trapezoidal with a variable bottom width between 4-10 feet, 2:1 side slopes, and is partially lined with concrete. The canal passes beneath Hogaboom Road and transitions to a grass-lined canal with a less defined shape. Jefferson Canal extends another 2,200 feet to a box culvert that goes beneath Farm to Market Road 366 (FM 366). The side slopes for this grassed section are approximately 12:1 and the bottom width is approximately 10-20 feet. At this location, Jefferson Canal is vegetated with trees on both sides. Several locations have wider cross sections and have side slopes of approximately 4:1. This canal is often partially inundated with water from storm runoff and a high water table. Water depth varies from 2.0-4.0 feet and is primarily influenced by surface runoff; tidally influenced in lower reaches. The bottom is soft with 8-10 inches of fine sediment easily resuspended. For the scope of the FS, Jefferson Canal is assumed to be a wetland. The soil classification for this section of the Jefferson Canal is identified as partially hydric. Wetland disturbance requires additional permitting and any altering of the wetland requires mitigation in the form of fees and additional wetland creation.

All pipelines at or near the Jefferson Canal AOI will be taken into consideration for all remedial alternatives developed for this AOI. A set-back or servitude will not be disturbed within 25 feet of the pipelines extending through the polygon corresponding to sample JC-18 for several alternatives described below. The pipeline servitude accounts for approximately 6 percent of the area to be remediated within the Jefferson Canal AOI. The terms partial removal and/or partial containment refer to the area outside the pipeline servitude. Figure 5-1 shows the Thiessen polygons and the approximate location of the pipeline servitude in the Jefferson Canal AOI. In addition, refer to Appendix B for more information regarding the pipelines in and around the Site. Individual analysis of remedial alternatives for the Jefferson Canal AOI are summarized in Table 5-1.

#### 5.3.1.1 ALTERNATIVE 1 – NO ACTION

***Overall Protection of the Environment***

Potential ecological receptor risk associated with current Site conditions were identified in the BERA. A No Action alternative does not lower the risk of interaction between benthic invertebrates and the sediment, nor does it reduce the volume or mobility of the COC-affected sediments identified.

***Compliance with the ARARs***

Since no remedial action is taken, the No Action alternative would not engage the chemical- , location- , or action-specific ARARs.

***Long-term effectiveness and permanence***

The No Action alternative provides no long-term effectiveness for the protection of ecological receptors or the reduction of any risks associated with exposure to COCs.

***Reduction of toxicity, mobility, and volume***

The No Action alternative does not reduce toxicity, mobility or volume of COCs, nor does it prevent or reduce risk of exposure to receptors.

***Short-term effectiveness***

The No Action alternative provides no short-term effectiveness for the protection of ecological receptors or the reduction of any risks associated with exposure to COCs**.**

***Implementability***

The No Action alternative does not require implementation or regulatory oversight.

#### 5.3.1.2 ALTERNATIVE 2A – CONTAINMENT: SOIL CAP AND PIPE AT JC-7, PARTIAL 12-INCH REMOVAL/DISPOSAL, AND PARTIAL CONTAINMENT: 12-INCH SOIL CAP

Alternative 2a includes containment with a soil cap and installation of a pipe at the polygon corresponding to sample location JC-7, partial 12-inch removal/disposal, and partial containment with a 12-inch soil cap of material in the areas outside the pipeline servitude in polygons JC-2, JC-13, JC-18, and JC-19 in the Jefferson Canal AOI. Figure 5-1 shows the Thiessen polygons and the approximate location of the pipeline servitude in

the Jefferson Canal AOI. Individual analysis of remedial alternatives for the Jefferson Canal AOI are summarized in Table 5-1.

A set-back or servitude will not be disturbed within 25 feet of the pipelines extending through the polygon corresponding to sample JC-18. The area outside the pipeline servitude in polygon corresponding to sample JC-18 will be excavated to a depth of 12 inches and contained with a 12-inch soil cap. For the remainder of the polygons associated with samples JC-2, JC-13, and JC-19, the affected COCs would be excavated to a depth of 12 inches and contained with a 12-inch soil cap. All removed sediment would be dewatered, if needed, and properly disposed off-Site. Additionally, sediment and erosion control best management practices such as silt curtains will be installed in the canal to prevent the migration of COC-affected sediments resuspended during the excavation process.

Jefferson Canal functions as a storm water conveyance canal with a required hydraulic capacity. Pipe containment is feasible along specific portions of Jefferson Canal identified by the Thiessen Polygon methodology presented in the Alignment Document. This alternative is viable for the polygon associated with sample JC-7 of the canal between the Huntsman facility and the box culvert at FM 366. The pipe would be designed to maintain the required hydraulic capacity along the piped section of the reach. The section would be prepared by placement of a thin soil cap and installation of a pipe bedded on limestone or sand wrapped in geotextile fabric. The pipe may be partially buried to maintain the natural bottom of the canal. The section between the pipe and existing side slopes would be backfilled with clean fill up to the elevation of the adjacent embankment. The backfill would be compacted to stabilize both the pipe and embankment. This alternative would further isolate the affected sediments from the environment, and prevent constituent migration. A hydraulic analysis would be conducted in order to size the pipe to safely convey the design storm event.

***Overall Protection of the Environment***

The pipe containment and 12-inch soil cap at polygon JC-7 will provide a barrier between benthic invertebrates and the COCs. The partial 12-inch removal and 12-inch soil cap (JC-2, JC-13, JC-18, and JC-19) will provide protection of the environment through the elimination of the COC-affected sediment and a disruption of the pathway between the ROCs and the COCs to areas outside the pipeline servitude. Excavation will require the sediment to be dewatered (possibly treated) and disposed. The partial containment with a 12-inch soil cap will restore the canal to its pre-excavation depth and provide a new benthic habitat to the areas outside the pipeline servitude. This alternative will maintain the hydraulic capacity of the canal. This alternative does not

meet the threshold criterion of overall protection of the environment for 6 percent of the polygons to be remediated in the Jefferson Canal AOI because the COC-affected material in the pipeline servitude (6 percent) area is not removed or contained.

***Compliance with the ARARs***

This alternative will be designed to comply with chemical-, location-, and action-specific ARARs for areas outside the pipeline servitude. The COC-affected material remaining in the pipeline servitude (6 percent) area may not comply with ARARs for the Site.

***Long-term effectiveness and permanence***

The long-term effectiveness and permanence of this action is moderate because this alternative provides a long-term solution to exposure of COCs within the sediment for areas outside the pipeline servitude.

***Reduction of toxicity, mobility, and volume***

This alternative does not reduce toxicity of the COC-affected sediments, however, through excavation and a 12-inch soil cap, mobility is eliminated and volume is reduced. The pipe further isolates any remaining sediment, eliminating mobility of the COCs to the benthic environment.

***Short-term effectiveness***

Short-term effectiveness depends upon the duration of implementation, the time it takes to sandbag and dewater the area, place the soil cap, lay geotextile or a thin layer of sand, set precast concrete pipe, backfill to grade, and vegetatively stabilize the canal. This remedial action alternative provides immediate relief from exposure to affected sediment upon implementation. Implementation of the excavation portion of the alternative provides a highly effective short-term solution to contact between benthic invertebrates and the COCs. Once the sediment is removed and a 12-inch soil cap is used for stabilization of the canal, the risk to benthic invertebrates from exposure to COC-affected sediment is eliminated. Additionally, care will be taken to install best management practices such as silt curtains to trap any affected sediment that may become resuspended in the water column by the excavation process.

***Implementability***

The pipe containment alternative has a high degree of implementability, because, materials and equipment are readily available. During implementation, logistical considerations will include proper timing of water diversion during preparation and pipe placement, staging requirements for backfill and equipment, and development of an erosion control plan to keep COC-affected sediment out of the waterway. A hydraulic

analysis will be conducted during the design to verify that the capacity of the pipe is adequate for current flow and will safely convey the design event. Additionally, the removed COC-affected sediment must be dewatered and disposed at an authorized facility. The removal/disposal and containment of the areas outside the pipeline servitude is also highly implementable and will not require any diversion of the stream; however, it will require the removed sediment to be dewatered and transported to an appropriate disposal facility. Materials and equipment are also readily available for removal/disposal and a 12-inch soil cap.

#### 5.3.1.3 ALTERNATIVE 2B – CONTAINMENT: SOIL CAP AND PIPE AT JC-7, PARTIAL 12-INCH REMOVAL/DISPOSAL, CONTAINMENT: 12-INCH SOIL CAP ON AREA OUTSIDE THE PIPELINE SERVITUDE AND A 12-INCH EROSION CONTROL MAT ON PIPELINE SERVITUDE

Alternative 2b includes containment with a soil cap and installation of a pipe of the polygon corresponding to sample location JC-7, partial 12-inch removal/disposal, and containment with a 12-inch soil cap in polygons JC-2, JC-13, JC-18, and JC-19 outside the pipeline servitude and a 12-inch erosion control mat on the pipeline servitude in the servitude that crosses JC-18. Figure 5-1 shows the Thiessen polygons and the approximate location of the pipeline servitude in the Jefferson Canal AOI. Individual analysis of remedial alternatives for the Jefferson Canal AOI are summarized in Table 5-1.

A set-back or servitude will not be disturbed within 25 feet of the pipelines extending through the polygon corresponding to sample JC-18. The pipeline servitude located in the polygon corresponding to sample JC-18 will be capped with a 12-inch erosion control mat. The area outside the pipeline servitude in polygon corresponding to sample JC-18 will be excavated to a depth of 12 inches and contained with a 12-inch soil cap. For the remainder of the polygons associated with samples JC-2, JC-13, and JC-19, the affected COCs would be excavated to a depth of 12 inches and contained with a 12-inch soil cap. All removed sediment would be dewatered, if needed, and properly disposed off-Site. Additionally, sediment and erosion control best management practices such as silt curtains will be installed in the canal to prevent the migration of COC-affected sediments resuspended during the excavation process.

Jefferson Canal functions as a storm water conveyance canal with a required hydraulic capacity. Pipe containment is feasible along specific portions of Jefferson Canal identified by the Thiessen Polygon methodology presented in the Alignment Document.

This alternative is viable for the polygons associated with sample JC-7 of the canal between the Huntsman Plant and the box culvert at FM 366. The pipe would be designed to maintain the required hydraulic capacity along the piped section of the reach. The section would be prepared by placement of a thin soil cap and installation of a pipe bedded on limestone or sand wrapped in geotextile fabric. The pipe may be partially buried to maintain the natural bottom of the canal. The section between the pipe and existing side slopes would be backfilled with clean fill up to the elevation of the adjacent embankment. The backfill would be compacted to stabilize both the pipe and embankment. This alternative would further isolate the affected sediments from the environment, and prevent constituent migration. A hydraulic analysis would be conducted in order to size the pipe to safely convey the design storm event.

***Overall Protection of the Environment***

The pipe containment and 12-inch soil cap at polygon JC-7 will provide a barrier between benthic invertebrates and the COCs. The partial 12-inch removal and 12-inch soil cap (JC-2, JC-13, JC-18, and JC-19) will provide protection of the environment through the elimination of the COC-affected sediment and a disruption of the pathway between the ROCs and the COCs to areas outside the pipeline servitude. Excavation will require the sediment to be dewatered (possibly treated) and disposed. The partial containment with a 12-inch soil cap will restore the canal to its pre-excavation depth and provide a new benthic habitat to the areas outside the pipeline servitude. This alternative will maintain the hydraulic capacity of the canal. An erosion control mat serves to protect the environment by partially inhibiting the migration of COC affected sediment by reduction of erosion, and by additionally trapping sediments and organic debris for marsh establishment. The lightweight aggregate within the mat allows it to lie atop existing sediment without sinking, highly reducing disruption caused by installation compared to other alternatives.

***Compliance with the ARARs***

This alternative will be designed to comply with chemical-, location-, and action-specific ARARs.

***Long-term effectiveness and permanence***

The long-term effectiveness and permanence of this action is high because this alternative provides a long-term solution to exposure of COCs within the sediment for areas outside the pipeline servitude. The long-term effectiveness of this action is high because the lightweight aggregate clay within the erosion control mat will remain in place, continuing to stabilize the sediment, even after the polymesh exterior degrades.

Additionally, if the setting is appropriate, marsh plants will populate the mat, or may be planted, increasing both effectiveness and permanence of the erosion control technology.

***Reduction of toxicity, mobility, and volume***

This alternative does not reduce toxicity of the COC-affected sediments, however, through excavation, a 12-inch soil cap, and an erosion control mat, mobility is eliminated and volume is reduced. The pipe further isolates any remaining sediment, eliminating mobility of the COCs to the benthic environment.

***Short-term effectiveness***

Short-term effectiveness depends upon the duration of implementation, the time it takes to sandbag and dewater the area, place a soil cap, lay geotextile or a thin layer of sand, set precast concrete pipe, backfill to grade, and vegetatively stabilize the canal. This remedial action of the alternative provides immediate relief from exposure to affected sediment upon implementation. Implementation of the excavation portion of the alternative provides a highly effective short-term solution to contact between benthic invertebrates and the COCs. Once the sediment is removed and a 12-inch soil cap is used for stabilization of the canal, the risk to benthic invertebrates from exposure to COC-affected sediment is eliminated. Additionally, care will be taken to install best management practices such as silt curtains to trap any affected sediment that may become resuspended in the water column by the excavation process. Implementation of the erosion control mat alternative provides a highly effective barrier between COC affected sediments and wave action or other erosive forces. Short-term effectiveness depends upon the duration of implementation, which consists only of the time it takes to lay the erosion control mat. This alternative provides immediate reduction of sediment erosion, in a level or inclined setting. Additionally, implementation causes only minimal disruption or re-suspension of sediments.

***Implementability***

The pipe containment alternative has a high degree of implementability, because, materials and equipment are readily available. During implementation, logistical considerations will include proper timing of water diversion during preparation and pipe placement, staging requirements for backfill and equipment, and development of an erosion control plan to keep COC-affected sediment out of the waterway. A hydraulic analysis will be conducted during the design to verify that the capacity of the pipe is adequate for current flow and will safely convey the design event. Additionally, the removed COC-affected sediment must be dewatered and disposed at an authorized facility. The removal/disposal and containment of the areas outside the pipeline servitude is also highly implementable and will not require any diversion of the stream;

however, it will require the removed sediment to be dewatered and transported to an appropriate disposal facility. Materials and equipment are also readily available for removal/disposal and a 12-inch soil cap. If it is determined in the Remedial Design that the erosion control mat can be installed without compromising the integrity of the pipelines, the erosion control mat alternative has a high degree of implementability, because materials are readily available, and easily installed. Logistical considerations are few, including transportation of materials, and coordination of Site access; no heavy equipment diversion of water, or dewatering of sediment is necessary.

#### 5.3.1.4 ALTERNATIVE 2C – CONTAINMENT: SOIL CAP AND PIPE AT JC-7, PARTIAL 12-INCH REMOVAL/DISPOSAL, AND PARTIAL CONTAINMENT: 12-INCH ARMORED CAP

Alternative 2c includes containment with a soil cap and installation of a pipe at the polygon corresponding to sample location JC-7, partial 12-inch removal/disposal, and partial containment with a 12-inch armored cap of material in the areas outside the pipeline servitude in polygons JC-2, JC-13, JC-18, and JC-19 in the Jefferson Canal AOI. Figure 5-1 shows the Thiessen polygons and the approximate location of the pipeline servitude in the Jefferson Canal AOI. Individual analysis of remedial alternatives for the Jefferson Canal AOI are summarized in Table 5-1.

A set-back or servitude will not be disturbed within 25 feet of the pipelines extending through the polygon corresponding to sample JC-18. The area outside the pipeline servitude in polygon corresponding to sample JC-18 will be excavated to a depth of 12 inches and contained with a 12-inch armored cap. For the remainder of the polygons associated with samples JC-2, JC-13, and JC-19, the affected COCs would be excavated to a depth of 12 inches and contained with a 12-inch armored cap. All removed sediment would be dewatered, if needed, and properly disposed off-Site. Additionally, sediment and erosion control best management practices such as silt curtains will be installed in the canal to prevent the migration of COC-affected sediments resuspended during the excavation process.

Jefferson Canal functions as a storm water conveyance canal with a required hydraulic capacity. Pipe containment is feasible along specific portions of Jefferson Canal identified by the Thiessen Polygon methodology presented in the Alignment Document. This alternative is viable for the polygon associated with sample JC-7 of the canal between the Huntsman Plant and the box culvert at FM 366. The pipe would be designed to maintain the required hydraulic capacity along the piped section of the reach. The section would be prepared by placement of a thin soil cap and installation of

a pipe bedded on limestone or sand wrapped in geotextile fabric. The pipe may be partially buried to maintain the natural bottom of the canal. The section between the pipe and existing side slopes would be backfilled with clean fill up to the elevation of the adjacent embankment. The backfill would be compacted to stabilize both the pipe and embankment. This alternative would further isolate the affected sediments from the environment, and prevent constituent migration. A hydraulic analysis would be conducted in order to size the pipe to safely convey the design storm event.

***Overall Protection of the Environment***

The pipe containment and 12-inch soil cap at polygon JC-7 will provide a barrier between benthic invertebrates and the COCs. The partial 12-inch removal and 12-inch armored cap (JC-2, JC-13, JC-18, and JC-19) will provide protection of the environment through the elimination of the COC-affected sediment and a disruption of the pathway between the ROCs and the COCs to areas outside the pipeline servitude. Excavation will require the sediment to be dewatered (possibly treated) and disposed. The partial containment with a 12-inch armored cap provides resistance from erosion. An armored cap does not provide a permanent barrier between benthic invertebrates and COC-affected sediment. This alternative will maintain the hydraulic capacity of the canal. This alternative does not meet the threshold criterion of overall protection of the environment for 6 percent of the polygons to be remediated in the Jefferson Canal AOI because the COC-affected material in the pipeline servitude (6 percent) area is not removed or contained.

***Compliance with the ARARs***

This alternative will be designed to comply with chemical-, location-, and action-specific ARARs for areas outside the pipeline servitude. The COC-affected material remaining in the pipeline servitude (6 percent) area may not comply with ARARs for the Site.

***Long-term effectiveness and permanence***

The long-term effectiveness and permanence of this action is moderate because this alternative provides a long-term solution to exposure of COCs within the sediment for areas outside the pipeline servitude. There is a high level of long-term effectiveness for an armored cap because of the prevention and reduction of erosion.

***Reduction of toxicity, mobility, and volume***

The pipe further isolates any remaining sediment, eliminating mobility of the COCs to the benthic environment. The removal of sediment does not reduce toxicity of the COC-affected sediments, however, mobility is eliminated and volume is reduced. An armor cap reduces mobility through the prevention of erosion.

*Short-term effectiveness*

Short-term effectiveness depends upon the duration of implementation, the time it takes to sandbag and dewater the area, place a soil cap, lay geotextile or a thin layer of sand, set precast concrete pipe, backfill to grade, and vegetatively stabilize the canal. This remedial action of the alternative provides immediate relief from exposure to affected sediment upon implementation. Implementation of the excavation portion of the alternative provides a highly effective short-term solution to contact between benthic invertebrates and the COCs. Once the sediment is removed and a 12-inch armor cap is used for stabilization of the canal, the risk to benthic invertebrates from exposure to COC-affected sediment is eliminated. An armor caps ability to reduce erosion is effective immediately after installation. Additionally, care will be taken to install best management practices such as silt curtains to trap any affected sediment that may become resuspended in the water column by the excavation process.

*Implementability*

The pipe containment alternative has a high degree of implementability, because, materials and equipment are readily available. During implementation, logistical considerations will include proper timing of water diversion during preparation and pipe placement, staging requirements for backfill and equipment, and development of an erosion control plan to keep COC-affected sediment out of the waterway. A hydraulic analysis will be conducted during the design to verify that the capacity of the pipe is adequate for current flow and will safely convey the design event. Additionally, the removed COC-affected sediment must be dewatered and disposed at an authorized facility. The removal/disposal and containment of the areas outside the pipeline servitude is also highly implementable and will not require any diversion of the stream; however, it will require the removed sediment to be dewatered and transported to an appropriate disposal facility. Materials and equipment are also readily available for removal/disposal and a 12-inch armored cap.

#### 5.3.1.5 ALTERNATIVE 2D – CONTAINMENT: SOIL CAP AND PIPE AT JC-7, PARTIAL 12-INCH REMOVAL/DISPOSAL, CONTAINMENT: 12-INCH ARMORED CAP ON AREA OUTSIDE THE PIPELINE SERVITUDE AND A 12-INCH EROSION CONTROL MAT ON PIPELINE SERVITUDE

Alternative 2d includes containment with a soil cap and installation of a pipe at the polygon corresponding to sample location JC-7, partial 12-inch removal/disposal, and containment with a 12-inch armored cap on area outside the pipeline servitude in

polygons JC-2, JC-13, JC-18, and JC-19 and a 12-inch erosion control mat on the pipeline servitude for the Jefferson Canal AOI. Figure 5-1 shows the Thiessen polygons and the approximate location of the pipeline servitude area in the Jefferson Canal AOI. Individual analysis of remedial alternatives for the Jefferson Canal AOI are summarized in Table 5-1.

A set-back or servitude will not be disturbed within 25 feet of the pipelines extending through the polygon corresponding to sample JC-18. The pipeline servitude located in polygon corresponding to sample JC-18 will be capped with a 12-inch erosion control mat. The area outside the pipeline servitude in polygon corresponding to sample JC-18 will be excavated to a depth of 12 inches and contained with a 12-inch armored cap. For the remainder of the polygons associated with samples JC-2, JC-13, and JC-19, the affected COCs would be excavated to a depth of 12 inches and contained with a 12-inch armored cap. All removed sediment would be dewatered, if needed, and properly disposed off-Site. Additionally, sediment and erosion control best management practices such as silt curtains will be installed in the canal to prevent the migration of COC-affected sediments resuspended during the excavation process.

Jefferson Canal functions as a storm water conveyance canal with a required hydraulic capacity. Pipe containment is feasible along specific portions of Jefferson Canal identified by the Thiessen Polygon methodology presented in the Alignment Document. This alternative is viable for the polygons associated with sample JC-7 of the canal between the Huntsman facility and the box culvert at FM 366. The pipe would be designed to maintain the required hydraulic capacity along the piped section of the reach. The section would be prepared by placement of a thin soil cap and installation of a pipe bedded on limestone or sand wrapped in geotextile fabric. The pipe may be partially buried to maintain the natural bottom of the canal. The section between the pipe and existing side slopes would be backfilled with clean fill up to the elevation of the adjacent embankment. The backfill would be compacted to stabilize both the pipe and embankment. This alternative would further isolate the affected sediments from the environment, and prevent constituent migration. A hydraulic analysis would be conducted in order to size the pipe to safely convey the design storm event.

***Overall Protection of the Environment***

The pipe containment and 12-inch soil cap at polygon JC-7 will provide a barrier between benthic invertebrates and the COCs. The partial 12-inch removal and 12-inch armored cap (JC-2, JC-13, JC-18, and JC-19) will provide protection of the environment through the elimination of the COC-affected sediment and a disruption of the pathway between the ROCs and the COCs to areas outside the pipeline servitude. Excavation will

require the sediment to be dewatered (possibly treated) and disposed. The partial containment with a 12-inch armored cap provides resistance from erosion. An armored cap does not provide a permanent barrier between benthic invertebrates and COC-affected sediment. This alternative will maintain the hydraulic capacity of the canal. An erosion control mat serves to protect the environment by partially inhibiting the migration of COC affected sediment by reduction of erosion, and by additionally trapping sediments and organic debris for marsh establishment. The lightweight aggregate within the mat allows it to lie atop existing sediment without sinking, highly reducing disruption caused by installation compared to other alternatives.

***Compliance with the ARARs***

This alternative will be designed to comply with chemical-, location-, and action-specific ARARs.

***Long-term effectiveness and permanence***

The long-term effectiveness and permanence of this action is high because this alternative provides a long-term solution to exposure of COCs within the sediment for areas outside the pipeline servitude. An armored cap is implemented on polygons downstream of sample number JC-7 and will provide erosion protection. The long-term effectiveness of the erosion control mat is high because the lightweight aggregate clay will remain in place, continuing to stabilize the sediment, even after the polymesh exterior degrades. Additionally, if the setting is appropriate, marsh plants will populate the mat, or may be planted, increasing both effectiveness and permanence of the erosion control technology.

***Reduction of toxicity, mobility, and volume***

This alternative does not reduce toxicity of the COC-affected sediments, however, through excavation, a 12-inch soil cap, and an erosion mat, mobility is eliminated and volume is reduced. The pipe further isolates any remaining sediment, eliminating mobility of the COCs to the benthic environment.

***Short-term effectiveness***

Short-term effectiveness depends upon the duration of implementation, the time it takes to sandbag and dewater the area, place a soil cap, lay geotextile or a thin layer of sand, set precast concrete pipe, backfill to grade, and vegetatively stabilize the canal. This remedial action of the alternative provides immediate relief from exposure to affected sediment upon implementation. Implementation of the excavation portion of the alternative provides a highly effective short-term solution to contact between benthic invertebrates and the COCs. Once the sediment is removed and a 12-inch armored cap

is used for stabilization of the canal, the risk to benthic invertebrates from exposure to COC-affected sediment is eliminated. Additionally, care will be taken to install best management practices such as silt curtains to trap any affected sediment that may become resuspended in the water column by the excavation process. Implementation of the erosion control mat alternative provides a highly effective barrier between COC affected sediments and wave action or other erosive forces. Short-term effectiveness depends upon the duration of implementation, which consists only of the time it takes to lay the erosion control mat. This alternative provides immediate reduction of sediment erosion, in a level or inclined setting. Additionally, implementation causes only minimal disruption or re-suspension of sediments.

***Implementability***

The pipe containment alternative has a high degree of implementability, because, materials and equipment are readily available. During implementation, logistical considerations will include proper timing of water diversion during preparation and pipe placement, staging requirements for backfill and equipment, and development of an erosion control plan to keep COC-affected sediment out of the waterway. A hydraulic analysis will be conducted during the design to verify that the capacity of the pipe is adequate for current flow and will safely convey the design event. Additionally, the removed COC-affected sediment must be dewatered and disposed at an authorized facility. The removal/disposal and containment of the areas outside the pipeline servitude is also highly implementable and will not require any diversion of the stream; however, it will require the removed sediment to be dewatered and transported to an appropriate disposal facility. Materials and equipment are also readily available for removal/disposal and a 12-inch armored cap. If it is determined in the Remedial Design that the erosion control mat can be installed without compromising the integrity of the pipelines, the erosion control mat alternative has a high degree of implementability, because materials are readily available, and easily installed. Logistical considerations are few, including transportation of materials, and coordination of Site access; no heavy equipment diversion of water, or dewatering of sediment is necessary.

#### 5.3.1.6 ALTERNATIVE 3A – PARTIAL 12-INCH REMOVAL/DISPOSAL AND PARTIAL CONTAINMENT: 12-INCH SOIL CAP

Alternative 3a includes partial 12-inch removal/disposal and partial containment with a 12-inch soil cap of material in the areas outside the pipeline servitude in the Jefferson Canal AOI. Figure 5-1 shows the Thiessen polygons and the approximate location of the pipeline servitude in the Jefferson Canal AOI. Individual analysis of remedial alternatives for the Jefferson Canal AOI are summarized in Table 5-1.

A set-back or servitude will not be disturbed within 25 feet of the pipelines extending through the polygon corresponding to sample JC-18. The area outside the pipeline servitude in polygon corresponding to sample JC-18 will be excavated to a depth of 12 inches and contained with a 12-inch soil cap. For the remainder of the polygons associated with samples JC-2, JC-7, JC-13, and JC-19, the affected COCs would be excavated to a depth of 12 inches and contained with a 12-inch soil cap. All removed sediment would be dewatered, if needed, and properly disposed off-Site. These excavated areas shall be backfilled with clean fill and stabilized along the bottom and sides of the canal. Additionally, sediment and erosion control best management practices such as silt curtains will be installed in the canal to prevent the migration of COC-affected sediments resuspended during the excavation process.

***Overall Protection of the Environment***

The partial 12-inch removal and partical 12-inch soil cap will provide protection of the environment through the elimination of the COC-affected sediment and a disruption of the pathway between the ROCs and the COCs to areas outside the pipeline servitude. Excavation will require the sediment to be dewatered (possibly treated) and disposed. The partial containment with a 12-inch soil cap will restore the canal to its pre-excavation depth and provide a new benthic habitat to the areas outside the pipeline servitude. This alternative will maintain the hydraulic capacity of the canal. This alternative does not meet the threshold criterion of overall protection of the environment for 6 percent of the polygons to be remediated in the Jefferson Canal AOI because the COC-affected material in the pipeline servitude (6 percent) area is not removed or contained.

***Compliance with the ARARs***

This alternative will be designed to comply with chemical-, location-, and action-specific ARARs for areas outside the pipeline servitude. The COC-affected material remaining in the pipeline servitude (6 percent) area may not comply with ARARs for the Site.

***Long-term effectiveness and permanence***

The long-term effectiveness and permanence of this action is moderate to high for partial 12-inch removal and and a partial 12-inch soil cap because this alternative provides a long-term solution to exposure of COCs within the sediment for areas outside the pipeline servitude.

*Reduction of toxicity, mobility, and volume*

This alternative does not reduce toxicity of the COC-affected sediments; however, through excavation and a 12-inch soil cap, mobility is eliminated and volume is reduced outside of the pipeline servitude.

*Short-term effectiveness*

Implementation of the excavation portion of the alternative provides a highly effective short-term solution to contact between benthic invertebrates and the COCs. Once the sediment is removed and a 12-inch soil cap is used for stabilization of the canal, the risk to benthic invertebrates from exposure to COC-affected sediment is eliminated. Additionally, care will be taken to install best management practices such as silt curtains to trap any affected sediment that may become resuspended in the water column by the excavation process.

*Implementability*

The removal/disposal and containment of the areas outside the pipeline servitude is also highly implementable and will not require any diversion of the stream; however, it will require the removed sediment to be dewatered and transported to an appropriate disposal facility. Additionally, the removed COC-affected sediment must be dewatered and disposed at an authorized facility. Materials and equipment are also readily available for removal/disposal and a 12-inch soil cap.

#### 5.3.1.7 ALTERNATIVE 3B – PARTIAL 12-INCH REMOVAL/DISPOSAL AND CONTAINMENT: 12-INCH SOIL CAP ON AREA OUTSIDE PIPELINE SERVITUDE AND A 12-INCH EROSION CONTROL MAT ON THE PIPELINE SERVITUDE

Alternative 3b includes partial 12-inch removal/disposal and containment with a 12-inch soil cap on area outside the pipeline servitude and a 12-inch erosion control mat on the pipeline servitude for the Jefferson Canal AOI. Figure 5-1 shows the Thiessen polygons and the approximate location of the pipeline servitude in the Jefferson Canal AOI. Individual analysis of remedial alternatives for the Jefferson Canal AOI are summarized in Table 5-1.

A set-back or servitude will not be disturbed within 25 feet of the pipelines extending through the polygon corresponding to sample JC-18. The pipeline servitude located in polygon corresponding to sample JC-18 will be capped with a 12-inch erosion control mat. The area outside the pipeline servitude in polygon corresponding to sample JC-18

will be excavated to a depth of 12 inches and contained with a 12-inch soil cap. For the remainder of the polygons associated with samples JC-2, JC-7, JC-13, and JC-19, the affected COCs would be excavated to a depth of 12 inches and contained with a 12-inch soil cap. All removed sediment would be dewatered, if needed, and properly disposed off-Site. These excavated areas shall be backfilled with clean fill and stabilized along the bottom and sides of the canal. Additionally, sediment and erosion control best management practices such as silt curtains will be installed in the canal to prevent the migration of COC-affected sediments resuspended during the excavation process.

***Overall Protection of the Environment***

The partial 12-inch removal and partical 12-inch soil cap will provide protection of the environment through the elimination of the COC-affected sediment and a disruption of the pathway between the ROCs and the COCs to areas outside the pipeline servitude. Excavation will require the sediment to be dewatered (possibly treated) and disposed. The partial containment with a 12-inch soil cap will restore the canal to its pre-excavation depth and provide a new benthic habitat to the areas outside the pipeline servitude. This alternative will maintain the hydraulic capacity of the canal. An erosion control mat serves to protect the environment by partially inhibiting the migration of COC affected sediment by reduction of erosion, and by additionally trapping sediments and organic debris for marsh establishment. The lightweight aggregate within the mat allows it to lie atop existing sediment without sinking, highly reducing disruption caused by installation compared to other alternatives.

***Compliance with the ARARs***

This alternative will be designed to comply with chemical-, location-, and action-specific ARARs.

***Long-term effectiveness and permanence***

The long-term effectiveness and permanence of this action is moderately high because this alternative provides a long-term solution to exposure of COCs within the sediment for areas outside the pipeline servitude. The long-term effectiveness of this action is high because the lightweight aggregate clay within the erosion control mat will remain in place, continuing to stabilize the sediment, even after the polymesh exterior degrades. Additionally, if the setting is appropriate, marsh plants will populate the mat, or may be planted, increasing both effectiveness and permanence of the erosion control technology.

*Reduction of toxicity, mobility, and volume*

This alternative does not reduce toxicity of the COC-affected sediments, however, through excavation, a 12-inch soil cap, and an erosion control mat, mobility is eliminated and volume is reduced.

*Short-term effectiveness*

Implementation of the excavation portion of the alternative provides a highly effective short-term solution to contact between benthic invertebrates and the COCs. Once the sediment is removed and a 12-inch soil cap is used for stabilization of the canal, the risk to benthic invertebrates from exposure to COC-affected sediment is eliminated. Additionally, care will be taken to install best management practices such as silt curtains to trap any affected sediment that may become resuspended in the water column by the excavation process. Implementation of the erosion control mat alternative provides a highly effective barrier between COC affected sediments and wave action or other erosive forces. Short-term effectiveness depends upon the duration of implementation, which consists only of the time it takes to lay the erosion control mat. This alternative provides immediate reduction of sediment erosion, in a level or inclined setting. Additionally, implementation causes only minimal disruption or re-suspension of sediments.

*Implementability*

The removal/disposal and containment of the areas outside the pipeline servitude is also highly implementable and will not require any diversion of the stream; however, it will require the removed sediment to be dewatered and transported to an appropriate disposal facility. Additionally, the removed COC-affected sediment must be dewatered and disposed at an authorized facility. Materials and equipment are also readily available for removal/disposal and a 12-inch soil cap. If it is determined in the Remedial Design that the erosion control mat can be installed without compromising the integrity of the pipelines, the erosion control mat alternative has a high degree of implementability, because materials are readily available, and easily installed. Logistical considerations are few, including transportation of materials, and coordination of Site access; no heavy equipment diversion of water, or dewatering of sediment is necessary.

#### 5.3.1.8 ALTERNATIVE 3C – PARTIAL 12-INCH REMOVAL/DISPOSAL AND PARTIAL CONTAINMENT: 12-INCH ARMORED CAP

Alternative 3c includes partial 12-inch removal/disposal and partial containment with a 12-inch armored cap of the material outside the pipeline servitude in the Jefferson Canal AOI. Figure 5-1 shows the Thiessen polygons and the approximate location of the

pipeline servitude in the Jefferson Canal AOI. Individual analysis of remedial alternatives for the Jefferson Canal AOI are summarized in Table 5-1.

A set-back or servitude will not be disturbed within 25 feet of the pipelines extending through the polygon corresponding to sample JC-18. The area outside the pipeline servitude in polygon corresponding to sample JC-18 will be excavated to a depth of 12 inches and contained with a 12-inch armored cap. For the remainder of the polygons associated with samples JC-2, JC-7, JC-13, and JC-19, the affected COCs would be excavated to a depth of 12 inches and contained with a 12-inch armored cap. All removed sediment would be dewatered, if needed, and properly disposed off-Site. These excavated areas shall be backfilled with clean fill and stabilized along the bottom and sides of the canal. Additionally, sediment and erosion control best management practices such as silt curtains will be installed in the canal to prevent the migration of COC-affected sediments resuspended during the excavation process.

***Overall Protection of the Environment***

The partial 12-inch removal and partial 12-inch armored cap will provide protection of the environment through the elimination of the COC-affected sediment and a disruption of the pathway between the ROCs and the COCs to areas outside the pipeline servitude. Excavation will require the sediment to be dewatered (possibly treated) and disposed. The partial containment with a 12-inch armored cap provides resistance from erosion. An armored cap does not provide a permanent barrier between benthic invertebrate and COC-affected sediment. This alternative will maintain the hydraulic capacity of the canal. This alternative does not meet the threshold criterion of overall protection of the environment for 6 percent of the polygons to be remediated in the Jefferson Canal AOI because the COC-affected material in the pipeline servitude (6 percent) area is not removed or contained.

***Compliance with the ARARs***

This alternative will be designed to comply with chemical-, location-, and action-specific ARARs for areas outside the pipeline servitude. The COC-affected material remaining in the pipeline servitude (6 percent) area may not comply with ARARs for the Site.

*Long-term effectiveness and permanence*

The long-term effectiveness and permanence of this action is moderate to high for 12-inch removal because this remedial action provides a long-term solution to exposure of COCs within the sediment for areas outside the pipeline servitude. There is a high level of long-term effectiveness for an armored cap because of the prevention and reduction of erosion.

*Reduction of toxicity, mobility, and volume*

The removal of sediment does not reduce toxicity of the COC-affected sediments, however, mobility is eliminated and volume is reduced. An armor cap reduces mobility through the prevention of erosion.

*Short-term effectiveness*

Implementation of the excavation portion of the alternative provides a highly effective short-term solution to contact between benthic invertebrates and the COCs. Once the sediment is removed and a 12-inch armor cap is used for stabilization of the canal, the risk to benthic invertebrates from exposure to COC-affected sediment is eliminated. An armor caps ability to reduce erosion is effective immediately after installation. Additionally, care will be taken to install best management practices such as silt curtains to trap any affected sediment that may become resuspended in the water column by the excavation process.

*Implementability*

The removal/disposal and containment of the areas outside the pipeline servitude is also highly implementable and will not require any diversion of the stream; however, it will require the removed sediment to be dewatered and transported to an appropriate disposal facility. Additionally, the removed COC-affected sediment must be dewatered and disposed at an authorized facility. Materials and equipment are also readily available for removal/disposal and a 12-inch armor cap.

#### 5.3.1.9 ALTERNATIVE 3D – PARTIAL 12-INCH REMOVAL/DISPOSAL AND CONTAINMENT: 12-INCH ARMORED CAP ON AREA OUTSIDE PIPELINE SERVITUDE AND A 12-INCH EROSION CONTROL MAT ON THE PIPELINE SERVITUDE

Alternative 3d includes partial 12-inch removal/disposal and containment with a 12-inch armored cap on area outside the pipeline servitude and a 12-inch erosion control mat on the pipeline servitude for the Jefferson Canal AOI. Figure 5-1 shows the Thiessen

polygons and the approximate location of the pipeline servitude in the Jefferson Canal AOI. Individual analysis of remedial alternatives for the Jefferson Canal AOI are summarized in Table 5-1.

A set-back or servitude will not be disturbed within 25 feet of the pipelines extending through the polygon corresponding to sample JC-18. The pipeline servitude located in polygon corresponding to sample JC-18 will be capped with a 12-inch erosion control mat. The area outside the pipeline servitude in polygon corresponding to sample JC-18 will be excavated to a depth of 12 inches and contained with a 12-inch armored cap. For the remainder of the polygons associated with samples JC-2, JC-7, JC-13, and JC-19, the affected COCs would be excavated to a depth of 12 inches and contained with a 12-inch armored cap. All removed sediment would be dewatered, if needed, and properly disposed off-Site. These excavated areas shall be backfilled with clean fill and stabilized along the bottom and sides of the canal. Additionally, sediment and erosion control best management practices such as silt curtains will be installed in the canal to prevent the migration of COC-affected sediments resuspended during the excavation process.

***Overall Protection of the Environment***

The partial 12-inch removal and partial 12-inch armored cap will provide protection of the environment through the elimination of the COC-affected sediment and a disruption of the pathway between the ROCs and the COCs to areas outside the pipeline servitude. Excavation will require the sediment to be dewatered (possibly treated) and disposed. The partial containment with a 12-inch armored cap provides resistance from erosion. An armored cap does not provide a permanent barrier between benthic invertebrates and COC-affected sediment. This alternative will maintain the hydraulic capacity of the canal. An erosion control mat serves to protect the environment by partially inhibiting the migration of COC affected sediment by reduction of erosion, and by additionally trapping sediments and organic debris for marsh establishment. The lightweight aggregate within the mat allows it to lie atop existing sediment without sinking, highly reducing disruption caused by installation compared to other alternatives.

***Compliance with the ARARs***

This alternative will be designed to comply with chemical-, location-, and action-specific ARARs.

***Long-term effectiveness and permanence***

The long-term effectiveness and permanence of this action is high for 12-inch removal because this remedial action provides a long-term solution to exposure of COCs within the sediment for areas outside the pipeline servitude. There is a high level of long-term

effectiveness for an armored cap because of the prevention and reduction of erosion. The long-term effectiveness of the erosion control mat is high because the lightweight aggregate clay within the erosion control mat will remain in place, continuing to stabilize the sediment, even after the polymesh exterior degrades. Additionally, if the setting is appropriate, marsh plants will populate the mat, or may be planted, increasing both effectiveness and permanence of the erosion control technology.

***Reduction of toxicity, mobility, and volume***

The removal of sediment does not reduce toxicity of the COC-affected sediments, however, mobility is eliminated and volume is reduced. An armor cap reduces mobility through the prevention of erosion. In addition, the erosion control mat does not reduce toxicity of the COC affected sediments, however, mobility is highly reduced.

***Short-term effectiveness***

Implementation of the excavation portion of the alternative provides a highly effective short-term solution to contact between benthic invertebrates and the COCs. Once the sediment is removed and a 12-inch armor cap is used for stabilization of the canal, the risk to benthic invertebrates from exposure to COC-affected sediment is eliminated. An armor caps ability to reduce erosion is effective immediately after installation. Additionally, care will be taken to install best management practices such as silt curtains to trap any affected sediment that may become resuspended in the water column by the excavation process. Implementation of the erosion control mat alternative provides a highly effective barrier between COC affected sediments and wave action or other erosive forces. Short-term effectiveness depends upon the duration of implementation, which consists only of the time it takes to lay the erosion control mat. This alternative provides immediate reduction of sediment erosion, in a level or inclined setting. Additionally, implementation causes only minimal disruption or re-suspension of sediments.

***Implementability***

The removal/disposal and containment of the areas outside the pipeline servitude is also highly implementable and will not require any diversion of the stream; however, it will require the removed sediment to be dewatered and transported to an appropriate disposal facility. Additionally, the removed COC-affected sediment must be dewatered and disposed at an authorized facility. Materials and equipment are also readily available for removal/disposal and a 12-inch armor cap. If it is determined in the Remedial Design that the erosion control mat can be installed without compromising the integrity of the pipelines, the erosion control mat alternative has a high degree of implementability, because materials are readily available, and easily installed. Logistical

considerations are few, including transportation of materials, and coordination of Site access; no heavy equipment diversion of water, or dewatering of sediment is necessary.

### 5.3.2 JEFFERSON CANAL SPOIL PILE

The spoil pile is located upstream from the Hurricane Protection Levee and downstream from FM 366. The southern limits of the spoil pile abut FM 366 Road, the Lower Neches Valley Authority Canal, and the Kansas City Southern Railroad. The western limit abuts to the overhead Entergy Power lines that extend south to north. Jefferson Canal extends from south to north on the eastern bank of the spoil pile. The area immediately east of Jefferson Canal is heavily vegetated with trees. The Jefferson Canal Spoil Pile was previously vegetated with trees, and during the Tier 2 RI those trees were removed to facilitate preparation of a topographic map and collection of soil samples. The spoil pile is partially composed of previously dredged material; therefore, it has a high lime content. The ground surface includes several low-lying "mounds" of the spoils that are a few feet in height and provide an uneven ground surface. The ground surface elevation is several feet above the groundwater table and drains from west to east into the Jefferson Canal.

All pipelines at or near the Jefferson Canal Spoil Pile AOI will be taken into consideration for all remedial alternatives developed for this AOI. A set-back or servitude will not be disturbed within 25 feet of the pipelines extending through the spoil pile for several alternatives below. The current assumption is that no heavy equipment will be used to implement any remedial alternative over the pipeline servitude areas. The pipeline servitude accounts for approximately 24 percent of the area to be remediated within the Jefferson Canal Spoil Pile AOI. The terms partial removal and/or partial containment refers to the area outside the pipeline servitude. Figure 5-2A shows the Thiessen polygons and the approximate location of the pipeline servitudes in the Jefferson Canal Spoil Pile AOI. Figures 5-2B through 5-2E show the excavation plan, the soil cover plan, the colorimetric plan with cut and fill areas, and the cross sections, respectively, for the removal of the mounds to grade. These plans may be modified in the Remedial Design. Figure 1-5 is a topographic survey map that shows the pipelines that extend south to north and east to west through the Jefferson Canal Spoil Pile. Individual analysis of remedial alternatives for the Jefferson Canal Spoil Pile AOI are summarized in Table 5-2.

#### 5.3.2.1 ALTERNATIVE 1 – NO ACTION

***Overall Protection of the Environment***

Potential ecological receptor risks associated with current Site conditions were identified in the BERA. A No Action alternative does not lower the risk of interaction between ROCs and the soil, nor does it reduce the volume or mobility of the COC-affected soils identified.

***Compliance with the ARARs***

Since no remedial action is taken, the No Action alternative would not engage the chemical- , location- , or action-specific ARARs.

***Long-term effectiveness and permanence***

The No Action alternative provides no long-term effectiveness for the protection of ecological receptors or the reduction of any risks associated with exposure to COCs.

***Reduction of toxicity, mobility, and volume***

The No Action alternative does not reduce toxicity, mobility, or volume of COCs, nor does it prevent or reduce risk of exposure to ROCs.

***Short-term effectiveness***

The No Action alternative provides no short-term effectiveness for the protection of ecological receptors or the reduction of any risks associated with exposure to COCs**.**

***Implementability***

The No Action alternative does not require implementation or regulatory oversight.

#### 5.3.2.2 ALTERNATIVE 2A – CONTAINMENT: TWO-FOOT COMPOSITE CAP

Alternative 2a includes containment with a 2-foot composite cap on the entire Jefferson Canal Spoil Pile AOI. Figure 5-2A shows the Thiessen polygons and the approximate location of the pipeline servitudes in the Jefferson Canal Spoil Pile AOI. Figures 5-2B through 5-2E show the excavation plan, the soil cover plan, the colorimetric plan with cut and fill areas, and the cross sections, respectively, for the removal of the mounds to grade. These plans may be modified in the Remedial Design. Figure 1-5 is a topographic survey map that shows the pipelines that extend south to north and east to west through

the Jefferson Canal Spoil Pile. Individual analysis of remedial alternatives for the Jefferson Canal Spoil Pile AOI are summarized in Table 5-2.

The containment alternative is feasible for the Jefferson Canal Spoil Pile AOI, because it would isolate the COC-affected soils from the environment. The composite cap would consist of 12 inches of topsoil and 12 inches of clay. Composite cap composition and thickness will be designed to prevent infiltration of rainwater and erosion by surface runoff. In addition, potential ROCs that utilize the Site generally burrow less than two feet below the ground surface and the cap will be installed to try and minimize access by ROCs. For Alternative 2a, the entire spoil pile will be capped with a composite cap.

***Overall Protection of the Environment***

A composite cap as defined in Section 4.2.3 provides a disruption of the pathway between COCs and the receptors.

***Compliance with the ARARs***

This alternative will be designed to comply with chemical-, location-, and action-specific ARARs applicable and relevant for the Site.

***Long-term effectiveness and permanence***

The composite cap alternative provides long-term effectiveness for the protection of ecological receptors and the reduction of any risks associated with exposure to the COCs, by providing a barrier between all COC-affected soil and the environment. This cap would be anchored and stabilized.

***Reduction of toxicity, mobility, and volume***

This alternative eliminates the mobility of the COC-affected soils. Volume of COC-affected soil is not reduced. Toxicity may be reduced depending on concentration per unit volume following cap implementation, and amendment materials in the composite cap.

***Short-term effectiveness***

The composite cap alternative provides short-term effectiveness for the protection of ecological receptors and the reduction of any risks associated with exposure to COCs, dependent upon duration of implementation. This includes time for standard construction mobilization, staging of equipment, transportation, and placement of cap materials.

*Implementability*

The composite cap alternative is moderately implementable. Materials and equipment are readily available. No COC-affected soil will be excavated. The capping material will be transported to the Site and anchored in place. The composite cap is considered impervious to rain water infiltration and erosion resistant. Implementability is reduced by the pipeline servitude which requires the cap to be installed in multiple pieces. Work within the servitude will be done by light equipment if it is determined in the Remedial design that this can be implemented without compromising pipeline integrity.

#### 5.3.2.3 ALTERNATIVE 2B – REMOVAL/DISPOSAL OF MOUNDS TO GRADE AND CONTAINMENT: TWO-FOOT COMPOSITE CAP

Alternative 2b includes removal of the mounds to grade and containment with a 2-foot composite cap over the entire Jefferson Canal Spoil Pile AOI. Figure 5-2A shows the Thiessen polygons and the approximate location of the pipeline servitude in the Jefferson Canal Spoil Pile AOI. Figures 5-2B through 5-2E show the excavation plan, the soil cover plan, the colorimetric plan with cut and fill areas, and the cross sections, respectively, for the removal of the mounds to grade. These plans may be modified in the Remedial Design. Figure 1-5 is a topographic survey map that shows the pipelines that extend south to north and east to west through the Jefferson Canal Spoil Pile. Individual analysis of remedial alternatives for the Jefferson Canal Spoil Pile AOI are summarized in Table 5-2.

A set-back or servitude will not be disturbed within 25 feet of the pipelines extending through the Jefferson Canal Spoil Pile AOI except as described below. The mounds (see Figures 5-2B through 5-2E) outside of the pipeline servitude will be removed to grade. The portion of the mound within the servitude shown on Section F of Figure 5-2E will be removed with light equipment during the Remedial Design if it is determined that this can be implemented without compromising the integrity of any pipelines. The entire spoil pile will be contained with a 2-foot composite cap, including the pipeline servitude areas. The composite cap will consist of 12 inches of topsoil and 12 inches of clay. Composite cap composition and thickness will be designed to prevent infiltration of rainwater and erosion by surface runoff. In addition, potential ROCs that utilize the Site generally burrow less than two feet below the ground surface and the cap will be installed to try and minimize access by ROCs.

*Overall Protection of the Environment*

This alternative serves to protect the environment through elimination of the COCs and a disruption of the pathway between receptors and the COC-affected soils. The COC-affected soils will be removed from the mounds at the Site and disposed in an appropriate off-Site waste facility. A composite cap as defined in Section 4.2.3 provides a disruption of the pathway between COCs and the receptors.

*Compliance with the ARARs*

This alternative will be designed to comply with chemical-, location-, and action-specific ARARs for the Site.

*Long-term effectiveness and permanence*

The long-term effectiveness and permanence of removal of the mounds to grade and containment of the affected soil is high. The COCs will be isolated from the receptors and the area will be stabilized. Infiltration from rain events and erosion will be prevented by the cap and established vegetation. The composite cap alternative provides long-term effectiveness for the protection of ecological receptors and the reduction of any risks associated with exposure to the COCs, by providing a barrier between all COC-affected soil and the environment. This cap would be anchored and stabilized.

*Reduction of toxicity, mobility, and volume*

This alternative eliminates the mobility of COC-affected soils. Volume of COC-affected soil is reduced with the removal of the mounds to grade. Toxicity may be reduced depending on concentration per unit volume following cap implementation.

*Short-term effectiveness*

The composite cap alternative provides short-term effectiveness for the protection of ecological receptors and the reduction of any risks associated with exposure to COCs, dependent upon duration of implementation. This includes time for standard construction mobilization, staging of equipment, transportation, and placement of cap materials.

*Implementability*

The removal/disposal of mounds to grade and containment alternative is moderately implementable. Materials and equipment are readily available. Standard excavation equipment will be used to remove the mounds to grade and facilitate transportation to an approved off-Site disposal facility. The composite cap is highly implementable. Materials and equipment are readily available. The capping material will be transported

to the Site and anchored in place. The composite cap is considered impervious to rain water infiltration and erosion resistant. Implementability is reduced by the pipeline servitude which requires the cap to be installed in multiple pieces. Work within the servitude will be done by light equipment if it is determined in the Remedial design that this can be implemented without compromising pipeline integrity.

#### 5.3.2.4 ALTERNATIVE 2C – PARTIAL CONTAINMENT: TWO-FOOT COMPOSITE CAP

Alternative 2c includes partial containment with a composite cap of material outside the pipeline servitude for Jefferson Canal Spoil Pile AOI. Figure 5-2A shows the Thiessen polygons and the approximate location of the pipeline servitude in the Jefferson Canal Spoil Pile AOI. Figure 1-5 is a topographic survey map that shows the pipelines that extend south to north and east to west through the Jefferson Canal Spoil Pile. Individual analysis of remedial alternatives for the Jefferson Canal Spoil Pile AOI are summarized in Table 5-2.

A set-back or servitude will not be disturbed within 25 feet of the pipelines extending through the Jefferson Canal Spoil Pile AOI during containment with a composite cap. The area of the spoil pile outside the pipeline servitude will be contained with a 2-foot composite cap. The composite cap will consist of 12 inches of topsoil and 12 inches of clay. Composite cap composition and thickness will be designed to prevent infiltration of rainwater and erosion by surface runoff. In addition, potential ROCs that utilize the Site generally burrow less than two feet below the ground surface and the cap will be installed to try and minimize access by ROCs.

***Overall Protection of the Environment***

A composite cap as defined in Section 4.2.3 provides a disruption of the pathway between COCs and the receptors, applicable for all areas of the Spoil Pile AOI outside of the pipeline servitude. This alternative does not meet the threshold criterion of overall protection of environment for 24 percent of the polygons to be remediated in the Jefferson Canal Spoil Pile AOI because the COC-affected material in the pipeline servitude (24 percent) area is not removed or contained.

***Compliance with the ARARs***

This alternative will be designed to comply with chemical-, location-, and action-specific ARARs applicable and relevant for the Site for areas outside the pipeline servitude. The

COC-affected material remaining in the pipeline servitude (24 percent) area may not comply with ARARs for the Site.

***Long-term effectiveness and permanence***

The partial composite cap alternative provides long-term effectiveness for the protection of ecological receptors and the reduction of any risks associated with exposure to the COCs for all areas of the Spoil Pile AOI outside of the pipeline servitude. This cap will be anchored and stabilized.

***Reduction of toxicity, mobility, and volume***

The composite cap eliminates the mobility of the COC-affected soils. Volume of affected soils is not reduced, and reduction of toxicity is dependent on components of the composite cap. For Alternative 2c, the servitude will not be capped, leaving 6 percent of COC-affected soils in place with no reduction of mobility, volume, or toxicity.

***Short-term effectiveness***

The partial composite cap alternative provides short-term effectiveness for the protection of ecological receptors and the reduction of any risks associated with exposure to COCs for all areas of the spoil pile outside of the pipeline servitude.

***Implementability***

The composite cap alternative is highly implementable; materials and equipment are readily available. Implementability is reduced by the pipeline servitude, which will require the composite cap to be installed as multiple pieces. Twenty-four percent of the AOI will be left undisturbed, and 76 percent will be covered by an impervious and erosion resistant composite cap. The capping material will be transported to the Site and anchored in place.

#### 5.3.2.5 ALTERNATIVE 3A – PARTIAL 12-INCH REMOVAL/DISPOSAL, REMOVAL/DISPOSAL OF MOUNDS TO GRADE, AND CONTAINMENT: TWO-FOOT COMPOSITE CAP

Alternative 3a includes partial 12-inch removal/disposal, removal of the mounds to grade, and containment with a composite cap for the entire Jefferson Canal Spoil Pile AOI. Figure 5-2A shows the Thiessen polygons and the approximate location of the pipeline servitude in the Jefferson Canal Spoil Pile AOI. Figures 5-2B through 5-2E show the excavation plan, the soil cover plan, the colorimetric plan with cut and fill areas, and the cross sections, respectively, for the removal of the mounds to grade. These plans

may be modified in the Remedial Design. Figure 1-5 is a topographic survey map that shows the pipelines that extend south to north and east to west through the Jefferson Canal Spoil Pile. Individual analysis of remedial alternatives for the Jefferson Canal Spoil Pile AOI are summarized in Table 5-2.

A set-back or servitude will not be disturbed within 25 feet of the pipelines extending through the Jefferson Canal Spoil Pile AOI during 12-inch removal and the removal of mounds to grade except as described below. The area of the spoil pile outside the pipeline servitude will be excavated to a depth of 12 inches and then contained with a composite cap. The mounds (see Figures 5-2B through 5-2E) outside of the pipeline servitude will be removed to grade, excavated to a depth of 12 inches, and then contained with a composite cap. The portion of the mound within the servitude shown on Section F of Figure 5-2E will be removed with light equipment during the Remedial Design if it is determined that this can be implemented without compromising the integrity of any pipelines. The pipeline servitude area will also be contained with a composite cap for this alternative if it is determined during the Remedial Design that this can be implemented without compromising pipeline integrity. The composite cap will consist of 12 inches of topsoil and 12 inches of clay. The ground surface will be graded to distribute material evenly following installation of the composite cap over the entire area. Composite cap composition and thickness will be designed to prevent infiltration of rainwater and erosion by surface runoff. In addition, potential ROCs that utilize the Site generally burrow from approximately less than two feet below the ground surface and the cap will be installed to try and minimize access by ROCs. Excavated material will be transported to an appropriate off-Site disposal facility.

***Overall Protection of the Environment***

This alternative serves to protect the environment through partial elimination of the COCs and a disruption of the pathway between receptors and the COC-affected soils. The COC-affected soils will be partially removed from the Site and disposed in an appropriate off-Site waste facility. A cap with 12 inches of clay and 12 inches of topsoil will cover the entire spoil pile after removal outside the pipeline servitude is completed.

***Compliance with the ARARs***

This alternative will be designed to comply with chemical-, location-, and action-specific ARARs for the Site.

***Long-term effectiveness and permanence***

The long-term effectiveness and permanence of partial removal/disposal, removal of mounds to grade, and containment of the affected soil is high. The COCs will be

isolated from the receptors and the area will be stabilized. Infiltration from rain events and erosion will be prevented by the cap and established vegetation. This cap would be anchored and stabilized.

***Reduction of toxicity, mobility, and volume***

This alternative eliminates the mobility of COC-affected soil through excavation of 94 percent of the area of the spoil pile and cap placement over the entire spoil pile. Volume is reduced by the 12-inch removal of soil outside the pipeline servitude and removal of the mounds to grade. Reduction of toxicity is dependent on the ratio of soil removed and components of the composite cap.

***Short-term effectiveness***

The partial 12-inch removal/disposal, removal/disposal of mounds to grade, and containment alternative, in correspondence to duration of implementation, provides short-term effectiveness for the protection of ecological receptors, and the reduction of any risks associated with exposure to COCs**.**

***Implementability***

The partial 12-inch removal/disposal, removal/disposal of mounds to grade, and containment alternative is moderately implementable. Materials and equipment are readily available. Standard excavation equipment will be used to remove the first 12 inches of excavated COC-affected soil outside the pipeline servitude, remove the mounds to grade, and facilitate transportation to an approved off-Site disposal facility. The capping material will be delivered to the Site and anchored in place. The composite cap is considered impervious to rain water infiltration and erosion resistant. Servitude requires cap be installed in pieces. Implementability is reduced by the pipeline servitude which requires the cap to be installed in multiple pieces. Work within the servitude will be done by light equipment if it is determined in the Remedial design that this can be implemented without compromising pipeline integrity.

#### 5.3.2.6 ALTERNATIVE 3B – PARTIAL 12-INCH REMOVAL/DISPOSAL, REMOVAL/DISPOSAL OF MOUNDS TO GRADE, AND PARTIAL CONTAINMENT: TWO-FOOT COMPOSITE CAP

Alternative 3b includes partial 12-inch removal/disposal, removal of the mounds to grade, and partial containment with a composite cap for the Jefferson Canal Spoil Pile AOI. Figure 5-2 shows the Thiessen polygons and the approximate location of the pipeline servitude in the Jefferson Canal Spoil Pile AOI. Figures 5-2B through 5-2E show

the excavation plan, the soil cover plan, the colorimetric plan with cut and fill areas, and the cross sections, respectively, for the removal of the mounds to grade. These plans may be modified in the Remedial Design. Figure 1-5 is a topographic survey map that shows the pipelines that extend south to north and east to west through the Jefferson Canal Spoil Pile. Individual analysis of remedial alternatives for the Jefferson Canal Spoil Pile AOI are summarized in Table 5-2.

A set-back or servitude will not be disturbed within 25 feet of the pipelines extending through the Jefferson Canal Spoil Pile AOI during 12-inch removal, removal of mounds to grade, and containment with a composite cap except as described below. The area of the spoil pile outside the pipeline servitude will be excavated to a depth of 12 inches and then contained with a composite cap. The mounds (see Figures 5-2B through 5-2E) outside of the pipeline servitude will be removed to grade and then contained with a composite cap. The portion of the mound within the servitude shown on Section F of Figure 5-2E will be removed with light equipment during the Remedial Design if it is determined that this can be implemented without compromising the integrity of any pipelines. The composite cap will consist of 12 inches of topsoil and 12 inches of clay. Composite cap composition and thickness will be designed to prevent infiltration of rainwater and erosion by surface runoff. In addition, potential ROCs that utilize the Site generally burrow less than two below the ground surface and the cap will be installed to try and minimize access by ROCs. Excavated material will be transported to an appropriate off-Site disposal facility.

***Overall Protection of the Environment***

This alternative serves to protect the environment through partial elimination of the COCs and a disruption of the pathway between receptors and the COC-affected soils. The COC-affected soils will be partially removed from Site and disposed in an appropriate off-Site waste facility. A cap with 12 inches of clay and 12 inches of topsoil will be anchored and stabilized to replace excavated soil outside of the pipeline servitude. This alternative does not meet the threshold criterion of overall protection of environment for 24 percent of the polygons to be remediated in the Jefferson Canal Spoil Pile AOI because the COC-affected material in the pipeline servitude (24 percent) area is not removed or contained.

***Compliance with the ARARs***

This alternative will be designed to comply with chemical-, location-, and action-specific ARARs for the Site for areas outside the pipeline servitude. The COC-affected material remaining in the pipeline servitude (24 percent) area may not comply with ARARs for the Site.

*Long-term effectiveness and permanence*

The long-term effectiveness and permanence of partial removal/disposal, removal/disposal of mounds to grade, and partial containment of the affected soil is high. For all areas of the spoil pile outside of the pipeline servitude, the COCs will be isolated from the receptors and the area will be stabilized. Infiltration from rain events and erosion will be prevented by the cap and established vegetation. This cap will be anchored and stabilized.

*Reduction of toxicity, mobility, and volume*

Removal and disposal reduces volume and mobility of COC-affected soils, and the composite cap eliminates mobility. Reduction of toxicity is dependent on ratio of soil removed and components of the composite cap. For Alternative 3b, the servitude will not be excavated or capped; leaving 24 percent of COC-affected soils in place with no reduction of mobility, volume, or toxicity.

*Short-term effectiveness*

The partial 12-inch removal/disposal, removal/disposal of mounds to grade, and partial containment alternative, in correspondence to duration of implementation, provides short-term effectiveness for the protection of ecological receptors, and the reduction of any risks associated with exposure to COCs for all areas of the spoil pile outside of the pipeline servitude.

*Implementability*

The partial 12-inch removal/disposal, removal/disposal of mounds to grade, and partial containment alternative is moderately to highly implementable. Materials and equipment are readily available. Implementability is reduced by the pipeline servitude, which will require the implementation area to be divided into multiple subsections, thus increasing fencing, staking, and other administrative controls. Twenty-four percent of the AOI will be left undisturbed, and 76 percent removed and covered by an impervious and erosion resistant composite cap. The capping material will be delivered to the Site and anchored in place.

### 5.3.3 FORMER STAR LAKE

The Former Star Lake AOI includes the area of the former Star Lake southwest of Atlantic Road and southeast of Star Lake Canal. The Former Star Lake AOI in plan view has the shape of two rectangles and the Star Lake Canal extends from southwest to

northeast through the former Star Lake and both rectangles abut northeast to Atlantic Road. The rectangle to the southeast of Star Lake Canal is approximately 300 feet in the northwest to southeast direction and 800 feet in the southwest to northeast direction. The rectangle to the northwest of Star Lake Canal extends approximately 800 feet in the southwest to northeast direction and 800 feet in the southeast to northwest direction. The Former Star Lake AOI is a marsh or wetland area with a silty bottom and wetland vegetation throughout. The bottom is generally 1 foot to 2 feet below tide and tidally inundated.

All pipelines at or near the Former Star Lake AOI will be taken into consideration for all remedial alternatives developed for this AOI. A set-back or servitude will not be disturbed within 25 feet of the pipelines extending through the polygons corresponding to sample locations SL-7 and SL-9 for several alternatives described below. Based on current information, the pipeline servitude accounts for approximately 13 percent of the area to be remediated within the Former Star Lake AOI. Through coordination with pipeline owners and/or geophysical surveying, the pipelines status and locations will be determined during the Remedial Design phase. The terms partial removal and/or partial containment refer to the area outside the pipeline servitude. Figure 5-3 shows the Thiessen polygons and the approximate location of the pipeline servitudes in the Former Star Lake AOI. Individual analysis of remedial alternatives for the Former Star Lake AOI are summarized in Table 5-3. Note that available information provides conflicting pipeline locations in this AOI and that both locations are shown on Figure 5-3 for several Total Petrochem pipelines.

#### 5.3.3.1 ALTERNATIVE 1 – NO ACTION

***Overall Protection of the Environment***

Potential ecological receptor risk associated with current Site conditions were identified in the BERA. A No Action alternative does not lower the risk of interaction between benthic invertebrates and the sediment, nor does it reduce the volume or mobility of the COC-affected sediments identified.

***Compliance with the ARARs***

Since no remedial action is taken, the No Action alternative would not engage the chemical- , location- , or action-specific ARARs.

*Long-term effectiveness and permanence*
The No Action alternative provides no long-term effectiveness for the protection of ecological receptors or the reduction of any risks associated with exposure to COCs.

*Reduction of toxicity, mobility, and volume*
The No Action alternative does not reduce toxicity, mobility or volume of COCs, nor does it prevent or reduce risk of exposure to benthic organisms.

*Short-term effectiveness*
The No Action alternative provides no short-term effectiveness for the protection of ecological receptors or the reduction of any risks associated with exposure to COCs.

*Implementability*
The No Action alternative does not require implementation or regulatory oversight.

#### 5.3.3.2 ALTERNATIVE 2A – PARTIAL 12-INCH REMOVAL/DISPOSAL AND PARTIAL CONTAINMENT: 12-INCH IMPERMEABLE CAP

Alternative 2a includes partial 12-inch removal/disposal and partial containment with a 12-inch impermeable cap of material outside the pipeline servitude in the Former Star Lake AOI. Figure 5-3 shows the Thiessen polygons and the approximate location of the pipeline servitudes in the Former Star Lake AOI. Individual analysis of remedial alternatives for the Former Star Lake AOI are summarized in Table 5-3.

A set-back or servitude will not be disturbed within 25 feet of the pipelines extending through the polygons corresponding to samples SL-7and SL-9. The area outside the pipeline servitudes will be excavated to a depth of 12 inches and contained with a 12-inch impermeable cap. All removed sediment would be dewatered, if needed, and properly disposed off-Site.

*Overall Protection of the Environment*
This alternative serves to protect the environment through partial elimination of the COCs and a disruption of the pathway between receptors and the COC-affected sediment. The COC-affected sediment will be partially removed from Site and disposed in an appropriate off-Site waste facility. Cap installation will restore the bottom of the Former Star Lake AOI to the pre-excavation depth. An impermeable cap will provide a barrier between the benthic invertebrates and COC-affected sediment, and resist erosion from an inundated drainage canal. The hydraulic capacity or the sediment topography

of the canal will not be modified by the cap design. This alternative does not meet the threshold criterion of overall protection of environment for 13 percent of the polygons to be remediated in the Former Star Lake AOI because the COC-affected material in the pipeline servitude (13 percent) area is not removed or contained.

***Compliance with the ARARs***

This alternative will be designed to comply with chemical-, location-, and action-specific ARARs for the Site for areas outside the pipeline servitude. The COC-affected material remaining in the pipeline servitude (13 percent) area may not comply with ARARs for the Site.

***Long-term effectiveness and permanence***

The long-term effectiveness and permanence of partial removal/disposal and partial containment of the affected sediment is moderately high. For all areas outside of the pipeline servitude, the COCs will be isolated from the receptors and the area will be stabilized. Infiltration from rain events and erosion will be prevented by the cap and established vegetation. The pathway between the COC-affected sediments and benthic organisms will be interrupted, and the area stabilized from erosion and bioturbation by benthic invertebrate burrowing and erosion.

***Reduction of toxicity, mobility, and volume***

Removal reduces volume and eliminates mobility of COC-affected sediment. The impermeable cap will further isolate any remaining affected sediment, and reduce erosion, eliminating mobility of the COCs to the benthic environment. Reduction of toxicity is dependent on ratio of soil removed and components of the impermeable cap. For Alternative 2a, the servitude will not be excavated or capped; leaving 13 percent of COC-affected soils in place with no reduction of mobility, volume, or toxicity.

***Short-term effectiveness***

The partial 12-inch removal/disposal and partial containment alternative, in correspondence to duration of implementation, provides short-term effectiveness for the protection of ecological receptors, and the reduction of any risks associated with exposure to COCs for all areas outside of the pipeline servitude**.**

***Implementability***

The partial 12-inch removal/disposal and partial containment alternative is moderately to highly implementable. Materials and equipment are readily available. Implementability is reduced by the pipeline servitude, which will require the implementation area to be divided into multiple subsections, thus increasing fencing,

staking, and other administrative controls. Thirteen percent of the AOI will be left undisturbed, and 87 percent removed and covered by an impermeable cap. The capping material will be delivered to the Site and anchored in place. The installed cap is considered erosion resistant and impervious to both infiltration and burrowing of benthic organisms.

#### 5.3.3.3 ALTERNATIVE 2B – PARTIAL 12-INCH REMOVAL/DISPOSAL AND CONTAINMENT: 12-INCH IMPERMEABLE CAP ON AREA OUTSIDE PIPELINE SERVITUDE AND 12-INCH EROSION CONTROL MAT AND 12-INCH COMPOSITE CAP ON THE PIPELINE SERVITUDE

Alternative 2b includes partial 12-inch removal/disposal and containment with a 12-inch impermeable cap (minimizes erosion) for the area outside the pipeline servitude. In addition, if it is determined in the Remedial Design that pipeline integrity will not be compromised a 12-inch erosion control mat on the pipeline servitudes near the banks of the Star Lake Canal, and a 12-inch composite cap on the pipeline servitudes remaining for the Former Star Lake AOI will also be completed. Figure 5-3 shows the Thiessen polygons and the approximate location of the pipeline servitudes in the Former Star Lake AOI. Individual analysis of remedial alternatives for the Former Star Lake AOI are summarized in Table 5-3.

A set-back or servitude will not be disturbed within 25 feet of the pipelines extending through the polygons corresponding to samples SL-7 and SL-9 except as described below. The area outside the pipeline servitudes will be excavated to a depth of 12 inches and contained with a 12-inch impermeable cap. If it is determined in the Remedial Desing that pipeline integrity will not be compromised, the pipeline servitudes will be contained with either a 12-inch erosion control mat or a composite cap depending on the location of the area along the bank of the Star Lake Canal. All removed sediment would be dewatered, if needed, and properly disposed off-Site.

***Overall Protection of the Environment***

The partial 12-inch removal will provide protection of the environment through the elimination of the COC-affected sediment and a disruption of the pathway between the ROCs and the COCs to areas outside the pipeline servitude. Excavation will require the sediment to be dewatered (possibly treated) and disposed. The containment with a 12-inch impermeable cap on areas outside the pipeline servitude will restore the area to its pre-excavation depth and provide a new benthic habitat to the areas outside the pipeline servitude. An impermeable cap will provide a barrier between the benthic

invertebrates and COC-affected sediment, and resist erosion from an inundated drainage canal. This alternative will not significantly alter the hydraulic capacity of the area. An erosion control mat serves to protect the environment by partially inhibiting the migration of COC affected sediment by reduction of erosion, and by additionally trapping sediments and organic debris for marsh establishment. The lightweight aggregate within the mat allows it to lie atop existing sediment without sinking, highly reducing disruption caused by installation compared to other alternatives. A composite cap as defined in Section 4.2.3 provides a disruption of the pathway between COCs and the ROCs. The erosion control mat and composite cap will be placed on the pipeline servitude.

***Compliance with the ARARs***

This alternative will be designed to comply with chemical-, location-, and action-specific ARARs.

***Long-term effectiveness and permanence***

The long-term effectiveness and permanence of removal, an impermeable cap, and a composite cap is high because all provide a long-term solution to exposure of COCs within the sediment. The long-term effectiveness of the erosion control mat is high because the lightweight aggregate clay within the erosion control mat will remain in place, continuing to stabilize the sediment, even after the polymesh exterior degrades. Additionally, if the setting is appropriate, marsh plants will populate the mat, or may be planted, increasing both effectiveness and permanence of the erosion control technology.

***Reduction of toxicity, mobility, and volume***

This alternative does not reduce toxicity of the COC-affected sediments, however, through excavation, a 12-inch impermeable cap, an erosion control mat, and a composite cap, mobility is eliminated and volume is reduced. The impermeable cap will further isolate any remaining affected sediment, and reduce erosion, eliminating mobility of the COCs to the benthic environment to areas outside the pipeline servitude.

***Short-term effectiveness***

Implementation of the excavation portion of the alternative provides a highly effective short-term solution to contact between benthic invertebrates and the COCs. Once the sediment is removed and a 12-inch impermeable cap is used for stabilization of Former Star Lake, the risk to benthic invertebrates from exposure to COC-affected sediment is eliminated. Implementation of the erosion control mat alternative provides a highly effective barrier between COC affected sediments and wave action or other erosive forces. Short-term effectiveness depends upon the duration of implementation, which

consists only of the time it takes to lay the erosion control mat. This alternative provides immediate reduction of sediment erosion, in a level or inclined setting. Additionally, implementation causes only minimal disruption or re-suspension of sediments.

***Implementability***

The removal/disposal and containment are moderately implementable. The removed COC-affected sediment must be dewatered and disposed at an authorized facility. A composite cap will be used on the pipeline servitude areas not near the banks of the Star Lake Canal. Materials and equipment are also readily available for removal/disposal, impermeable cap, and a composite cap. The erosion control mat alternative has a high degree of implementability, because materials are readily available, and easily installed. Logistical considerations are few, including transportation of materials, and coordination of Site access; no heavy equipment diversion of water, or dewatering of sediment is necessary. Implementability is reduced by the pipeline servitude which requires the cap to be installed in multiple pieces. Work within the servitude will be done by light equipment if it is determined in the Remedial Design that this can be implemented without compromising pipeline integrity.

#### 5.3.3.4 ALTERNATIVE 3A – PARTIAL 12-INCH REMOVAL/DISPOSAL AND PARTIAL CONTAINMENT: 12-INCH COMPOSITE CAP

Alternative 3a includes partial 12-inch removal/disposal and partial containment with a 12-inch composite cap of the material outside the pipeline servitude in the Former Star Lake AOI. Figure 5-3 shows the Thiessen polygons and the approximate location of the pipeline servitudes in the Former Star Lake AOI. Individual analysis of remedial alternatives for the Former Star Lake AOI are summarized in Table 5-3.

A set-back or servitude will not be disturbed within 25 feet of the pipelines extending through the polygons corresponding to samples SL-7 and SL-9. The areas outside the pipeline servitude will be excavated to a depth of 12 inches and contained with a 12-inch composite cap. All removed sediment would be dewatered, if needed, and properly disposed off-Site.

***Overall Protection of the Environment***

This alternative serves to protect the environment through partial elimination of the COCs and a disruption of the pathway between receptors and the COC-affected sediment. The COC-affected sediment will be partially removed from Site and disposed in an appropriate off-Site waste facility. A cap with 6 inches of clay and 6 inches of

topsoil will be anchored and stabilized to replace excavated soil outside of the pipeline servitude. This alternative will be designed not to modify the hydraulic capacity of the Former Star Lake AOI. This alternative does not meet the threshold criterion of overall protection of environment for 13 percent of the polygons to be remediated in the Former Star Lake AOI because the COC-affected material in the pipeline servitude (13 percent) area is not removed or contained.

***Compliance with the ARARs***

This alternative will be designed to comply with chemical-, location-, and action-specific ARARs for the Site for areas outside the pipeline servitude. The COC-affected material remaining in the pipeline servitude (13 percent) area may not comply with ARARs for the Site.

***Long-term effectiveness and permanence***

The long-term effectiveness and permanence of partial removal/disposal and partial containment of the affected sediment is moderately high. For all areas outside of the pipeline servitude, the COCs will be isolated from the receptors and the area will be stabilized. The pathway between the COC-affected sediments and benthic organisms will be interrupted by excavation; bioturbation from benthic invertebrate burrowing and erosion from water movement will be reduced by the composite cap. The cap will be anchored and stabilized.

***Reduction of toxicity, mobility, and volume***

Removal and disposal reduces volume and mobility of COC-affected sediment, and the composite cap eliminates mobility. Reduction of toxicity is dependent on ratio of soil removed and components of the composite cap. For Alternative 3a, the servitude will not be excavated or capped; leaving 13 percent of COC-affected sediment in place with no reduction of mobility, volume, or toxicity.

***Short-term effectiveness***

The partial 12-inch removal/disposal and partial containment alternative, in correspondence to duration of implementation, provides short-term effectiveness for the protection of ecological receptors, and the reduction of any risks associated with exposure to COCs for all areas outside of the pipeline servitude**.**

***Implementability***

The partial 12-inch removal/disposal and partial containment alternative is moderately to highly implementable. Materials and equipment are readily available. Implementability is reduced by the pipeline servitude, which will require the

implementation area to be divided into multiple subsections, thus increasing fencing, staking, and other administrative controls. Eighty-seven percent of the AOI will be removed and covered by an impervious and erosion resistant composite cap. The capping material will be delivered to the Site and anchored in place. Implementability is reduced by the pipeline servitude which requires caps to be implemented in pieces.

#### 5.3.3.5 ALTERNATIVE 3B – PARTIAL 12-INCH REMOVAL/DISPOSAL, CONTAINMENT: 12-INCH COMPOSITE CAP ON AREA OUTSIDE PIPELINE SERVITUDE AND 12-INCH EROSION CONTROL MAT AND 12-INCH COMPOSITE CAP ON THE PIPELINE SERVITUDE

Alternative 3b includes partial 12-inch removal/disposal and containment with a 12-inch composite cap for the area outside the pipeline servitude. In addition, if it is determined in the Remedial Design that pipeline integrity will not be compromised, a 12-inch erosion control mat on the pipeline servitudes near the banks of the Star Lake Canal, and a composite cap on the pipeline servitudes will also be completed. Figure 5-3 shows the Thiessen polygons and the approximate location of the pipeline servitudes in the Former Star Lake AOI. Individual analysis of remedial alternatives for the Former Star Lake AOI are summarized in Table 5-3.

A set-back or servitude will not be disturbed within 25 feet of the pipelines extending through the polygons corresponding to samples SL-7 and SL-9 except as described below. The area outside the pipeline servitudes will be excavated to a depth of 12 inches and contained with a 12-inch composite cap. If it is determined in the Remedial Design that pipeline integrity will not be compromised, the pipeline servitudes will be contained with either a 12-inch erosion control mat or a composite cap depending on the location of the area along the bank of the Star Lake Canal. All removed sediment would be dewatered, if needed, and properly disposed off-Site.

***Overall Protection of the Environment***

The COCs are either to be isolated and immobilized, or removed completely depending on which remedial action is utilized in this alternative. The 12-inch removal will provide protection of the environment through the elimination of the COC-affected sediment and a disruption of the pathway between the ROCs and the COCs to areas outside the pipeline servitude. Excavation will require the sediment to be dewatered (possibly treated) and disposed. This alternative will be designed not to modify the hydraulic capacity of the Former Star Lake AOI except for the servitude areas. An erosion control mat serves to protect the environment by partially inhibiting the migration of COC

affected sediment by reduction of erosion, and by additionally trapping sediments and organic debris for marsh establishment. The lightweight aggregate within the mat allows it to lie atop existing sediment without sinking, highly reducing disruption caused by installation compared to other alternatives. A composite cap as defined in Section 4.2.3 provides a disruption of the pathway between COCs and the ROCs.

***Compliance with the ARARs***

This alternative will be designed to comply with chemical-, location-, and action-specific ARARs.

***Long-term effectiveness and permanence***

The long-term effectiveness and permanence of removal, an impermeable cap, and a composite cap is high because all provide a long-term solution to exposure of COCs within the sediment. The erosion control mat and composite cap will be placed on the pipeline servitude. The long-term effectiveness of the erosion control mat is high because the lightweight aggregate clay within the erosion control mat will remain in place, continuing to stabilize the sediment, even after the polymesh exterior degrades. Additionally, if the setting is appropriate, marsh plants will populate the mat, or may be planted, increasing both effectiveness and permanence of the erosion control technology.

***Reduction of toxicity, mobility, and volume***

This alternative does not reduce toxicity of the COC-affected sediments, however, through excavation, a 12-inch composite cap, and an erosion control mat, mobility is eliminated and volume is reduced. Reduction of toxicity is dependent on ratio of soil removed and components of the composite cap.

***Short-term effectiveness***

Implementation of the excavation portion of the alternative provides a highly effective short-term solution to contact between benthic invertebrates and the COCs. Once the sediment is removed and a 12-inch composite cap is used for stabilization of Former Star Lake, the risk to benthic invertebrates from exposure to COC-affected sediment is eliminated. Implementation of the erosion control mat alternative provides a highly effective barrier between COC affected sediments and wave action or other erosive forces. Short-term effectiveness depends upon the duration of implementation, which consists only of the time it takes to lay the erosion control mat. This alternative provides immediate reduction of sediment erosion, in a level or inclined setting. Additionally, implementation causes only minimal disruption or re-suspension of sediments.

*Implementability*

The removal/disposal and containment is moderately implementable. The removed COC-affected sediment must be dewatered and disposed at an authorized facility. Materials and equipment are also readily available for partial removal/disposal and a 12-inch composite cap. The erosion control mat alternative has a high degree of implementability, because materials are readily available, and easily installed. Logistical considerations are few, including transportation of materials, and coordination ofSite access; no heavy equipment diversion of water, or dewatering of sediment is necessary. Implementability is reduced by the pipeline servitude which requires the use of light equipment and the cap to be installed in multiple pieces.

### 5.3.4 STAR LAKE CANAL

The distance along Star Lake Canal from its origin east of the intersection of Highway 136 and FM 366 to its confluence with the Neches River is approximately 16,500 feet. The Star Lake Canal portion of the AOI for the FS commences at the point of intersection with Jefferson Canal and extends approximately 10,000 feet to the confluence with the Neches River. Immediately northeast of the intersection with the Atlantic Road is the Associated Marine Services, Inc., dock. The channel is approximately 5 feet to 6 feet deep at the intersection with Jefferson Canal and about 20 feet wide with steep side slopes and a silty bottom. Beginning at Atlantic Road, it is about 50 feet wide and gradually increases in width towards the Neches River to a width of about 150 feet to its confluence with the Neches River. The average depth is about 10 feet near the dock and 20 feet near the confluence with the Neches River. The canal is tidally influenced and navigable.

All pipelines at or near the Star Lake Canal AOI will be taken into consideration for all remedial alternatives developed for this AOI. It is assumed that the pipelines under the Star Lake Canal are deep enough to allow for sediment removal. Through evaluation of easements, coordination with pipeline owners and/or completion of a geophysical survey, the pipeline's operational status and location will be determined during the Remedial Design phase. If sediment removal is not possible due to the pipeline depth, a 12-inch impermeable cap or 12-inch erosion control mat will be installed on the pipeline servitude if it is determined in the Remedial Design that this can be done without compromising the integrity of the pipelines. Based on current information, the pipeline servitude accounts for approximately 32 percent of the area to be remediated within the Star Lake Canal AOI. Figure 5-4 shows the Thiessen polygons and the approximate location of the pipeline servitudes in the Star Lake Canal AOI. Individual analysis of

remedial alternatives for Star Lake Canal AOI are summarized in Table 5-4. Note that available information provides conflicting pipeline locations in this AOI and that both locations are shown on Figure 5-4 for several Total Petrochem pipelines.

#### 5.3.4.1 ALTERNATIVE 1 – NO ACTION

***Overall Protection of the Environment***

Potential ecological receptor risk associated with current Site conditions were identified in the BERA. A No Action alternative does not lower the risk of interaction between benthic invertebrates and the sediment, nor does it reduce the volume or mobility of the COC-affected sediments identified.

***Compliance with the ARARs***

Since no remedial action is taken, the No Action alternative would not engage the chemical- , location- , or action-specific ARARs.

***Long-term effectiveness and permanence***

The No Action alternative provides no long-term effectiveness for the protection of ecological receptors or the reduction of any risks associated with exposure to COCs.

***Reduction of toxicity, mobility, and volume***

The No Action alternative does not reduce toxicity, mobility or volume of COCs, nor does it prevent or reduce risk of exposure to benthic organisms.

***Short-term effectiveness***

The No Action alternative provides no short-term effectiveness for the protection of ecological receptors or the reduction of any risks associated with exposure to COCs.

***Implementability***

The No Action alternative does not require implementation or regulatory oversight.

#### 5.3.4.2 ALTERNATIVE 2 –12-INCH REMOVAL/DISPOSAL AND CONTAINMENT: 12-INCH IMPERMEABLE CAP

The 12-inch removal/disposal and containment alternative is a feasible option for polygons located in the Star Lake Canal AOI (Polygons that correspond to sample numbers: SLC-6 and SLC-11). Hydraulic excavation is the preferred removal technology

for the navigable portion of the Star Lake Canal (the polygon associated with sample number SLC-11).

All pipelines at or near the Star Lake Canal AOI will be taken into consideration for all remedial alternatives developed for this AOI. It is assumed that the pipeline under the Star Lake Canal is deep enough to allow for sediment removal. Through evaluation of easements, coordination with pipeline owners and/or completion of a geophysical survey, the pipeline's operational status and location will be determined during the Remedial Design phase. If sediment removal is not possible, the 12-inch Impermeable Cap will be installed on the pipeline servitude if it is determined in the Remedial Design that this can be done without compromising the integrity of the pipelines. Figure 5-4 shows the Thiessen polygons and the approximate location of the pipeline servitudes in the Star Lake Canal AOI. Individual analysis of remedial alternatives for Star Lake Canal AOI are summarized in Table 5-4.

***Overall Protection of the Environment***

Potential ecological receptor risk associated with current Site conditions were identified in the BERA. This alternative serves to protect the environment through the partial elimination of the COC-affected sediment. This process provides a disruption of the pathway between receptor organisms and COC-affected sediments. The sediment would be partially removed from the Site and disposed in an appropriate waste facility. An impermeable cap will replace the removed sediment. The impermeable cap will be designed to provide isolation between the affected sediments and benthic invertebrates and to resist erosion. The hydraulic capacity of the canal will not be modified by this alternative.

***Compliance with the ARARs***

This alternative will be designed to comply with chemical-, location-, and action-specific ARARs for the Site.

***Long-term effectiveness and permanence***

The long-term effectiveness and permanence of excavation/disposal and containment of the affected sediment is moderate. The pathway between the COC-affected sediments and benthic organisms will be interrupted, and the area stabilized from erosion and bioturbation by benthic invertebrate burrowing. An impermeable cap provides better isolation of COCs than an armored cap.

*Reduction of toxicity, mobility, and volume*

This alternative does not reduce toxicity of the COC-affected sediments, however, through excavation of the Star Lake Canal AOI, mobility is eliminated and volume is reduced. The impermeable cap will further isolate any remaining affected sediment, and reduce erosion, eliminating mobility of the COCs to the benthic environment. An impermeable cap provides better isolation of COCs than an armored cap.

*Short-term effectiveness*

Excavation, disposal, and construction of the impermeable cap will provide short-term effectiveness, in correspondence with duration of implementation, for the protection of ecological receptors or the reduction of any risks associated with exposure to COCs.

*Implementability*

The removal/disposal and containment alternative is moderately to highly implementable. Materials and equipment are readily available. Standard excavation equipment will be used to remove COC-affected sediment and facilitate transportation. Capping material will be delivered to the Site and put in place if it is determined in the Remedial Design that it can be installed without compromising the integrity of the pipelines. The excavated sediment will need to be dewatered and disposed in an authorized disposal facility. Sediment and erosion control will be in place to prevent any COC-affected sediments from becoming resuspended and entering the waterway during excavation and placement of the impermeable cap. Hydraulic capacity will be maintained for this navigable waterway and a Section 10 Permit will be in place.

#### 5.3.4.3 ALTERNATIVE 3 – 12-INCH REMOVAL/DISPOSAL AND CONTAINMENT: 12-INCH ARMORED CAP

Alternative 3 includes 12-inch removal/disposal and containment with a 12-inch armored cap for the Star Lake Canal AOI (polygons that correspond to sample numbers: SLC-6 and SLC-11). Hydraulic excavation is the preferred removal technology for the navigable portion of the Star Lake Canal (the polygon associated with sample number SLC-11).

All pipelines at or near the Star Lake Canal AOI will be taken into consideration for all remedial alternatives developed for this AOI. It is assumed that the pipeline under the Star Lake Canal is deep enough to allow for sediment removal. Through evaluation of easements, coordination with pipeline owners and/or completion of a geophysical survey, the pipeline's operational status and location will be determined during the

Remedial Design phase. If removal is not possible, a 12-inch Erosion Control Mat will be installed on the pipeline servitude if it is determined in the Remedial Design that this can be done without compromising the integrity of the pipelines. Figure 5-4 shows the Thiessen polygons and the approximate location of the pipeline servitudes in the Star Lake Canal AOI. Individual analysis of remedial alternatives for Star Lake Canal AOI are summarized in Table 5-4.

***Overall Protection of the Environment***

This alternative provides overall protection by isolation of COC-affected sediments from benthic invertebrates and the environment. This alternative will reduce erosion of the soft sediments, and provide a new benthic habitat.

***Compliance with the ARARs***

This alternative will be designed to comply with chemical-, location-, and action-specific ARARs for the Site.

***Long-term effectiveness and permanence***

The long-term effectiveness and permanence of this alternative is moderate to high. Removal will interrupt the pathway between COC-affected sediments and ROCs, and the migration of any remaining COCs would be continually inhibited by the placement of an armored cap.

***Reduction of toxicity, mobility, and volume***

Toxicity may be reduced depending on the concentration per unit volume remaining in place; however, volume is reduced by the amount of sediment excavated from the Site. Mobility is also reduced by the use of an erosion resistant cap.

***Short-term effectiveness***

Short-term effectiveness of the removal/disposal and containment alternative depends upon duration of implementation. This includes time for standard construction mobilization, staging of equipment, dewatering, and removal of COC-affected sediment. The areas of excavation will be replaced with fill, and cap materials that will be staged at the Site. Additionally, care will be taken to implement best management practices such as curtains to trap any affected sediment that may become resuspended in the water column by the excavation process, or placement of backfill and cap materials.

***Implementability***

This alternative is moderately to highly implementable if removal is possible over pipelines in the Star Lake Canal AOI. The removed sediment will have to be dewatered

and transported to an appropriate disposal facility. Materials, equipment, and technology are readily available for removal/disposal and a 12-inch armored cap. Cap material will be placed to maintain the hydraulic capacity of the canal, and serve to anchor any remaining sediment.

### 5.3.5 GULF STATES UTILITY CANAL

The Gulf States Utility Canal extends parallel to the Star Lake Canal and is shallow, with side slopes at 4 horizontal to 1 vertical (4:1) or less. The canal was initially created to construct the overhead utility lines and is tidally inundated.

All pipelines at or near the Gulf States Utility Canal AOI will be taken into consideration for all remedial alternatives developed for this AOI. Based on available information, it is assumed that there are no pipeline crossings in the polygon to be remediated in the Gulf States Utility Canal. Through evaluation of easements, coordination with pipeline owners and/or completion of a geophysical survey, the operational status and location of the pipelines will be determined during the Remedial Design phase. If sediment removal is not possible due to the presence of a shallow pipeline, a 12-inch composite cap will be installed in the polygons to be remediated. Figure 5-5 shows the Thiessen polygons and the approximate location of the pipelines near the Gulf States Utility Canal AOI. Individual analysis of remedial alternatives for the Gulf States Utility Canal AOI are summarized in Table 5-5.

#### 5.3.5.1 ALTERNATIVE 1 – NO ACTION

***Overall Protection of the Environment***

Potential ecological receptor risk associated with current Site conditions were identified in the BERA. A No Action alternative does not lower the risk of interaction between benthic invertebrates and the sediment, nor does it reduce the volume or mobility of the COC-affected sediments identified.

***Compliance with the ARARs***

Since no remedial action is taken, the No Action alternative would not engage the chemical-, location-, or action-specific ARARs.

*Long-term effectiveness and permanence*
The No Action alternative provides no long-term effectiveness for the protection of ecological receptors or the reduction of any risks associated with exposure to COCs.

*Reduction of toxicity, mobility, and volume*
The No Action alternative does not reduce toxicity, mobility or volume of COCs, nor does it prevent or reduce risk of exposure to benthic organisms.

*Short-term effectiveness*
The No Action alternative provides no short-term effectiveness for the protection of ecological receptors or the reduction of any risks associated with exposure to COCs**.**

*Implementability*
The No Action alternative does not require implementation or regulatory oversight.

#### 5.3.5.2 ALTERNATIVE 2 – CONTAINMENT: 12-INCH COMPOSITE CAP

Alternative 2 includes containment with a 12-inch composite cap for the Gulf States Utility Canal (polygon corresponding to sample GSUC-7).

All pipelines at or near the Gulf States Utility Canal AOI will be taken into consideration for this remedial alternative. Based on available information, it is assumed that there are no pipeline crossings in the polygons to be remediated in the Gulf States Utility Canal. Through evaluation of easements, coordination with pipeline owners and/or completion of a geophysical survey, the operational status and location of the pipelines will be determined during the Remedial Design phase. If removal is not possible due to the presence of a shallow pipeline, a 12-inch composite cap will be installed in the polygons to be remediated. Figure 5-5 shows the Thiessen polygon and the approximate location of the pipelines near the Gulf States Utility Canal AOI. Individual analysis of remedial alternatives for the Gulf States Utility Canal AOI are summarized in Table 5-5.

*Overall Protection of the Environment*
The containment alternative using a composite cap serves to protect the environment by isolation of COC-affected sediments from benthic invertebrates and the environment. This alternative would reduce erosion of the canal bottom and provide a new benthic habitat.

*Compliance with the ARARs*
This alternative will be designed to comply with chemical- , location- , and action-specific ARARs for the Site.

*Long-term effectiveness and permanence*
The long-term effectiveness and permanence of a composite cap is high. The migration of COCs caused by erosion and bioturbation from the burrowing of benthic invertebrates will be continually inhibited.

*Reduction of toxicity, mobility, and volume*
This alternative does not reduce toxicity or volume; however, the composite cap reduces the mobility of the constituents by providing a barrier between the affected sediment and the environment.

*Short-term effectiveness*
Short-term effectiveness of the composite cap alternative depends upon duration of implementation. This includes standard construction, mobilization and staging of equipment, cap material placement, and stabilization of the area following cap installation.

*Implementability*
The containment alternative is moderately to highly implementable. Materials, equipment, and technology are readily available. Timing is not critical because the canal is not continually inundated, and does not require any water diversion. The cap will serve to anchor the sediment, and erosion control matting will stabilize the embankment.

#### 5.3.5.3 ALTERNATIVE 3 – 12-INCH REMOVAL/DISPOSAL AND CONTAINMENT: 12-INCH ARMORED CAP

Alternative 3 includes 12-inch removal/disposal and containment with a 12-inch armored cap for the Gulf States Utility Canal (polygon corresponding to sample GSUC-7).

All pipelines at or near the Gulf States Utility Canal AOI will be taken into consideration for this remedial alternative. Based on available information, it is assumed that there are no pipeline crossings in the polygons to be remediated in the Gulf States Utility Canal. Through evaluation of easements, coordination with pipeline owners and/or

completion of a geophysical survey, the operational status and location of the pipelines will be determined during the Remedial Design phase. If removal is not possible due to the presence of a shallow pipeline, a 12-inch composite cap will be installed in the polygons to be remediated. Figure 5-5 shows the Thiessen polygons and the approximate location of the pipelines near the Gulf States Utility Canal AOI. Individual analysis of remedial alternatives for the Gulf States Utility Canal AOI are summarized in Table 5-5.

***Overall Protection of the Environment***

This alternative serves to protect the environment by permanent elimination of the pathway between COC-affected sediments and benthic organisms, through excavation of the affected sediment and placement of a cap to isolate remaining sediment. The use of an armored cap following excavation will reduce erosion of the canal bottom, promote the creation of a new benthic environment, and provide isolation from interaction with any remaining COC-affected sediment.

***Compliance with the ARARs***

This alternative will be designed to comply with chemical-, location-, and action-specific ARARs for the Site.

***Long-term effectiveness and permanence***

The long-term effectiveness and permanence of 12-inch removal/disposal and containment of the affected sediment is high. The COC-affected sediment will be permanently removed and the canal stabilized from erosion caused by intermittent tidal influx and rain events.

***Reduction of toxicity, mobility, and volume***

This alternative does not reduce toxicity of the COC-affected sediments; however, through excavation of the Gulf States Utility Canal AOI, mobility is eliminated and volume is reduced. The armor cap will reduce the mobility of the any remaining COCs affected sediments by reducing erosion.

***Short-term effectiveness***

Short-term effectiveness of the 12-inch removal/disposal and containment alternative depends upon duration of implementation. This includes time for standard construction mobilization, staging of equipment, dewatering and removal of COC-affected sediments. The areas of excavation will be replaced with cap materials that will be staged at the Site. Sediment and erosion control measures will be implemented to

prevent COC-affected sediment from being redistributed in the area by the excavation, dewatering, or cap placement process.

***Implementability***

This alternative is moderately to highly implementable. Materials, equipment and technology are readily available. Timing is not critical because the canal is infrequently inundated with water and does not require water diversion. Removed sediment will be dewatered in a controlled manor and removed to an appropriate facility for permanent disposal. Cap material, will be placed to maintain the hydraulic capacity of the canal. The cap will serve to anchor any remaining sediment. Erosion control matting will stabilize the embankments.

#### 5.3.5.4 ALTERNATIVE 4 – 12-INCH REMOVAL/DISPOSAL

Alternative 4 includes 12-inch removal/disposal for the Gulf States Utility Canal (polygon corresponding to sample GSUC-7).

All pipelines at or near the Gulf States Utility Canal AOI will be taken into consideration for this remedial alternative. The operational status and location of the pipelines will be determined during the Remedial Design phase, and if removal is not possible, remedial alternative 2 will be implemented. Figure 5-5 shows the Thiessen polygons and the approximate location of the pipelines near the Gulf States Utility Canal AOI. Individual analysis of remedial alternatives for the Gulf States Utility Canal AOI are summarized in Table 5-5.

***Overall Protection of the Environment***

This alternative serves to protect the environment through permanent elimination of the pathway between COC-affected sediments and benthic organisms through removal/disposal.

***Compliance with the ARARs***

This alternative will be designed to comply with chemical-, location-, and action-specific ARARs for the Site.

*Long-term effectiveness and permanence*
The long-term effectiveness and permanence of removal/disposal of the affected sediment is high. The COCs would no longer present a risk to benthic invertebrates in the Gulf States Utility Canal.

*Reduction of toxicity, mobility, and volume*
Toxicity may be reduced depending on the concentration per unit volume remaining in place after 12-ich removal. Through excavation of the Gulf States Utility Canal AOI, mobility is eliminated and volume is reduced.

*Short-term effectiveness*
Short-term effectiveness of the removal/disposal alternative depends upon duration of implementation. This includes standard construction mobilization, staging of equipment, and the removal and dewatering of COC-affected sediment. Sediment and erosion control measures must be implemented to prevent COC-affected sediment from being redistributed by the excavation.

*Implementability*
This alternative is moderately to highly implementable. Materials, equipment and technology are readily available. Timing is not critical because the canal is infrequently inundated with water and does not require water diversion. Removed sediment will be dewatered in a controlled manor and removed to an appropriate facility for permanent disposal. Vegetation impregnated sediment and erosion control matting will provide immediate stabilization of the excavated area and adjacent embankments.

### 5.3.6 MOLASSES BAYOU WATERWAY

The Molasses Bayou Waterway is a narrow, shallow, heavily vegetated meandering reach of slow moving water often overgrown with reeds and other vegetation. The bayou is approximately 2 feet to 3 feet in depth with a bed consisting of 2 feet to 3 feet of fine-grained sediment and is tidally inundated. The cross section of the bayou varies from 3 feet to 30 feet in width. The area is accessible by small boat. The waterway is influenced by tidal flow from the Neches River.

Figure 5-6 shows the Thiessen polygons and the approximate location of the pipelines near the Molasses Bayou Waterway AOI. Individual analysis of remedial alternatives for the Molasses Bayou Waterway AOI are summarized in Table 5-6.

#### 5.3.6.1 ALTERNATIVE 1 – NO ACTION

***Overall Protection of the Environment***

Potential ecological receptor risk associated with current Site conditions were identified in the BERA. A No Action alternative does not lower the risk of interaction between benthic invertebrates and the sediment, nor does it reduce the volume or mobility of the COC-affected sediments identified.

***Compliance with the ARARs***

Since no remedial action is taken, the No Action alternative would not engage the chemical-, location-, or action-specific ARARs.

***Long-term effectiveness and permanence***

The No Action alternative provides no long-term effectiveness for the protection of ecological receptors or the reduction of any risks associated with exposure to COCs.

***Reduction of toxicity, mobility, and volume***

The No Action alternative does not reduce toxicity, mobility or volume of COCs, nor does it prevent or reduce risk of exposure to benthic organisms.

***Short-term effectiveness***

The No Action alternative provides no short-term effectiveness for the protection of ecological receptors or the reduction of any risks associated with exposure to COCs**.**

***Implementability***

The No Action alternative does not require implementation or regulatory oversight.

#### 5.3.6.2 ALTERNATIVE 2A – MONITORED NATURAL RECOVERY

Alternative 2a includes Monitored Natural Recovery (MNR) for the Molasses Bayou Waterway AOI (Polygons that correspond to sample numbers: MB-10, MB-14, MB-18/MB-18R, MB-21, MB-24, MB-49, MB-52, MB-54, MB-60, and MB-61).

***Overall Protection of the Environment***

Potential ecological receptor risk associated with current Site conditions were identified in the BERA. The MNR alternative lowers the risk of interaction between benthic

invertebrates and the sediment very gradually. Overall protection of the environment depends upon the rate of naturally driven degradation and dispersion processes.

***Compliance with the ARARs***

This alternative will be designed to comply with chemical-, location-, and action-specific ARARs for the Site.

***Long-term effectiveness and permanence***

The MNR alternative provides a moderate level of long term effectiveness for the protection of ecological receptors and the reduction of risks associated with exposure to COCs. As natural processes occur over time, MNR provides a greater degree of effectiveness by slowly reducing the pathway between the COCs and the environment. Long-term effectiveness would be monitored through a 10-year sampling program. Pilot tests will be considered to enhance MNR during the 5-year process, if needed.

***Reduction of toxicity, mobility, and volume***

The MNR alternative reduces the toxicity of COC-affected sediments by optimizing the natural biological processes in Molasses Bayou. The mobility of metals may be reduced over time as the metals sorb to clays present in the existing sediment. The current within Molasses Bayou Waterway is weak, thus reduction of sediment volume by dispersion or reduction of mobility by placement of new sediment would occur slowly. Pilot tests will be considered to enhance MNR during the 5-year process, if needed.

***Short-term effectiveness***

The MNR alternative provides a low level of short-term effectiveness since it depends upon the occurrence of natural processes over time. Implementation provides no immediate protection of ecological receptors or reduction of risks associated with exposure to COCs**.** Implementation does not cause bioturbation of COC-affected sediments or marsh disturbance which may occur with other alternatives that have more active implementation.

***Implementability***

Implementability of MNR is high within the Molasses Bayou Waterway because little action is taken to optimize the naturally occurring processes. Heavy equipment, difficult to maneuver in areas surrounding the bayou, is not necessary. Administrative responsibilities are minimal, consisting of those associated with a 10-year sampling program for long term monitoring.

#### 5.3.6.3 ALTERNATIVE 2B – MONITORED NATURAL RECOVERY AND 12-INCH REMOVAL/DISPOSAL AND CONTAINMENT: 12-INCH ARMORED CAP

Alternative 2b includes MNR for the Molasses Bayou Waterway polygons that correspond to sample numbers MB-10, MB-14, MB-18/MB-18R, MB-49, MB-52, MB-54, and MB-60; and 12-inch removal/disposal and containment with a 12-inch armored cap for the polygons that correspond to sample numbers MB-24, MB-61, and MB-21.

***Overall Protection of the Environment***

Potential ecological receptor risk associated with current Site conditions were identified in the BERA. The MNR portion of the alternative lowers the risk of interaction between benthic invertebrates and the sediment very gradually. Overall protection of the environment depends upon the rate of naturally driven degradation and dispersion processes.

The removal/disposal and containment portion of the alternative, using armored cap, provides overall protection by isolation of COC-affected sediments from benthic invertebrates and the environment. This alternative will reduce erosion of the soft bayou sediments in the polygons where it is implemented, and provide a new benthic habitat.

***Compliance with the ARARs***

This alternative will be designed to comply with chemical-, location-, and action-specific ARARs for the Site.

***Long-term effectiveness and permanence***

The MNR portion of the alternative provides a moderate level of long term effectiveness for the protection of ecological receptors and the reduction of risks associated with exposure to COCs. As natural processes occur over time, MNR provides a greater degree of effectiveness by slowly reducing the pathway between the COCs and the environment. Long-term effectiveness would be monitored through a 10-year sampling program. Pilot tests will be considered to enhance MNR during the 5-year process, if needed.

The long-term effectiveness and permanence of removal, disposal, and an armor cap is high in the polygons where those actions are implemented. Excavation will interrupt the pathway between COC-affected sediments and receptors, and the migration of any remaining COCs would be continually inhibited by the placement of an armored cap.

***Reduction of toxicity, mobility, and volume***

The MNR alternative reduces the toxicity of COC-affected sediments by optimizing the natural biological processes in Molasses Bayou. The mobility of metals may be reduced over time as the metals sorb to clays present in the existing sediment. The current within Molasses Bayou Waterway is weak, thus reduction of sediment volume by dispersion or reduction of mobility by placement of new sediment would occur slowly. Pilot tests will be considered to enhance MNR during the 5-year process, if needed.

In the polygons where removal/disposal and containment is implemented toxicity may be reduced depending on the concentration per unit volume remaining in place; however, volume is reduced by the amount of sediment excavated from the Site. Mobility is also reduced by the use of an erosion resistant cap.

***Short-term effectiveness***

The MNR alternative provides a low level of short-term effectiveness since it depends upon the occurrence of natural processes over time. Implementation provides no immediate protection of ecological receptors or reduction of risks associated with exposure to COCs**.** Implementation does not cause bioturbation of COC-affected sediments or marsh disturbance which may occur with other alternatives that have more active implementation. In the polygons where the removal/disposal and containment portion of the alternative is implemented, short-term effectiveness depends upon duration of implementation. This includes time for standard construction mobilization, staging of equipment, dewatering, and removal of COC-affected sediment. The areas of excavation will be replaced with fill, and cap materials that will be staged at the Site. Additionally, care will be taken to implement best management practices such as curtains to trap any affected sediment that may become resuspended in the water column by the excavation process, or placement of backfill and cap materials.

***Implementability***

Implementability of MNR is high within the Molasses Bayou Waterway because little action is taken to optimize the naturally occurring processes. Heavy equipment, difficult to maneuver in areas surrounding the bayou, is not necessary for the MNR portion of the alternative. Administrative responsibilities are minimal, consisting of those associated with a 10-year sampling program for long term monitoring.

The removal/disposal and containment portion of the alternative has a low level of implementability within the Molasses Bayou Waterway. Removal requires a high degree of accessibility and generates a large volume of sediment for disposal. Heavy

equipment access and the preparation of staging and dewatering areas will cause damage to portions of the shallow and narrow bayou as well as the adjacent wetlands. Transportation of cap materials requires a high degree of accessibility and there is no convenient location for staging of cap materials. Administrative responsibilities include permitting and coordination of off-Site transportation for removed sediment, and application for a Section 10 permit to work in navigable waters. The hydraulic capacity of the waterway or the soil/water topography will not be modified.

#### 5.3.6.4 ALTERNATIVE 3 – 12-INCH REMOVAL/DISPOSAL AND CONTAINMENT: 12-INCH ARMORED CAP

Alternative 3 includes 12-inch removal/disposal and containment with a 12-inch armored cap for the Molasses Bayou Waterway AOI (Polygons that correspond to sample numbers: MB-10, MB-14, MB-18/MB-18R, MB-21, MB-24, MB-49, MB-52, MB-54, MB-60, and MB-61).

***Overall Protection of the Environment***

The removal/disposal and containment alternative using an armored cap, provides overall protection by isolation of COC-affected sediments from benthic invertebrates and the environment. This alternative will reduce erosion of the soft bayou sediments, and provide a new benthic habitat.

***Compliance with the ARARs***

This alternative will be designed to comply with chemical-, location-, and action-specific ARARs for the Site.

***Long-term effectiveness and permanence***

The long-term effectiveness and permanence of removal, disposal, and an armor cap is high. Excavation will interrupt the pathway between COC-affected sediments and receptors, and the migration of any remaining COCs would be continually inhibited by the placement of an armored cap.

***Reduction of toxicity, mobility, and volume***

Toxicity may be reduced depending on the concentration per unit volume remaining in place; however, volume is reduced by the amount of sediment excavated from the Site. Mobility is also reduced by the use of the erosion resistant cap.

*Short-term effectiveness*

Short-term effectiveness of the removal/disposal and containment alternative depends upon duration of implementation. This includes time for standard construction mobilization, staging of equipment, dewatering, and removal of COC-affected sediment. The areas of excavation will be replaced with fill, and cap materials that will be staged at the Site. Additionally, care will be taken to implement best management practices such as curtains to trap any affected sediment that may become resuspended in the water column by the excavation process, or placement of backfill and cap materials.

*Implementability*

The removal/disposal and containment alternative has a low level of implementability within the Molasses Bayou Waterway. Dredging and excavation both require a high degree of accessibility and generate a large volume of sediment for disposal. Heavy equipment access and the preparation of staging and dewatering areas will cause damage to portions of the shallow and narrow bayou as well as the adjacent wetlands. Transportation of cap materials requires a high degree of accessibility and there is no convenient location for staging of cap materials. Administrative responsibilities include permitting and coordination of off-Site transportation for removed sediment, and application for a Section 10 permit to work in navigable waters. The hydraulic capacity of the waterway or the soil/water topography will not be modified.

### 5.3.7 MOLASSES BAYOU WETLAND

The Molasses Bayou Wetland is a heavily vegetated marsh, with water approximately 1 foot to 2.5 feet in depth underlain by 2 feet to 3 feet of fine-grained sediment. The wetland has been silted in over time and is choked with vegetation. This wetland is tidally inundated, and the wetland is accessible by small boat.

All pipelines at or near the Molasses Bayou Wetland AOI will be taken into consideration for all remedial alternatives developed for this AOI. A set-back or servitude will not be disturbed within 25 feet of the pipelines extending through the polygons corresponding to sample locations MB-56, MB-63, and MB-26 for several alternatives described below. The pipeline servitude accounts for approximately 1 percent of the area to be remediated within the Molasses Bayou Wetland AOI. The terms partial removal and/or partial containment refer to the area outside the pipeline servitudes. Figure 5-7 shows the Thiessen polygons and the approximate location of the pipeline servitudes in the Molasses Bayou Wetland AOI. Individual analysis of remedial alternatives for the Molasses Bayou Wetland AOI are summarized in Table 5-7.

#### 5.3.7.1 ALTERNATIVE 1 – NO ACTION

***Overall Protection of the Environment***

Potential ecological receptor risk associated with current Site conditions were identified in the BERA. A No Action alternative does not lower the risk of interaction between benthic invertebrates and the sediment, nor does it reduce the volume or mobility of the COC-affected sediments identified.

***Compliance with the ARARs***

Since no remedial action is taken, the No Action alternative would not engage the chemical- , location- , or action-specific ARARs.

***Long-term effectiveness and permanence***

The No Action alternative provides no long-term effectiveness for the protection of ecological receptors or the reduction of any risks associated with exposure to COCs.

***Reduction of toxicity, mobility, and volume***

The No Action alternative does not reduce toxicity, mobility or volume of COCs, nor does it prevent or reduce risk of exposure to benthic organisms.

***Short-term effectiveness***

The No Action alternative provides no short-term effectiveness for the protection of ecological receptors or the reduction of any risks associated with exposure to COCs**.**

***Implementability***

The No Action alternative does not require implementation or regulatory oversight.

#### 5.3.7.2 ALTERNATIVE 2A – MONITORED NATURAL RECOVERY

Alternative 2a includes Monitored Natural Recovery (MNR) for the Molasses Bayou Wetland AOI (polygons that correspond to sample numbers: MB-26, MB-51, MB-56, MB-58, MB-59, MB-62, and MB-63).

***Overall Protection of the Environment***

Potential ecological receptor risk associated with current Site conditions were identified in the BERA. The MNR alternative lowers the risk of interaction between benthic

invertebrates and the sediment very gradually. Overall protection of the environment depends upon the rate of naturally driven degradation and dispersion processes.

***Compliance with the ARARs***

The MNR alternative will be designed to comply with chemical-, location-, and action-specific ARARs for the Site.

***Long-term effectiveness and permanence***

The MNR alternative provides a moderate level of long term effectiveness for the protection of ecological receptors and the reduction of risks associated with exposure to COCs. As natural processes occur over time, MNR provides a greater degree of effectiveness by slowly reducing the pathway between the COCs and the environment. Long-term effectiveness would be monitored through a 10-year sampling program. Pilot tests will be considered to enhance MNR during the 5-year process, if needed.

***Reduction of toxicity, mobility, and volume***

The MNR alternative reduces the toxicity of COC-affected sediments by optimizing the natural biological processes in Molasses Bayou Wetland. The mobility of heavy metals may be reduced over time as the metals sorb to clays present in the existing sediment. The current within Molasses Bayou Wetland is weak and is restrained by vegetation, thus reduction of sediment volume by dispersion, or reduction of mobility by placement of new sediment would occur slowly. Pilot tests will be considered to enhance MNR during the 5-year process, if needed.

***Short-term effectiveness***

The MNR alternative provides a low level of short-term effectiveness since it depends upon the occurrence of natural processes over time. Implementation provides no immediate protection of ecological receptors or reduction of risks associated with exposure to COCs**.** Implementation does not cause redistribution of COC-affected sediments as may occur with alternatives that are more active. MNR does not cause any disturbance of the marsh as will occur with the use of heavy equipment.

***Implementability***

Implementability of MNR is high within the Molasses Bayou Wetland because little action is taken to optimize the naturally occurring processes. Heavy equipment, difficult to maneuver in areas surrounding the bayou, is not necessary. Administrative responsibilities are minimal, consisting of those associated with a 10-year sampling program for long term monitoring.

### 5.3.7.3 ALTERNATIVE 2B – MONITORED NATURAL RECOVERY AND CONTAINMENT: 12-INCH COMPOSITE CAP

Alternative 2b includes MNR for the Molasses Bayou Wetland polygons that correspond to sample numbers MB-51, MB-56, MB-58, and MB-59; and containment with a 12-inch composite cap for the polygons that correspond to sample numbers MB-26 MB-62, and MB-63.

***Overall Protection of the Environment***

Potential ecological receptor risk associated with current Site conditions were identified in the BERA. The MNR portion of the alternative lowers the risk of interaction between benthic invertebrates and the sediment very gradually. Overall protection of the environment depends upon the rate of naturally driven degradation and dispersion processes.

The composite cap portion of the alternative serves to protect the environment by isolation of COC-affected sediments from benthic invertebrates and the environment within the polygons where it is implemented. The composite cap will reduce erosion of the soft bottom, and provide a new benthic habitat.

***Compliance with the ARARs***

This alternative will be designed to comply with chemical-, location-, and action-specific ARARs applicable and relevant for the Site.

***Long-term effectiveness and permanence***

The MNR portion of the alternative provides a moderate level of long term effectiveness for the protection of ecological receptors and the reduction of risks associated with exposure to COCs, in the polygons where it is implemented. As natural processes occur over time, MNR provides a greater degree of effectiveness by slowly reducing the pathway between the COCs and the environment. Long-term effectiveness would be monitored through a 10-year sampling program. Pilot tests will be considered to enhance MNR during the 5-year process, if needed.

The long-term effectiveness and permanence of a composite cap is high. The migration of COCs from erosion and bioturbation from the burrowing of benthic invertebrates will be continually inhibited in the polygons where a composite cap is implemented.

***Reduction of toxicity, mobility, and volume***

The MNR portion of the alternative reduces the toxicity of COC-affected sediments by optimizing the natural biological processes in Molasses Bayou Wetland. The mobility of heavy metals may be reduced over time as the metals sorb to clays present in the existing sediment. The current within Molasses Bayou Wetland is weak and is restrained by vegetation, thus reduction of sediment volume by dispersion, or reduction of mobility by placement of new sediment would occur slowly in the polygons where it is implemented. Pilot tests will be considered to enhance MNR during the 5-year process, if needed.

A composite cap will reduce the mobility of the constituents by providing a barrier between the affected sediment and the ecological system in the polygons where it is implemented. The toxicity and volume of the COCs will not be reduced by the installation of the composite cap.

***Short-term effectiveness***

The MNR portion of the alternative provides a low level of short-term effectiveness since it depends upon the occurrence of natural processes over time. Implementation provides no immediate protection of ecological receptors or reduction of risks associated with exposure to COCs**.** Implementation does not cause redistribution of COC-affected sediments as may occur with alternatives that are more active. MNR will not cause any disturbance of the marsh in the polygons where it is implemented, as will occur with the use of heavy equipment.

Short-term effectiveness of the composite cap alternative depends upon duration of implementation. This includes time for specialized construction mobilization, staging of equipment and cap materials, and stabilization of the area following cap installation.

***Implementability***

Implementability of MNR is high within the Molasses Bayou Wetland polygons where it is implemented because little action is taken to optimize the naturally occurring processes. Heavy equipment, difficult to maneuver in areas surrounding the bayou, is not necessary. Administrative responsibilities are minimal, consisting of those associated with a 10-year sampling program for long term monitoring.

The containment alternative has a low level of implementability within the Molasses Bayou Wetland. The wetland has a low degree of accessibility, which impedes delivery of cap materials and equipment. Delivery and operations will damage portions of the wetlands within the polygons where it is implemented. The cap must be anchored, but

the loose sediment within the wetland is not conducive to accepted anchoring methods. No convenient location exists for staging of cap materials. Administrative responsibilities would permit for disturbance of wetlands.

#### 5.3.7.4 ALTERNATIVE 2C – MONITORED NATURAL RECOVERY AND 12-INCH REMOVAL/DISPOSAL AND CONTAINMENT: 12-INCH ARMORED CAP

Alternative 2c includes MNR for the Molasses Bayou Wetland polygons that correspond to sample numbers MB-51, MB-56, MB-58, and MB-59; and 12-inch removal/disposal and containment with a 12-inch armored cap for the polygons that correspond to sample numbers MB-26 MB-62, and MB-63.

***Overall Protection of the Environment***

Potential ecological receptor risk associated with current Site conditions were identified in the BERA. The MNR portion of the alternative lowers the risk of interaction between benthic invertebrates and the sediment very gradually. Overall protection of the environment depends upon the rate of naturally driven degradation and dispersion processes.

The removal/disposal and containment portion of the alternative using an armored cap will serve to protect the environment through permanent elimination of the pathway between COC-affected sediments and benthic organisms, through excavation, in the polygons where it is implemented. Placement of armored cap following removal would reduce erosion of the wetland floor and promote the creation of a new benthic environment.

***Compliance with the ARARs***

This alternative will be designed to comply with chemical- , location- , and action-specific ARARs for the Site.

***Long-term effectiveness and permanence***

The MNR portion of the alternative provides a moderate level of long term effectiveness for the protection of ecological receptors and the reduction of risks associated with exposure to COCs, in the polygons where it is implemented. As natural processes occur over time, MNR provides a greater degree of effectiveness by slowly reducing the pathway between the COCs and the environment. Long-term effectiveness would be

monitored through a 10-year sampling program. Pilot tests will be considered to enhance MNR during the 5-year process, if needed.

The long-term effectiveness and permanence of removal/disposal and containment of the affected sediment is high. The COCs will no longer present a risk to benthic invertebrates in the Molasses Bayou Wetland in the polygons where removal/disposal and containment is implemented. The long-term effectiveness of the armored cap is also high, because it continually resists erosion.

***Reduction of toxicity, mobility, and volume***

The MNR portion of the alternative reduces the toxicity of COC-affected sediments by optimizing the natural biological processes in Molasses Bayou Wetland. The mobility of metals may be reduced over time as the metals sorb to clays present in the existing sediment. The current within Molasses Bayou Wetland is weak and is restrained by vegetation, thus reduction of sediment volume by dispersion, or reduction of mobility by placement of new sediment would occur slowly in the polygons where it is implemented. Pilot tests will be considered to enhance MNR during the 5-year process, if needed.

In the polygons where the removal/disposal and containment portion of the alternative is implemented toxicity may be reduced depending on the concentration per unit volume remaining in place; however, volume is reduced by the amount of sediment excavated from the Site. Mobility is also reduced by the use of the erosion resistant cap.

***Short-term effectiveness***

The MNR portion of the alternative provides a low level of short-term effectiveness since it depends upon the occurrence of natural processes over time. Implementation provides no immediate protection of ecological receptors or reduction of risks associated with exposure to COCs**.** Implementation does not cause redistribution of COC-affected sediments as may occur with alternatives that are more active. MNR will not cause any disturbance of the marsh in the polygons where it is implemented, as will occur with the use of heavy equipment.

Short-term effectiveness of the removal/disposal and containment portion of the alternative depends upon the duration of implementation. This includes time for standard construction mobilization, staging of equipment, and the removal and dewatering of COC-affected sediment. The areas of excavation will be replaced with unaffected sediment, and cap materials will be staged at the Site. Additionally, care will be taken to implement best management practices such as curtains to trap any affected

sediment that may become resuspended in the water column by the excavation process or by the placement of backfill and cap materials.

***Implementability***

Implementability of MNR is high within the Molasses Bayou Wetland polygons where it is implemented because little action is taken to optimize the naturally occurring processes. Heavy equipment, difficult to maneuver in areas surrounding the bayou, is not necessary. Administrative responsibilities are minimal, consisting of those associated with a 10-year sampling program for long term monitoring.

The removal/disposal and containment portion of the alternative has a low level of implementability within the Molasses Bayou Wetland polygons where it is implemented. Dredging and excavation both require a high degree of accessibility and generate a large volume of sediment for disposal. Heavy equipment access and the preparation of staging and dewatering areas will cause damage to portions of the marsh. Administrative responsibilities will include permitting and coordination of off-Site transportation for removed sediment and for disturbance of wetlands.

#### 5.3.7.5 ALTERNATIVE 2D – MONITORED NATURAL RECOVERY AND 12-INCH REMOVAL/DISPOSAL

Alternative 2d includes MNR for the Molasses Bayou Wetland polygons that correspond to sample numbers MB-51, MB-56, MB-58, and MB-59; and 12-inch removal/disposal for the polygons that correspond to sample numbers MB-26 MB-62, and MB-63.

***Overall Protection of the Environment***

Potential ecological receptor risk associated with current Site conditions were identified in the BERA. The MNR portion of the alternative lowers the risk of interaction between benthic invertebrates and the sediment very gradually. Overall protection of the environment depends upon the rate of naturally driven degradation and dispersion processes.

The 12-inch removal/disposal portion of the alternative serves to protect the environment by permanent elimination of the pathway between COC-affected sediments and benthic organisms, through removal/disposal, in the polygons where it is implemented.

***Compliance with the ARARs***

This alternative will be designed to comply with chemical- , location- , and action-specific ARARs for the Site.

***Long-term effectiveness and permanence***

The MNR portion of the alternative provides a moderate level of long term effectiveness for the protection of ecological receptors and the reduction of risks associated with exposure to COCs, in the polygons where it is implemented. As natural processes occur over time, MNR provides a greater degree of effectiveness by slowly reducing the pathway between the COCs and the environment. Long-term effectiveness would be monitored through a 10-year sampling program. Pilot tests will be considered to enhance MNR during the 5-year process, if needed.

The long-term effectiveness and permanence of the removal/disposal of the affected sediment is high. The COC-affected sediment would no longer present a risk to benthic invertebrates in the Molasses Bayou Wetland in the polygons where removal/disposal is implemented.

***Reduction of toxicity, mobility, and volume***

The MNR portion of the alternative reduces the toxicity of COC-affected sediments by optimizing the natural biological processes in Molasses Bayou Wetland. The mobility of metals may be reduced over time as the metals sorb to clays present in the existing sediment. The current within Molasses Bayou Wetland is weak and is restrained by vegetation, thus reduction of sediment volume by dispersion, or reduction of mobility by placement of new sediment would occur slowly in the polygons where it is implemented. Pilot tests will be considered to enhance MNR during the 5-year process, if needed.

In the polygons where it is implemented, the removal/disposal portion of the alternative reduces the toxicity, mobility and volume of the constituents by removal of COC-affected sediment from the ecological system.

***Short-term effectiveness***

The MNR portion of the alternative provides a low level of short-term effectiveness since it depends upon the occurrence of natural processes over time. Implementation provides no immediate protection of ecological receptors or reduction of risks associated with exposure to COCs**.** Implementation does not cause redistribution of COC-affected sediments as may occur with alternatives that are more active. MNR will not cause any

disturbance of the marsh in the polygons where it is implemented, as will occur with the use of heavy equipment.

Short-term effectiveness of the removal/disposal portion of the alternative depends upon duration of implementation. This includes time for standard construction mobilization, staging of equipment, removal, and dewatering of COC-affected sediment. Sediment and erosion control measures will be implemented to prevent COC-affected sediment from being redistributed by the excavation or dewatering process.

***Implementability***

Implementability of MNR is high within the Molasses Bayou Wetland polygons where it is implemented because little action is taken to optimize the naturally occurring processes. Heavy equipment, difficult to maneuver in areas surrounding the bayou, is not necessary. Administrative responsibilities are minimal, consisting of those associated with a 10-year sampling program for long term monitoring.

The removal/disposal portion of the alternative has a low level of implementability within the Molasses Bayou Wetland. Dredging and excavation both require a high degree of accessibility and generate a large volume of sediment for disposal. Heavy equipment access and the preparation of staging and dewatering areas may cause damage to portions of this shallow wetland in the polygons where it is implemented. Administrative responsibilities would include permitting and coordination of off-Site transportation for removed sediment and for the disturbance of wetlands.

#### 5.3.7.6 ALTERNATIVE 3 – CONTAINMENT: 12-INCH COMPOSITE CAP

Alternative 3 includes containment with a 12-inch composite cap for the Molasses Bayou Wetland AOI (polygons that correspond to sample numbers: MB-26, MB-51, MB-56, MB-58, MB-59, MB-62, and MB-63).

***Overall Protection of the Environment***

The composite cap alternative serves to protect the environment by isolation of COC-affected sediments from benthic invertebrates and the environment. This alternative will reduce erosion of the soft bottom, and provide a new benthic habitat.

*Compliance with the ARARs*
This alternative will be designed to comply with chemical- , location- , and action-specific ARARs applicable and relevant for the Site.

*Long-term effectiveness and permanence*
The long-term effectiveness and permanence of a composite cap is high. The migration of COCs from erosion and bioturbation from the burrowing of benthic invertebrates will be continually inhibited.

*Reduction of toxicity, mobility, and volume*
A composite cap will reduce the mobility of the constituents by providing a barrier between the affected sediment and the ecological system. The toxicity and volume of the COCs will not be reduced by the installation of the composite cap.

*Short-term effectiveness*
Short-term effectiveness of the composite cap alternative depends upon duration of implementation. This includes time for specialized construction mobilization, staging of equipment and cap materials, and stabilization of the area following cap installation.

*Implementability*
The containment alternative has a low level of implementability within the Molasses Bayou Wetland. The wetland has a low degree of accessibility, which impedes delivery of cap materials and equipment. Delivery and operations will damage portions of the wetlands. The cap must be anchored, but the loose sediment within the wetland is not conducive to accepted anchoring methods. No convenient location exists for staging of cap materials. Administrative responsibilities would permit for disturbance of wetlands.

#### 5.3.7.7 ALTERNATIVE 4 – PARTIAL 12-INCH REMOVAL/DISPOSAL AND PARTIAL CONTAINMENT: 12-INCH ARMORED CAP

Alternative 4 includes partial 12-inch removal/disposal and partial containment with a 12-inch armored cap of the material outside the pipeline servitude in the Molasses Bayou Wetland AOI. Figure 5-7 shows the Thiessen polygons and the approximate location of the pipeline servitudes in the Molasses Bayou Wetland AOI. Individual analysis of remedial alternatives for the Molasses Bayou Wetland AOI are summarized in Table 5-7.

A set-back or servitude will not be disturbed within 25 feet of the pipelines extending through the polygons corresponding to samples MB-26, MB-56, and MB-63. The area outside the pipeline servitudes will be excavated to a depth of 12 inches and contained with a 12-inch armored cap. All removed sediment would be dewatered, if needed, and properly disposed off-Site.

***Overall Protection of the Environment***

The partial 12-inch removal/disposal and partial containment alternative using an armored cap serves to protect the environment through permanent elimination of the pathway between COC-affected sediments and benthic organisms, through excavation. Placement of armored cap following removal would reduce erosion of the wetland floor and promote the creation of a new benthic environment in the areas where it is implemented.

***Compliance with the ARARs***

This alternative will be designed to comply with chemical- , location- , and action-specific ARARs for the Site.

***Long-term effectiveness and permanence***

The long-term effectiveness and permanence of removal/disposal and containment of the affected sediment is high. The COCs will no longer present a risk to benthic invertebrates in the portions of Molasses Bayou Wetland where removal/disposal is implemented. The long-term effectiveness of the armored cap is also high, because it continually resists erosion.

***Reduction of toxicity, mobility, and volume***

Toxicity may be reduced depending on the concentration per unit volume remaining in place; however, volume is reduced by the amount of sediment excavated from the Site. Mobility is also reduced by the use of the erosion resistant cap.

***Short-term effectiveness***

Short-term effectiveness of the partial 12-inch removal/disposal and partial containment alternative depends upon the duration of implementation. This includes time for standard construction mobilization, staging of equipment, and the removal and dewatering of COC-affected sediment. The areas of excavation will be replaced with unaffected sediment, and cap materials will be staged at the Site. Additionally, care will be taken to implement best management practices such as curtains to trap any affected sediment that may become resuspended in the water column by the excavation process or by the placement of backfill and cap materials.

*Implementability*
The partial 12-inch removal/disposal and partial containment alternative has a low level of implementability within the Molasses Bayou Wetland. Dredging and excavation both require a high degree of accessibility and generate a large volume of sediment for disposal. Heavy equipment access and the preparation of staging and dewatering areas may cause damage to portions of the marsh. Administrative responsibilities will include permitting and coordination of off-Site transportation for removed sediment and for disturbance of wetlands.

### 5.3.7.8 ALTERNATIVE 5 – PARTIAL 12-INCH REMOVAL/DISPOSAL

Alternative 5 includes partial 12-inch removal/disposal of the material outside the pipeline servitude in the Molasses Bayou Wetland AOI. Figure 5-7 shows the Thiessen polygons and the approximate location of the pipeline servitudes in the Molasses Bayou Wetland AOI. Individual analysis of remedial alternatives for the Molasses Bayou Wetland AOI are summarized in Table 5-7.

A set-back or servitude will not be disturbed within 25 feet of the pipelines extending through the polygons corresponding to samples MB-26, MB-56, and MB-63. The areas outside the pipeline servitude will be excavated to a depth of 12 inches. All removed sediment would be dewatered, if needed, and properly disposed off-Site.

*Overall Protection of the Environment*
This alternative serves to protect the environment by permanent elimination of the pathway between COC-affected sediments and benthic organisms, through removal/disposal.

*Compliance with the ARARs*
This alternative will be designed to comply with chemical-, location-, and action-specific ARARs for the Site.

*Long-term effectiveness and permanence*
The long-term effectiveness and permanence of partial 12-inch removal/disposal of the affected sediment is high. The COC-affected sediment would no longer present a risk to benthic invertebrates in the portions of Molasses Bayou Wetland where this alternative is implemented.

***Reduction of toxicity, mobility, and volume***

This alternative reduces the toxicity, mobility and volume of the constituents by removal of COC-affected sediment from the ecological system.

***Short-term effectiveness***

Short-term effectiveness of the partial 12-inch removal/disposal alternative depends upon duration of implementation. This includes time for standard construction mobilization, staging of equipment, removal, and dewatering of COC-affected sediment. Sediment and erosion control measures will be implemented to prevent COC-affected sediment from being redistributed by the excavation or dewatering process.

***Implementability***

The partial 12-inch removal/disposal alternative has a low level of implementability within the Molasses Bayou Wetland. Dredging and excavation both require a high degree of accessibility and generate a large volume of sediment for disposal. Heavy equipment access and the preparation of staging and dewatering areas may cause damage to portions of this shallow wetland. Administrative responsibilities would include permitting and coordination of off-Site transportation for removed sediment and for the disturbance of wetlands.

## 6.0 COST

The FS cost estimates are estimates developed to allow comparison of alternatives with respect to project cost and other criteria. A cost estimate is a calculation of the estimated quantities of various items of work, and the expenses likely to be incurred. The total of these probable expenses to be incurred on the work is known as the estimated cost of the work. A reliable estimate of costs will affect decisions in selection of a preferred remedial alternative.

Several techniques may be used to estimate the cost of environmental remediation. This FS uses the unit cost method where work is divided into as many operations or items as are required. A unit of measurement is determined. The total quantity of work under each item is apportioned into a proper unit of measurement. The total cost per unit quantity of each item is determined by estimation, by collection of vendor price quotations, or use of citation of publisher unit costs. The total cost for the item is found by multiplying the cost per unit quantity by the number of units. For example, while estimating the cost of a building, the quantity of brickwork in the building would be measured in cubic meters. The total cost (which includes cost of materials, labor, plant, overheads and profit) per cubic meter of brickwork would be found; this unit cost, multiplied by the number of cubic meters of brickwork in the building, would give the estimated cost of brickwork. This method has the advantage that the unit costs on various jobs can be readily compared and that the total estimate can easily be corrected for variations in quantities.

The project cost information is evaluated to compare remedial alternatives and to evaluate the comparison among alternatives. Estimated costs for each alternative were prepared on a unit-cost basis. Material, equipment, and labor quantities specific to each alternative were each assigned a unit cost. For each alternative, the extended cost of each quantity listed in the alternative was determined by multiplication of that quantity by the corresponding unit cost, and extended cost values were then summed to develop the total estimated cost of each alternative. Costs associated with each alternative were estimated for initial capital expenditures at project commencement and for annual operation and maintenance (O&M) expenditures, as appropriate for each alternative. Annual O&M costs also include monitoring costs, as applicable. For each alternative, an equivalent net present value (NPV) of estimated annual O&M costs was developed. The estimated NPV of annual O&M costs for each alternative was determined on the basis of an anticipated average annual simple interest rate of 2.8 percent and an estimated project life of 10 years.

Total estimated costs of each alternative evaluated were determined through addition of total initial capital expenditures and total estimated NPV of annual O&M costs. The total estimated cost of each alternative was used for the basis of cost comparison between alternatives within each AOI.

Estimated unit costs presented for each alternative are based on typical values from environmental remediation and engineering projects of similar size and scope, price quotations requested from equipment and service vendors, and other published cost values for CERCLA sites from public-sector and other sources. Where practical, the same unit cost values were used for comparable unit quantities in all alternatives that were compared, so that cost differences between alternatives reflected differences in alternative scope not biased by differences in unit cost for comparable cost items.

Expenditures that occur over different periods were analyzed using the present-worth analysis, which discounts all future costs to a base year. Present-worth analysis allows the cost of remedial action alternatives to be compared on the basis of a single figure which represents the amount of money that, if invested in the base year and disbursed as needed, would be sufficient to cover all costs associated with the life of the remedial project. Assumptions associated with the present-worth calculations include a discount rate of 2.8 percent before taxes and after inflation, cost estimates in the planning years in constant dollars, a 10-year period for O&M, and one year of construction to implement the remedy.

The order-of-magnitude cost estimates were prepared using USEPAs *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (USEPA, 2000) in conjunction with a standard "unit cost" approach for each alternative. In this approach all alternatives are divided into as many operations or items as are required and a unit of measurement is assigned to each (ton, days, cubic yard, etc.). Total operation cost is then calculated by multiplying the cost per unit quantity by the number of units needed for that defined operation. The summation of all total unit costs is then the total cost for that particular alternative.

All present worth values are based on real discount rates from Appendix C of the Office of Management and Budget (OMB) Circular A-94, Appendix C (revised December 2011). The 10-year discount rate of 2.8 percent was selected since operations and maintenance (O&M) durations are assumed to be over 10 years. This estimate is based on existing conditions. Uncertain market conditions such as, but not limited to, local labor or contractor availability, wages, other work, material market fluctuations, price escalations, and force majeure events, may affect the accuracy of this estimate. The

order-of-magnitude cost estimates presented herein provide an accuracy of positive fifty percent to negative thirty percent.

The cost summary tables include capital costs and O&M costs. Capital costs consist of direct and indirect costs. Direct costs include the cost of construction, equipment, land and Site development, labor, transportation, and disposal. Indirect costs include engineering expenses, license or permit costs, and contingency allowances (20 percent). Annual O&M costs are the post-construction costs required for the continued effectiveness of the remedy. Components of annual O&M costs include the cost of maintenance materials and labor, monitoring, and periodic Site reviews.

The cost estimates were prepared based on available Site information at the time of preparation of this submittal and the components of the remedial alternatives discussed in Section 5.0. Additional investigation activities and evaluations will be performed during the remedial design phase. The volume of sediment which requires removal and dewatering or disposal may be refined and cap designs will be finalized based on information collected during the remedial design phase. The cost estimates were prepared using quotes provided by reliable suppliers, technology reference documents, and actual costs from other sediment remediation projects available at the time of preparation of this submittal.

In summary, the cost estimates were prepared in order to compare the different remedial alternatives and disposal options by AOI. The actual cost of the selected remedial alternative will depend on a number of factors which include:

- Final sediment/soil volumes removed
- Final cap design and associated material volumes
- Inclusion of additional emerging technologies that are not currently proposed within the alternatives presented in Section 5.0
- Competitive market conditions
- Actual labor and material costs

Although these factors will affect the cost of each remedial action alternative, they are not expected to affect the relative cost differences between alternatives for the purpose of comparing alternatives. The final costs will likely vary from the estimates presented in this submittal, so funding must be carefully reviewed before specific financial decisions are made or the final budget is established.

Tables 6-1 through 6-7 provide the cost estimates for the remedial alternatives of Jefferson Canal AOI, Jefferson Canal Spoil Pile AOI, Former Star Lake AOI, Star Lake Canal AOI, Gulf States Utility Canal AOI, Molasses Bayou Waterway AOI, and Molasses Bayou Wetlands AOI, respectively.

## 6.1 COST ESTIMATION ASSUMPTIONS

In the development of cost estimates for all AOIs, assumptions were made. The following is a detailed description of said assumptions.

### 6.1.1 TOPOGRAPHY

*Jefferson Canal:* The distance along Jefferson Canal from its origin on the east side of Hogaboom Road south of Farm to Market Road 366 (FM 366) to its confluence with Star Lake Canal, north of the Hurricane Protection Levee, is approximately 4,000 feet. The canal cross-section is trapezoidal with a variable bottom width between 4 feet and 10 feet, with side slopes that are approximately 2 horizontal to 1 vertical (2:1). Most of the length of the canal is unlined; however, a small portion (80 feet) is lined with concrete. Jefferson Canal extends 460 feet beneath Hogaboom Road and continues 2,200 feet to a box culvert that goes beneath FM 366. In this section of the canal, the bottom width in variable ranges between 4 feet and 10 feet with a depth that varies from 6 feet to 10 feet. For the scope of the FS, Jefferson Canal is assumed to be a wetland. Thiessen polygons for Jefferson Canal AOI are shown on Figure 5-1.

*Jefferson Canal Spoil Pile:* The spoil pile is located upstream from the Hurricane Protection Levee and downstream from FM 366. The southern limits of the spoil pile abut FM 366 Road, the Lower Neches Valley Authority Canal, and the Kansas City Southern Railroad. The western limit abuts to the overhead Entergy Power lines that extend south to north. Jefferson Canal extends from south to north on the eastern bank of the spoil pile. The area immediately east of Jefferson Canal is heavily vegetated with trees. The Jefferson Canal Spoil Pile was previously vegetated with trees, and during the Tier 2 RI those trees were removed to facilitate preparation of a topographic map and collection of sediment and soil samples. The spoil pile is partially composed of previously dredged material; therefore, it has a high lime content. The ground surface includes several "mounds" of the spoils that are a few feet in height and provide an

uneven ground surface. The ground surface elevation is several feet above the groundwater table and drains from west to east into the Jefferson Canal.

*Former Star Lake:* The Former Star Lake AOI in plan view has the shape of two rectangles and the Star Lake Canal extends from southwest to northeast through the former Star Lake and both rectangles abut northeast to Atlantic Road. The rectangle to the southeast of Star Lake Canal is approximately 300 feet in the northwest to southeast direction and 800 feet in the southwest to northeast direction. The rectangle to the northwest of Star Lake Canal extends approximately 800 feet in the southwest to northeast direction and 800 feet in the southeast to northwest direction. The Former Star Lake AOI is a marsh or wetland area with a silty bottom and wetland vegetation throughout. The bottom is generally 1 foot to 2 feet below tide and tidally inundated. Thiessen polygons for Former Star Lake AOI are shown on Figure 5-3.

*Star Lake Canal:* The distance along Star Lake Canal from its origin east of the intersection of Highway 136 and FM 366 to its confluence with the Neches River is approximately 16,500 feet. The Star Lake Canal portion of the AOI for the FS commences at the point of intersection with Jefferson Canal and extends approximately 10,000 feet to the confluence with the Neches River. Immediately northeast of the intersection with the Atlantic Road is the Associated Marine Services, Inc., dock. The channel is approximately 5 feet to 6 feet deep at the intersection with Jefferson Canal and about 20 feet wide with steep side slopes and a silty bottom. Beginning at Atlantic Road, it is about 50 feet wide and gradually increases in width towards the Neches River to a width of about 150 feet to its confluence with the Neches River. The average depth is about 10 feet near the dock and 20 feet near the confluence with the Neches River. The canal is tidally influenced and navigable. Thiessen polygons for Star Lake Canal AOI are shown on Figure 5-4.

*Gulf States Utility Canal:* The Gulf States Utility Canal extends parallel to the Star Lake Canal and is shallow, with side slopes at 4 horizontal to 1 vertical (4:1) or less. The canal was initially created to construct the overhead utility lines and is tidally inundated. Thiessen polygons for Gulf States Utility Canal AOI are shown on Figure 5-5.

*Molasses Bayou Waterway:* The Molasses Bayou Waterway is a narrow, shallow, heavily vegetated meandering reach of slow moving water often overgrown with reeds and other vegetation. The bayou is approximately 2 feet to 3 feet in depth with a bed consisting of 2 feet to 3 feet of fine-grained sediment and is tidally inundated. The cross section of the bayou varies from 3 feet to 30 feet in width. The area is accessible by small

boat. The waterway is influenced by tidal flow from the Neches River. Thiessen polygons for Molasses Bayou Waterway AOI are shown on Figure 5-6.

*Molasses Bayou Wetland:* The Molasses Bayou Wetland is a heavily vegetated marsh, with water approximately 1 foot to 2.5 feet in depth underlain by 2 feet to 3 feet of fine-grained sediment. The wetland has been silted in over time and is choked with vegetation. This wetland is tidally inundated, and the wetland is accessible by small boat. Thiessen polygons for Molasses Bayou Wetland AOI are shown on Figure 5-7.

### 6.1.2 AREA AND VOLUME CALCULATIONS

To prepare remedial cost estimates it was necessary to estimate the total area of each AOI and determine an estimation of total volume of material to be removed. The surface area was measured using the Scenario 10b Thiessen Polygons and these areas were then multiplied by an assessment depth to determine the volume. When calculating irregular areas it was assumed that the area had an average width throughout. Molasses Bayou Waterway was assumed to have an average width range of 3 to 30 feet, Jefferson Canal was assumed to have an average width range of 4 to 10 feet. Both canal width assumptions were formulated for the top of the canal during a one foot tide. From these assumptions and calculations the following areas were calculated for each AOI: Jefferson Canal: 0.85 acres (without Jefferson Canal pipeline servitude: 0.80 acres), Jefferson Canal Spoil Pile: 9.80 acres (without Jefferson Canal Spoil Pile pipeline servitude: 7.50 acres), Former Star Lake: 5.74 acres (without Former Star Lake pipeline servitude: 5.00 acres), Star Lake Canal: 3.45 acres (without Star lake Canal pipeline servitude: 2.35 acres), Gulf States Utility Canal: 0.55 acres, Molasses Bayou Waterway: 3.70 acres, Molasses Bayou Wetlands: 30.10 acres (without Molasses Bayou Wetlands pipeline servitude: 29.70 acres).

### 6.1.3 EXCAVATION, TRANSPORTATION, AND MATERIALS

To prepare remedial cost estimates, assumptions were made in regards to the amount of excavation that could be feasibly accomplished per day, the amount of backfill that could be feasibly accomplished per day, no expansion of soil during excavation, the increased cubic yardage of soil needed for backfill, and the amount of material that could be transported to and from the Site per day. It was assumed that excavation could proceed at a rate of 250 cubic yards per day, hydraulic dredge could proceed at a rate of 250 cubic yards per day (does not include dewatering), backfill excavations could

proceed at a rate of 400 cubic yards per day assuming that two dozers were operating 10-hour days, backfill would require 1.4 times the volume of the excavation to be filled. When transporting waste from the Site, it was assumed that each load would carry 15 cubic yards (~20 tons) of excavated material at a total cost of each load being $1,325 (this includes transportation, liners, cost of sediment/soil disposal, fuel surcharge and environmental fees). When transporting backfill and clay to the Site, it was assumed that each load would carry 15 and 12 cubic yards per load (~20 ton), at the cost of $240 and $140 per load, respectively.

### 6.1.4 SAMPLE COLLECTION AND ANALYSIS

To classify waste and monitor progress of implemented remedial actions, sample collection and analysis is necessary. Waste characterization samples will be obtained for analysis from 10 percent of the trucks leaving the Site. These samples will be analyzed for an array of constituents including:

- PAHs
- PCBs
- total metals
- hexavalent chromium
- SVOCs
- VOCs
- Pesticides

During implementation of remedial actions that involve excavation, it was assumed that confirmatory samples will be obtained from each of the following AOIs:

- Jefferson Canal – 15 samples
- Former Star Lake – 15 samples
- Star Lake Canal – 15 samples
- Molasses Bayou Waterway – 15 samples
- Jefferson Canal Spoil Pile – 10 samples
- Gulf States Utility Canal – 10 samples
- Molasses Bayou Wetland – 10 samples

Samples will be analyzed for COCs that have an established PRG. For a full list of analytes see Tables 3-4A and 3-4B.

Molasses Bayou Wetland and Waterway AOIs have the alternative option of MNR. An appropriate number of samples will be collected to monitor the effectiveness of MNR. The monitoring and sampling program will be established during the Remedial Design phase and will contain elements designed to reflect reductions in bioavailability and, hence, toxicity of contaminated sediments in Molasses Bayou. All samples will be analyzed for the COCs that have an established PRG as referenced in Tables 3-4A and 3-4B.

Soil/sediment sample analysis was assumed to cost $350 per sample for waste characterization tests and $900 per sample for the PRG suite of analytes (PAHs, PCBs, total metals, hexavalent chromium, SVOCs, VOCs, and pesticides). Full Data Validation will be completed and will include review of deliverables, batch and instrument level quality control (QC), calibration information, raw and supporting data, and 10 percent calculation of data present in the package. A final report will be produced to review all findings.

### 6.1.5 COST PRECISION

Equal quotes for equipment, materials, and labor rates were used to develop a cost estimate for each alternative. Although the cost estimates may not be fully precise or accurate, the accuracy and precision of the cost estimate had limited affect on the selection of the alternative. If a quote for equipment, material, or labor rate changes, the increase or decrease shall apply to each alternative. This allows for an effective comparison since the cost change was applied to each alternative.

### 6.1.6 OPERATION AND MAINTENANCE COSTS

When developing cost estimates for remedial actions, it is necessary to accrue operation and maintenance (O&M) costs. It was assumed that all remedial alternatives would be monitored for a 10-year timeframe, on a semiannual basis. Cost estimates associated with O&M include, but are not limited to, site inspections, remedial design maintenance, land survey, and AOI-specific annual and semiannual reports.

## 6.2 JEFFERSON CANAL

### 6.2.1 ALTERNATIVE 1 – NO ACTION

A cost estimate is not needed since there is no remedial action taken for the No Action alternative.

### 6.2.2 ALTERNATIVE 2A – CONTAINMENT: SOIL CAP AND PIPE AT JC-7, PARTIAL 12-INCH REMOVAL/DISPOSAL, AND PARTIAL CONTAINMENT: 12-INCH SOIL CAP

This alternative requires the installation of a three 48-inch reinforced concrete pipes that will be extended 700 feet off an already existing set of concrete pipes at the Site. Pipes are designed to maintain the required hydraulic capacity along the polygon associated with sample number JC-7 of the canal. The remaining polygons of interest within Jefferson Canal (JC-2, JC-13, JC-18, and JC-19) will be excavated to a depth of 12-inches beneath existing grade and materials shall be transported to a licensed off-Site disposal facility. Excavation activities within polygons with pipeline servitudes will maintain a 25-foot boundary to ensure pipeline security. Clean backfill (12-inch soil cap) will be placed into excavated polygons and brought to original grade. Table 6-1 displays the cost summary to implement this alternative. The costs are separated into three categories: Base Implementation, Remediation and Disposal, and Present-Worth O&M Costs. Base Implementation Costs are defined as, but not limited to, equipment and personnel mobilization to and from the Site, pre-remediation Site work, facilities, and Site characterization sampling and analysis. Remediation and Disposal Costs are defined as, but not limited to, equipment (excavator, loader, trucks, etc.), operators (includes lodging, transportation, per diem and wages), materials (cap, backfill, pipe, etc.), and disposal costs of the off-Site disposal facility. All material, equipment, and disposal price calculations were based from verbal or written quotes obtained from licensed, regional vendors approved by the EPA and Potentially Responsible Parties (PRPs). Present Worth O&M Costs are defined as, but are not limited to, engineered monitoring equipment (including installation), annual maintenance, and monitoring. Maintenance and monitoring events are scheduled semiannually for a 10-year time frame. Monitoring events include sample collection and analysis to determine status and progress of remedial action implementation and a thorough AOI site inspection. All sample analysis costs were calculated from quotes obtained from a qualified laboratory.

### 6.2.3 ALTERNATIVE 2B – CONTAINMENT: SOIL CAP AND PIPE AT JC-7, PARTIAL 12-INCH REMOVAL/DISPOSAL, AND CONTAINMENT: 12-INCH SOIL CAP ON AREA OUTSIDE THE PIPELINE SERVITUDE AND A 12-INCH EROSION CONTROL MAT ON THE PIPELINE SERVITUDE

This alternative requires the installation of a three 48-inch reinforced concrete pipes that will be extended 700 feet off an already existing set of concrete pipes at the Site. Pipes are designed to maintain the required hydraulic capacity along the polygon associated with sample number JC-7 of the canal. The remaining polygons of interest within Jefferson Canal (JC-2, JC-13, JC-18, and JC-19) will be excavated to a depth of 12-inches beneath existing grade and materials shall be transported to a licensed off-Site disposal facility. Excavation activities within polygons with pipeline servitudes will maintain a 25-foot boundary to ensure pipeline security. Clean backfill will be placed into excavated areas of the polygons and brought to original grade. Erosion control mats will be installed over the pipeline servitude. Table 6-1 displays the cost summary to implement this alternative. The costs are separated into three categories: Base Implementation, Remediation and Disposal, and Present-Worth O&M Costs. Base Implementation Costs are defined as, but not limited to, equipment and personnel mobilization to and from the Site, pre-remediation Site work, facilities, and Site characterization sampling and analysis. Remediation and Disposal Costs are defined as, but not limited to, equipment (excavator, loader, trucks, etc.), operators (includes lodging, transportation, per diem and wages), materials (cap, backfill, pipe, etc.), and disposal costs of the off-Site disposal facility. All material, equipment, and disposal price calculations were based from verbal or written quotes obtained from licensed, regional vendors approved by the EPA and Potentially Responsible Parties (PRPs). Present Worth O&M Costs are defined as, but are not limited to, engineered monitoring equipment (including installation), annual maintenance, and monitoring. Maintenance and monitoring events are scheduled semiannually for a 10-year time frame. Monitoring events include sample collection and analysis to determine status and progress of remedial action implementation and a thorough AOI site inspection. All sample analysis costs were calculated from quotes obtained from a qualified laboratory.

### 6.2.4 ALTERNATIVE 2C – CONTAINMENT: SOIL CAP AND PIPE AT JC-7, PARTIAL 12-INCH REMOVAL/DISPOSAL, AND PARTIAL CONTAINMENT: 12-INCH ARMORED CAP

This alternative requires the installation of a three 48-inch reinforced concrete pipes that will be extended 700 feet off an already existing set of concrete pipes at the Site. Pipes

are designed to maintain the required hydraulic capacity along the polygon associated with sample number JC-7 of the canal. The remaining polygons of interest within Jefferson Canal (JC-2, JC-13, JC-18, and JC-19) will be excavated to a depth of 12-inches beneath existing grade and materials shall be transported to a licensed off-Site disposal facility. Excavation activities within polygons with pipeline servitudes will maintain a 25-foot boundary to ensure pipeline security. Armored backfill (layer of cobbles, pebbles or other large material and prohibits disturbance by its ability to prevent burrowing by organisms, stabilize materials, and prevent erosion) will be placed into excavated areas of the polygons and brought to original grade. Table 6-1 displays the cost summary to implement this alternative. The costs are separated into three categories: Base Implementation, Remediation and Disposal, and Present-Worth O&M Costs. Base Implementation Costs are defined as, but not limited to, equipment and personnel mobilization to and from the Site, pre-remediation Site work, facilities, and Site characterization sampling and analysis. Remediation and Disposal Costs are defined as, but not limited to, equipment (excavator, loader, trucks, etc.), operators (includes lodging, transportation, per diem and wages), materials (cap, backfill, pipe, etc.), and disposal costs of the off-Site disposal facility. All material, equipment, and disposal price calculations were based from verbal or written quotes obtained from licensed, regional vendors approved by the EPA and Potentially Responsible Parties (PRPs). Present Worth O&M Costs are defined as, but are not limited to, engineered monitoring equipment (including installation), annual maintenance, and monitoring. Maintenance and monitoring events are scheduled semiannually for a 10-year time frame. Monitoring events include sample collection and analysis to determine status and progress of remedial action implementation and a thorough AOI site inspection. All sample analysis costs were calculated from quotes obtained from a qualified laboratory.

### 6.2.5 ALTERNATIVE 2D – CONTAINMENT: SOIL CAP AND PIPE AT JC-7, PARTIAL 12-INCH REMOVAL/DISPOSAL, AND CONTAINMENT: 12-INCH ARMORED CAP ON AREA OUTSIDE THE PIPELINE SERVITUDE AND A 12-INCH EROSION CONTROL MAT ON THE PIPELINE SERVITUDE

This alternative requires the installation of a three 48-inch reinforced concrete pipes that will be extended 700 feet off an already existing set of concrete pipes at the Site. Pipes are designed to maintain the required hydraulic capacity along the polygon associated with sample number JC-7 of the canal. The remaining polygons of interest within Jefferson Canal (JC-2, JC-13, JC-18, and JC-19) will be excavated to a depth of 12-inches beneath existing grade and materials shall be transported to a licensed off-Site disposal facility. Excavation activities within polygons with pipeline servitudes will maintain a

25-foot boundary to ensure pipeline security. A 12-inch armored backfill (layer of cobbles, pebbles or other large material and prohibits disturbance by its ability to prevent burrowing by organisms, stabilize materials, and prevent erosion) will be placed into excavated areas of the polygons and brought to original grade. Erosion control mats will be installed over the pipeline servitude. Table 6-1 displays the cost summary to implement this alternative. The costs are separated into three categories: Base Implementation, Remediation and Disposal, and Present-Worth O&M Costs. Base Implementation Costs are defined as, but not limited to, equipment and personnel mobilization to and from the Site, pre-remediation Site work, facilities, and Site characterization sampling and analysis. Remediation and Disposal Costs are defined as, but not limited to, equipment (excavator, loader, trucks, etc.), operators (includes lodging, transportation, per diem and wages), materials (cap, backfill, pipe, etc.), and disposal costs of the off-Site disposal facility. All material, equipment, and disposal price calculations were based from verbal or written quotes obtained from licensed, regional vendors approved by the EPA and Potentially Responsible Parties (PRPs). Present Worth O&M Costs are defined as, but are not limited to, engineered monitoring equipment (including installation), annual maintenance, and monitoring. Maintenance and monitoring events are scheduled semiannually for a 10-year time frame. Monitoring events include sample collection and analysis to determine status and progress of remedial action implementation and a thorough AOI site inspection. All sample analysis costs were calculated from quotes obtained from a qualified laboratory.

### 6.2.6 ALTERNATIVE 3A – PARTIAL 12-INCH REMOVAL/DISPOSAL AND PARTIAL CONTAINMENT: 12-INCH SOIL CAP

This alternative requires a 12-inch excavation of all polygons of interest within Jefferson Canal (JC-2, JC-7, JC-13, JC-18, and JC-19). Material will be excavated with heavy equipment and transported to a licensed off-Site disposal facility. Excavation activities within polygons with pipeline servitudes will maintain a 25-foot boundary to ensure pipeline security. Clean backfill will be placed into excavated areas of the polygons and brought to original grade. Table 6-1 displays the cost summary to implement this alternative. The costs are separated into three categories: Base Implementation, Remediation and Disposal, and Present-Worth O&M Costs. Base Implementation Costs are defined as, but not limited to, equipment and personnel mobilization to and from the Site, pre-remediation Site work, facilities, and Site characterization sampling and analysis. Remediation and Disposal Costs are defined as, but not limited to, equipment (excavator, loader, trucks, etc.), operators (includes lodging, transportation, per diem and wages), materials (cap, backfill, pipe, etc.), and disposal costs of the off-Site disposal

facility. All material, equipment, and disposal price calculations were based from verbal or written quotes obtained from licensed, regional vendors approved by the EPA and PRPs. Present Worth O&M Costs are defined as, but are not limited to, engineered monitoring equipment (including installation), annual maintenance, and monitoring. Maintenance and monitoring events are scheduled semiannually for a 10-year time frame. Monitoring events include sample collection and analysis to determine status and progress of remedial action implementation and a thorough AOI site inspection. All sample analysis costs were calculated from quotes obtained from a qualified laboratory.

### 6.2.7 ALTERNATIVE 3B – PARTIAL 12-INCH REMOVAL/DISPOSAL AND CONTAINMENT: 12-INCH SOIL CAP ON AREA OUTSIDE THE PIPELINE SERVITUDE AND A 12-INCH EROSION CONTROL MAT ON THE PIPELINE SERVITUDE

This alternative requires a 12-inch excavation of all polygons of interest within Jefferson Canal (JC-2, JC-7, JC-13, JC-18, and JC-19). Material will be excavated with heavy equipment and transported to a licensed off-Site disposal facility. Excavation activities within polygons with pipeline servitudes will maintain a 25-foot boundary to ensure pipeline security. Clean backfill will be placed into excavated areas of the polygons and brought to original grade. Erosion control mats will be installed over the pipeline servitude. Table 6-1 displays the cost summary to implement this alternative. The costs are separated into three categories: Base Implementation, Remediation and Disposal, and Present-Worth O&M Costs. Base Implementation Costs are defined as, but not limited to, equipment and personnel mobilization to and from the Site, pre-remediation Site work, facilities, and Site characterization sampling and analysis. Remediation and Disposal Costs are defined as, but not limited to, equipment (excavator, loader, trucks, etc.), operators (includes lodging, transportation, per diem and wages), materials (cap, backfill, pipe, etc.), and disposal costs of the off-Site disposal facility. All material, equipment, and disposal price calculations were based from verbal or written quotes obtained from licensed, regional vendors approved by the EPA and PRPs. Present Worth O&M Costs are defined as, but are not limited to, engineered monitoring equipment (including installation), annual maintenance, and monitoring. Maintenance and monitoring events are scheduled semiannually for a 10-year time frame. Monitoring events include sample collection and analysis to determine status and progress of remedial action implementation and a thorough AOI site inspection. All sample analysis costs were calculated from quotes obtained from a qualified laboratory.

### 6.2.8 ALTERNATIVE 3C – PARTIAL 12-INCH REMOVAL/DISPOSAL AND PARTIAL CONTAINMENT: 12-INCH ARMORED CAP

This alternative requires a 12-inch excavation of all polygons of interest within Jefferson Canal (JC-2, JC-7, JC-13, JC-18, and JC-19). Material will be excavated with heavy equipment and transported to a licensed off-Site disposal facility. Excavation activities within polygons with pipeline servitudes will maintain a 25-foot boundary to ensure pipeline security. A 12-inch armored backfill (layer of cobbles, pebbles or other large material and prohibits disturbance by its ability to prevent burrowing by organisms, stabilize materials, and prevent erosion) will be placed over all polygons in Jefferson Canal AOI, including pipeline servitude areas. Table 6-1 displays the cost summary to implement this alternative. The costs are separated into three categories: Base Implementation, Remediation and Disposal, and Present-Worth O&M Costs. Base Implementation Costs are defined as, but not limited to, equipment and personnel mobilization to and from the Site, pre-remediation Site work, facilities, and Site characterization sampling and analysis. Remediation and Disposal Costs are defined as, but not limited to, equipment (excavator, loader, trucks, etc.), operators (includes lodging, transportation, per diem and wages), materials (cap, backfill, pipe, etc.), and disposal costs of the off-Site disposal facility. All material, equipment, and disposal price calculations were based from verbal or written quotes obtained from licensed, regional vendors approved by the EPA and PRPs. Present Worth O&M Costs are defined as, but are not limited to, engineered monitoring equipment (including installation), annual maintenance, and monitoring. Maintenance and monitoring events are scheduled semiannually for a 10-year time frame. Monitoring events include sample collection and analysis to determine status and progress of remedial action implementation and a thorough AOI site inspection. All sample analysis costs were calculated from quotes obtained from a qualified laboratory.

### 6.2.9 ALTERNATIVE 3D – PARTIAL 12-INCH REMOVAL/DISPOSAL AND CONTAINMENT: 12-INCH ARMORED CAP ON AREA OUTSIDE THE PIPELINE SERVITUDE AND A 12-INCH EROSION CONTROL MAT ON THE PIPELINE SERVITUDE

This alternative requires a 12-inch excavation of all polygons of interest within Jefferson Canal (JC-2, JC-7, JC-13, JC-18, and JC-19). Material will be excavated with heavy equipment and transported to a licensed off-Site disposal facility. Excavation activities within polygons with pipeline servitudes will maintain a 25-foot boundary to ensure pipeline security. A 12-inch armored backfill (layer of cobbles, pebbles or other large material and prohibits disturbance by its ability to prevent burrowing by organisms,

stabilize materials, and prevent erosion) will be placed into excavated areas of the polygons and brought to original grade. Erosion control mats will be installed over the pipeline servitude. Table 6-1 displays the cost summary to implement this alternative. The costs are separated into three categories: Base Implementation, Remediation and Disposal, and Present-Worth O&M Costs. Base Implementation Costs are defined as, but not limited to, equipment and personnel mobilization to and from the Site, pre-remediation Site work, facilities, and Site characterization sampling and analysis. Remediation and Disposal Costs are defined as, but not limited to, equipment (excavator, loader, trucks, etc.), operators (includes lodging, transportation, per diem and wages), materials (cap, backfill, pipe, etc.), and disposal costs of the off-Site disposal facility. All material, equipment, and disposal price calculations were based from verbal or written quotes obtained from licensed, regional vendors approved by the EPA and PRPs. Present Worth O&M Costs are defined as, but are not limited to, engineered monitoring equipment (including installation), annual maintenance, and monitoring. Maintenance and monitoring events are scheduled semiannually for a 10-year time frame. Monitoring events include sample collection and analysis to determine status and progress of remedial action implementation and a thorough AOI site inspection. All sample analysis costs were calculated from quotes obtained from a qualified laboratory.

## 6.3 JEFFERSON CANAL SPOIL PILE

### 6.3.1 ALTERNATIVE 1 - NO ACTION

A cost estimate is not needed since there is no remedial action taken for the No Action alternative.

### 6.3.2 ALTERNATIVE 2A - CONTAINMENT: TWO-FOOT COMPOSITE CAP

This alternative utilizes a composite cap as the form of containment of COCs within the existing media. Cap composition and thickness must be designed to prevent infiltration of rainwater and erosion by surface runoff. Cap composition will consist of a 12-inch layer of clay, to inhibit infiltration, overlaid with a 12-inch layer of top soil to allow for vegetative stabilization, throughout the entire AOI. Table 6-2 displays the cost summary to implement this alternative. The costs are separated into three categories: Base Implementation, Remediation and Disposal, and Present-Worth O&M Costs. Base Implementation Costs are defined as, but not limited to, equipment and personnel

mobilization to and from the Site, pre-remediation Site work, facilities, and Site characterization sampling and analysis. Remediation and Disposal Costs are defined as, but not limited to, equipment (excavator, loader, trucks, etc.), operators (includes lodging, transportation, per diem and wages), materials (cap, backfill, pipe, etc.), and disposal costs of the off-Site disposal facility. All material, equipment and disposal price calculations were based from verbal or written quotes obtained from licensed, regional vendors approved by the EPA and PRPs. Present Worth O&M Costs are defined as, but are not limited to, engineered monitoring equipment (including installation), annual maintenance, and monitoring. Maintenance and monitoring events are scheduled semiannually for a 10-year time frame. Monitoring events include sample collection and analysis to determine status and progress of remedial action implementation and a thorough AOI site inspection. All sample analysis costs were calculated from quotes obtained from a qualified laboratory.

### 6.3.3 ALTERNATIVE 2B – REMOVAL/DISPOSAL OF MOUNDS TO GRADE AND CONTAINMENT: TWO-FOOT COMPOSITE CAP

This alternative utilizes a cut/fill to grade of existing contour. The remaining balance of excavated material will be transported to a licensed off-Site disposal facility. A composite cap will be utilized as the form of containment of COCs within the existing media. Cap composition and thickness must be designed to prevent infiltration of rainwater and erosion by surface runoff. Cap composition will consist of a 12-inch layer of clay, to inhibit infiltration, overlaid with a 12-inch layer of top soil to allow for vegetative stabilization. Table 6-2 displays the cost summary to implement this alternative. The costs are separated into three categories: Base Implementation, Remediation and Disposal, and Present-Worth O&M Costs. Base Implementation Costs are defined as, but not limited to, equipment and personnel mobilization to and from the Site, pre-remediation Site work, facilities, and Site characterization sampling and analysis. Remediation and Disposal Costs are defined as, but not limited to, equipment (excavator, loader, trucks, etc.), operators (includes lodging, transportation, per diem and wages), materials (cap, backfill, pipe, etc.), and disposal costs of the off-Site disposal facility. All material, equipment and disposal price calculations were based from verbal or written quotes obtained from licensed, regional vendors approved by the EPA and PRPs. Present Worth O&M Costs are defined as, but are not limited to, engineered monitoring equipment (including installation), annual maintenance, and monitoring. Maintenance and monitoring events are scheduled semiannually for a 10-year time frame. Monitoring events include sample collection and analysis to determine status

and progress of remedial action implementation and a thorough AOI site inspection. All sample analysis costs were calculated from quotes obtained from a qualified laboratory.

### 6.3.4 ALTERNATIVE 2C – PARTIAL CONTAINMENT: TWO-FOOT COMPOSITE CAP

This alternative utilizes a composite cap as the form of containment of COCs within the existing media. Cap composition and thickness must be designed to prevent infiltration of rainwater and erosion by surface runoff. Cap composition will consist of a 12-inch layer of clay, to inhibit infiltration, overlaid with a 12-inch layer of top soil to allow for vegetative stabilization. A 25-foot boundary surrounding the existing pipelines will be established and cap placement will follow the contour of this boundary to eliminate disturbance of materials near the established pipelines. Table 6-2 displays the cost summary to implement this alternative. The costs are separated into three categories: Base Implementation, Remediation and Disposal, and Present-Worth O&M Costs. Base Implementation Costs are defined as, but not limited to, equipment and personnel mobilization to and from the Site, pre-remediation Site work, facilities, and Site characterization sampling and analysis. Remediation and Disposal Costs are defined as, but not limited to, equipment (excavator, loader, trucks, etc.), operators (includes lodging, transportation, per diem and wages), materials (cap, backfill, pipe, etc.), and disposal costs of the off-Site disposal facility. All material, equipment, and disposal price calculations were based from verbal or written quotes obtained from licensed, regional vendors approved by the EPA and PRPs. Present Worth O&M Costs are defined as, but are not limited to, engineered monitoring equipment (including installation), annual maintenance, and monitoring. Maintenance and monitoring events are scheduled semiannually for a 10-year time frame. Monitoring events include sample collection and analysis to determine status and progress of remedial action implementation and a thorough AOI site inspection. All sample analysis costs were calculated from quotes obtained from a qualified laboratory.

### 6.3.5 ALTERNATIVE 3A – PARTIAL 12-INCH REMOVAL/DISPOSAL, REMOVAL DISPOSAL OF MOUNDS TO GRADE, AND CONTAINMENT: TWO-FOOT COMPOSITE CAP

This alternative requires a removal of mounds to grade and a 12-inch excavation of polygons of interest within Jefferson Canal Spoil Pile, excluding the pipeline servitude. A 25-foot boundary surrounding existing pipelines will be created and excavation will only occur outside of this established boundary. Material will be excavated with heavy

equipment and transported to a licensed off-Site disposal facility. A composite cap will be utilized as the form of containment of COCs within the existing media. Cap composition and thickness must be designed to prevent infiltration of rainwater and erosion by surface runoff. Cap composition will consist of a 12-inch layer of clay, to inhibit infiltration, overlaid with a 12-inch layer of top soil to allow for vegetative stabilization, throughout the entire Jefferson Canal Spoil Pile AOI. Table 6-2 displays the cost summary to implement this alternative. The costs are separated into three categories: Base Implementation, Remediation and Disposal, and Present-Worth O&M Costs. Base Implementation Costs are defined as, but not limited to, equipment and personnel mobilization to and from the Site, pre-remediation Site work, facilities, and Site characterization sampling and analysis. Remediation and Disposal Costs are defined as, but not limited to, equipment (excavator, loader, trucks, etc.), operators (includes lodging, transportation, per diem and wages), materials (cap, backfill, pipe, etc.), and disposal costs of the off-Site disposal facility. All material, equipment and disposal price calculations were based from verbal or written quotes obtained from licensed, regional vendors approved by the EPA and PRPs. Present Worth O&M Costs are defined as, but are not limited to, engineered monitoring equipment (including installation), annual maintenance, and monitoring. Maintenance and monitoring events are scheduled semiannually for a 10-year time frame. Monitoring events include sample collection and analysis to determine status and progress of remedial action implementation and a thorough AOI site inspection. All sample analysis costs were calculated from quotes obtained from a qualified laboratory.

### 6.3.6 ALTERNATIVE 3B – PARTIAL 12-INCH REMOVAL/DISPOSAL, REMOVAL AND DISPOSAL OF MOUNDS TO GRADE, AND PARTIAL CONTAINMENT: TWO-FOOT COMPOSITE CAP

This alternative requires a removal of mounds to grade and a 12-inch excavation of polygons of interest within Jefferson Canal Spoil Pile, excluding the pipeline servitude. A 25-foot boundary surrounding existing pipelines will be created and excavation will only occur outside of this established boundary. Material will be excavated with heavy equipment and transported to a licensed off-Site disposal facility. A composite cap will be utilized as the form of containment of COCs within the existing media. Cap composition and thickness must be designed to prevent infiltration of rainwater and erosion by surface runoff. Cap composition will consist of a 12-inch layer of clay, to inhibit infiltration, overlaid with a 12-inch layer of top soil to allow for vegetative stabilization, only over the excavated area of the Jefferson Canal Spoil Pile AOI. Table 6-2 displays the cost summary to implement this alternative. The costs are separated into

three categories: Base Implementation, Remediation and Disposal, and Present-Worth O&M Costs. Base Implementation Costs are defined as, but not limited to, equipment and personnel mobilization to and from the Site, pre-remediation Site work, facilities, and Site characterization sampling and analysis. Remediation and Disposal Costs are defined as, but not limited to, equipment (excavator, loader, trucks, etc.), operators (includes lodging, transportation, per diem and wages), materials (cap, backfill, pipe, etc.), and disposal costs of the off-Site disposal facility. All material, equipment and disposal price calculations were based from verbal or written quotes obtained from licensed, regional vendors approved by the EPA and PRPs. Present Worth O&M Costs are defined as, but are not limited to, engineered monitoring equipment (including installation), annual maintenance, and monitoring. Maintenance and monitoring events are scheduled semiannually for a 10-year time frame. Monitoring events include sample collection and analysis to determine status and progress of remedial action implementation and a thorough AOI site inspection. All sample analysis costs were calculated from quotes obtained from a qualified laboratory.

## 6.4 FORMER STAR LAKE

### 6.4.1 ALTERNATIVE 1 – NO ACTION

A cost estimate is not needed since there is no remedial action taken for the No Action alternative.

### 6.4.2 ALTERNATIVE 2A – PARTIAL 12-INCH REMOVAL/DISPOSAL AND PARTIAL CONTAINMENT: 12-INCH IMPERMEABLE CAP

This alternative requires a 12-inch excavation of all polygons of interest within Former Star Lake AOI excluding the pipeline servitude. A 25-foot boundary surrounding existing pipelines will be created and excavation will only occur outside of this established boundary. Material will be excavated with heavy equipment and transported to a licensed off-Site disposal facility. A 12-inch impermeable cap (clay) will be utilized to form a barrier between the benthic invertebrates and COC-affected sediment and resist erosion from a partially inundated drainage canal, only in the excavated areas of the AOI. The hydraulic capacity or the soil/water topography of the canal will not be modified by the cap design. Table 6-3 displays the cost summary to implement this alternative. The costs are separated into three categories: Base Implementation, Remediation and Disposal, and Present-Worth O&M Costs. Base

Implementation Costs are defined as, but not limited to, equipment and personnel mobilization to and from the Site, pre-remediation Site work, facilities, and Site characterization sampling and analysis. Remediation and Disposal Costs are defined as, but not limited to, equipment (excavator, loader, trucks, etc.), operators (includes lodging, transportation, per diem and wages), materials (cap, backfill, pipe, etc.), and disposal costs of the off-Site disposal facility. All material, equipment, and disposal price calculations were based from verbal or written quotes obtained from licensed, regional vendors approved by the EPA and PRPs. Present Worth O&M Costs are defined as, but are not limited to, engineered monitoring equipment (including installation), annual maintenance, and monitoring. Maintenance and monitoring events are scheduled semiannually for a 10-year time frame. Monitoring events include sample collection and analysis to determine status and progress of remedial action implementation and a thorough AOI site inspection. All sample analysis costs were calculated from quotes obtained from a qualified laboratory.

### 6.4.3 ALTERNATIVE 2B – PARTIAL 12-INCH REMOVAL/DISPOSAL AND CONTAINMENT: 12-INCH IMPERMEABLE CAP ON AREA OUTSIDE OF PIPELINE SERVITUDE AND A 12-INCH EROSION CONTROL MAT AND COMPOSITE CAP ON THE PIPELINE SERVITUDE

This alternative requires a 12-inch excavation of all polygons of interest within Former Star Lake AOI excluding the pipeline servitude. A 25-foot boundary surrounding existing pipelines will be created and excavation will only occur outside of this established boundary. Material will be excavated with heavy equipment and transported to a licensed off-Site disposal facility. A 12-inch impermeable cap (clay) will be utilized to form a barrier between the benthic invertebrates and COC-affected sediment and resist erosion from a partially inundated drainage canal, only in the excavated areas of the AOI. The hydraulic capacity or the soil/water topography of the canal will not be modified by the cap design. A 12-inch erosion control mat will be placed onto pipeline servitude areas of the polygons that are on the banks of the Star Lake Canal. A 12-inch composite cap will be placed onto pipeline servitude area of the polygons that are not on the banks of the Star Lake Canal. Table 6-3 displays the cost summary to implement this alternative. The costs are separated into three categories: Base Implementation, Remediation and Disposal, and Present-Worth O&M Costs. Base Implementation Costs are defined as, but not limited to, equipment and personnel mobilization to and from the Site, pre-remediation Site work, facilities, and Site characterization sampling and analysis. Remediation and Disposal Costs are defined as, but not limited to, equipment (excavator, loader, trucks, etc.), operators (includes

lodging, transportation, per diem and wages), materials (cap, backfill, pipe, etc.), and disposal costs of the off-Site disposal facility. All material, equipment, and disposal price calculations were based from verbal or written quotes obtained from licensed, regional vendors approved by the EPA and PRPs. Present Worth O&M Costs are defined as, but are not limited to, engineered monitoring equipment (including installation), annual maintenance, and monitoring. Maintenance and monitoring events are scheduled semiannually for a 10-year time frame. Monitoring events include sample collection and analysis to determine status and progress of remedial action implementation and a thorough AOI site inspection. All sample analysis costs were calculated from quotes obtained from a qualified laboratory.

### 6.4.4 ALTERNATIVE 3A – PARTIAL 12-INCH REMOVAL/DISPOSAL AND PARTIAL CONTAINMENT: 12-INCH COMPOSITE CAP

This alternative requires a 12-inch excavation of all polygons of interest within Former Star Lake AOI excluding the pipeline servitude. A 25-foot boundary surrounding existing pipelines will be created and excavation will only occur outside of this established boundary. Material will be excavated with heavy equipment and transported to a licensed off-Site disposal facility. A composite cap will be utilized as the form of containment of COCs within the existing media. Cap composition and thickness must be designed to prevent infiltration of rainwater and erosion by surface runoff. Cap composition will consist of a 6-inch layer of clay, to inhibit infiltration, overlaid with a 6-inch layer of top soil to allow for vegetative stabilization. Table 6-3 displays the cost summary to implement this alternative. The costs are separated into three categories: Base Implementation, Remediation and Disposal, and Present-Worth O&M Costs. Base Implementation Costs are defined as, but not limited to, equipment and personnel mobilization to and from the Site, pre-remediation Site work, facilities, and Site characterization sampling and analysis. Remediation and Disposal Costs are defined as, but not limited to, equipment (excavator, loader, trucks, etc.), operators (includes lodging, transportation, per diem and wages), materials (cap, backfill, pipe, etc.), and disposal costs of the off-Site disposal facility. All material, equipment, and disposal price calculations were based from verbal or written quotes obtained from licensed, regional vendors approved by EPA and the PRPs. Present Worth O&M Costs are defined as, but are not limited to, engineered monitoring equipment (including installation), annual maintenance, and monitoring. Maintenance and monitoring events are scheduled semiannually for a 10-year time frame. Monitoring events include sample collection and analysis to determine status and progress of remedial action

implementation and a thorough AOI site inspection. All sample analysis costs were calculated from quotes obtained from a qualified laboratory.

### 6.4.5 ALTERNATIVE 3B – PARTIAL 12-INCH REMOVAL/DISPOSAL AND CONTAINMENT: 12-INCH COMPOSITE CAP ON AREA OUTSIDE OF THE PIPELINE SERVITUDE AND A 12-INCH EROSION CONTROL MAT AND COMPOSITE CAP ON THE PIPELINE SERVITUDE

This alternative requires a 12-inch excavation of all polygons of interest within Former Star Lake AOI excluding the pipeline servitude. A 25-foot boundary surrounding existing pipelines will be created and excavation will only occur outside of this established boundary. Material will be excavated with heavy equipment and transported to a licensed off-Site disposal facility. A 12-inch composite cap will be utilized as the form of containment of COCs within the existing media, on excavated areas outside of pipeline servitudes. Cap composition and thickness must be designed to prevent infiltration of rainwater and erosion by surface runoff. Cap composition will consist of a 6-inch layer of clay, to inhibit infiltration, overlaid with a 6-inch layer of top soil to allow for vegetative stabilization. A 12-inch erosion control mat will be placed onto pipeline servitude areas of the polygons that are on the banks of the Star Lake Canal. A 12-inch composite cap will be placed onto pipeline servitude areas of the polygons that are not on the banks of the Star Lake Canal. Table 6-3 displays the cost summary to implement this alternative. The costs are separated into three categories: Base Implementation, Remediation and Disposal, and Present-Worth O&M Costs. Base Implementation Costs are defined as, but not limited to, equipment and personnel mobilization to and from the Site, pre-remediation Site work, facilities, and Site characterization sampling and analysis. Remediation and Disposal Costs are defined as, but not limited to, equipment (excavator, loader, trucks, etc.), operators (includes lodging, transportation, per diem and wages), materials (cap, backfill, pipe, etc.), and disposal costs of the off-Site disposal facility. All material, equipment, and disposal price calculations were based from verbal or written quotes obtained from licensed, regional vendors approved by EPA and the PRPs. Present Worth O&M Costs are defined as, but are not limited to, engineered monitoring equipment (including installation), annual maintenance, and monitoring. Maintenance and monitoring events are scheduled semiannually for a 10-year time frame. Monitoring events include sample collection and analysis to determine status and progress of remedial action implementation and a thorough AOI site inspection. All sample analysis costs were calculated from quotes obtained from a qualified laboratory.

## 6.5 STAR LAKE CANAL

### 6.5.1 ALTERNATIVE 1 – NO ACTION

A cost estimate is not needed since there is no remedial action taken for the No Action alternative.

### 6.5.2 ALTERNATIVE 2 – 12-INCH REMOVAL/DISPOSAL AND CONTAINMENT: 12-INCH IMPERMEABLE CAP

This alternative requires a 12-inch excavation of all polygons of interest within Former Star Lake AOI. Material will be excavated with heavy equipment and transported to a licensed off-Site disposal facility. A 12-inch impermeable cap (clay) will be utilized to form a barrier between the benthic invertebrates and COC-affected sediment and resist erosion. The hydraulic capacity or the soil/water topography of the canal will not be modified by the cap design. Table 6-4 displays the cost summary to implement this alternative. The costs are separated into three categories: Base Implementation, Remediation and Disposal, and Present-Worth O&M Costs. Base Implementation Costs are defined as, but not limited to, equipment and personnel mobilization to and from the Site, pre-remediation Site work, facilities, and Site characterization sampling and analysis. Remediation and Disposal Costs are defined as, but not limited to, equipment (excavator, loader, trucks, etc.), operators (includes lodging, transportation, per diem and wages), materials (cap, backfill, pipe, etc.), and disposal costs of the off-Site disposal facility. All material, equipment, and disposal price calculations were based from verbal or written quotes obtained from licensed, regional vendors approved by the EPA and PRPs. Present Worth O&M Costs are defined as, but are not limited to, engineered monitoring equipment (including installation), annual maintenance, and monitoring. Maintenance and monitoring events are scheduled semiannually for a 10-year time frame. Monitoring events include sample collection and analysis to determine status and progress of remedial action implementation and a thorough AOI site inspection. All sample analysis costs were calculated from quotes obtained from a qualified laboratory.

### 6.5.3 ALTERNATIVE 3 – 12-INCH REMOVAL/DISPOSAL AND CONTAINMENT: 12-INCH ARMORED CAP

This alternative requires a 12-inch excavation of all polygons of interest within Star Lake Canal (SLC-11 and SLC-6). Material will be excavated with heavy equipment and

transported to a licensed off-Site disposal facility. A 12-inch armored backfill (layer of cobbles, pebbles or other large material and prohibits disturbance by its ability to prevent burrowing by organisms, stabilize materials, and prevent erosion) will be placed into excavated areas of the polygons and brought to original grade. The hydraulic capacity or the soil/water topography of the canal will not be modified by the cap design. Table 6-4 displays the cost summary to implement this alternative. The costs are separated into three categories: Base Implementation, Remediation and Disposal, and Present-Worth O&M Costs. Base Implementation Costs are defined as, but not limited to, equipment and personnel mobilization to and from the Site, pre-remediation Site work, facilities, and Site characterization sampling and analysis. Remediation and Disposal Costs are defined as, but not limited to, equipment (excavator, loader, trucks, etc.), operators (includes lodging, transportation, per diem and wages), materials (cap, backfill, pipe, etc.), and disposal costs of the off-Site disposal facility. All material, equipment, and disposal price calculations were based from verbal or written quotes obtained from licensed, regional vendors approved by EPA and the PRPs. Present Worth O&M Costs are defined as, but are not limited to, engineered monitoring equipment (including installation), annual maintenance, and monitoring. Maintenance and monitoring events are scheduled semiannually for a 10-year time frame. Monitoring events include sample collection and analysis to determine status and progress of remedial action implementation and a thorough AOI site inspection. All sample analysis costs were calculated from quotes obtained from a qualified laboratory.

## 6.6 GULF STATES UTILITY CANAL

### 6.6.1 ALTERNATIVE 1 – NO ACTION

A cost estimate is not needed since there is no remedial action taken for the No Action alternative.

### 6.6.2 ALTERNATIVE 2 – CONTAINMENT: 12-INCH COMPOSITE CAP

This alternative utilizes a composite cap as the form of containment of COCs within the polygon associated with sample number GSUC-7. Cap composition and thickness must be designed to prevent erosion of the soft canal bottom, and provide a new benthic habitat. Cap composition will consist of a 6-inch layer of clay, to inhibit infiltration, overlaid with a 6-inch layer of top soil to allow for vegetative stabilization. Table 6-5 displays the cost summary to implement this alternative. The costs are separated into

three categories: Base Implementation, Remediation and Disposal, and Present-Worth O&M Costs. Base Implementation Costs are defined as, but not limited to, equipment and personnel mobilization to and from the Site, pre-remediation Site work, facilities, and Site characterization sampling and analysis. Remediation and Disposal Costs are defined as, but not limited to, equipment (excavator, loader, trucks, etc.), operators (includes lodging, transportation, per diem and wages), materials (cap, backfill, pipe, etc.), and disposal costs of the off-Site disposal facility. All material, equipment, and disposal price calculations were based from verbal or written quotes obtained from licensed, regional vendors approved by the EPA and PRPs. Present Worth O&M Costs are defined as, but are not limited to, engineered monitoring equipment (including installation), annual maintenance, and monitoring. Maintenance and monitoring events are scheduled semiannually for a 10-year time frame. Monitoring events include sample collection and analysis to determine status and progress of remedial action implementation and a thorough AOI site inspection. All sample analysis costs were calculated from quotes obtained from a qualified laboratory.

### 6.6.3 ALTERNATIVE 3 – 12-INCH REMOVAL/DISPOSAL AND CONTAINMENT: 12-INCH ARMORED CAP

This alternative requires a 12-inch excavation of the polygon associated with sample number GSUC-7. Material will be excavated with heavy equipment and transported to a licensed off-Site disposal facility. A 12-inch armored backfill (layer of cobbles, pebbles or other large material and prohibits disturbance by its ability to prevent burrowing by organisms, stabilize materials, and prevent erosion) will be placed on all polygons within the GSUC, including pipeline servitude areas. Armored cap will be utilized to form a barrier between the benthic invertebrates and COC-affected sediment and resist erosion from a partially inundated drainage canal. The hydraulic capacity or the soil/water topography of the canal will not be modified by the cap design. Table 6-5 displays the cost summary to implement this alternative. The costs are separated into three categories: Base Implementation, Remediation and Disposal, and Present-Worth O&M Costs. Base Implementation Costs are defined as, but not limited to, equipment and personnel mobilization to and from the Site, pre-remediation Site work, facilities, and Site characterization sampling and analysis. Remediation and Disposal Costs are defined as, but not limited to, equipment (excavator, loader, trucks, etc.), operators (includes lodging, transportation, per diem and wages), materials (cap, backfill, pipe, etc.), and disposal costs of the off-Site disposal facility. All material, equipment, and disposal price calculations were based from verbal or written quotes obtained from licensed, regional vendors approved by the EPA and PRPs. Present Worth O&M Costs

are defined as, but are not limited to, engineered monitoring equipment (including installation), annual maintenance, and monitoring. Maintenance and monitoring events are scheduled semiannually for a 10-year time frame. Monitoring events include sample collection and analysis to determine status and progress of remedial action implementation and a thorough AOI site inspection. All sample analysis costs were calculated from quotes obtained from a qualified laboratory.

### 6.6.4 ALTERNATIVE 4 – 12-INCH REMOVAL AND DISPOSAL

This alternative requires a 12-inch excavation of all polygons of interest within the Gulf States Utility Canal AOI. Material will be excavated with heavy equipment and transported to a licensed off-Site disposal facility. Excavation will not be backfilled and the hydraulic capacity or the soil/water topography of the canal will be modified by this design. Table 6-5 displays the cost summary to implement this alternative. The costs are separated into three categories: Base Implementation, Treatment and Disposal, and Present-Worth O&M Costs. Base Implementation Costs are defined as, but not limited to, equipment and personnel mobilization to and from the Site, pre-remediation Site work, facilities, and Site characterization sampling and analysis. Treatment and Disposal Costs are defined as, but not limited to, equipment (excavator, loader, trucks, etc.), operators (includes lodging, transportation, per diem and wages), materials (cap, backfill, pipe, etc.), and disposal costs of the off-Site disposal facility. All material, equipment and disposal price calculations were based from verbal or written quotes obtained from licensed, regional vendors approved by the EPA and PRPs. Present Worth O&M Costs are defined as, but are not limited to, engineered monitoring equipment (including installation), annual maintenance, and monitoring. Maintenance and monitoring events are scheduled semiannually for a 10-year time frame. Monitoring events include sample collection and analysis to determine status and progress of remedial action implementation and a thorough AOI site inspection. All sample analysis costs were calculated from quotes obtained from a qualified laboratory.

## 6.7 MOLASSES BAYOU WATERWAY

### 6.7.1 ALTERNATIVE 1 – NO ACTION

A cost estimate is not needed since there is no remedial action taken for the No Action alternative.

### 6.7.2 ALTERNATIVE 2A – MONITORED NATURAL RECOVERY

This alternative utilizes naturally driven degradation and dispersion processes within the polygons associated with sample numbers MB-10, MB-14, MB-18/MB-18R, MB-21, MB-24, MB-49, MB-52, MB-54, MB-60, and MB-61. The MNR alternative lowers the risk of interaction between benthic invertebrates and the sediment very gradually. Overall protection of the environment depends upon the rate of naturally driven degradation and dispersion processes. Natural processes will be monitored by scheduled sampling events over the 10 year time period. Table 6-6 displays the cost summary to implement this alternative. The costs are separated into three categories: Base Implementation, Remediation and Disposal, and Present-Worth O&M Costs. Base Implementation Costs are defined as, but not limited to, equipment and personnel mobilization to and from the Site, pre-remediation Site work, facilities, and Site characterization sampling and analysis. Remediation and Disposal Costs are defined as, but not limited to, equipment (excavator, loader, trucks, etc.), operators (includes lodging, transportation, per diem and wages), materials (cap, backfill, pipe, etc.), and disposal costs of the off-Site disposal facility. All material, equipment, and disposal price calculations were based from verbal or written quotes obtained from licensed, regional vendors approved by the EPA and PRPs. Present Worth O&M Costs are defined as, but are not limited to, engineered monitoring equipment (including installation), annual maintenance, and monitoring. Maintenance and monitoring events are scheduled monthly for the first two years, quarterly for years three through five, and semiannually for the remainder of the 10-year time frame. Semiannual site inspections will be conducted every year in addition to the scheduled sampling events. Scheduled sampling events (years one, two, four, eight, and ten) will include extensive sediment and soil sample collection. Samples will be collected from the same vicinity to verify and validate a true representation of remedial progress over time. Monitoring events include sample collection and analysis to determine status and progress of remedial action implementation and a thorough AOI site inspection. All sample analysis costs were calculated from quotes obtained from a qualified laboratory.

### 6.7.3 ALTERNATIVE 2B – MONITORED NATURAL RECOVERY AND 12-INCH REMOVAL AND DISPOSAL AND CONTAINMENT: 12-INCH ARMORED CAP

This alternative utilizes MNR for the Molasses Bayou Waterway polygons that correspond to sample numbers MB-10, MB-14, MB-18/MB-18R, MB-49, MB-52, MB-54, and MB-60; and 12-inch removal/disposal and containment with a 12-inch armored cap

for the polygons that correspond to sample numbers MB-24, MB-61, and MB-21. Material will be excavated with hydraulic dredge equipment, staged in an area to be de-watered (by filter press or Geo-Tubes) and transported to a licensed off-Site disposal facility. A 12-inch armored backfill (layer of cobbles, pebbles or other large material and prohibits disturbance by its ability to prevent burrowing by organisms, stabilize materials, and prevent erosion) will be placed into excavated areas of the polygons and brought to original grade. Armored cap will be utilized to form a barrier between the benthic invertebrates and COC-affected sediment and resist erosion from a partially inundated drainage canal. Monitored Natural Recovery which utilizes naturally driven degradation and dispersion processes will then be employed to monitor the recovery of the AOI. The MNR alternative lowers the risk of interaction between benthic invertebrates and the sediment very gradually. Overall protection of the environment depends upon the rate of naturally driven degradation and dispersion processes. Natural processes will be monitored by scheduled sampling events over the 10 year time period. Table 6-6 displays the cost summary to implement this alternative. The costs are separated into three categories: Base Implementation, Remediation and Disposal, and Present-Worth O&M Costs. Base Implementation Costs are defined as, but not limited to, equipment and personnel mobilization to and from the Site, pre-remediation Site work, facilities, and Site characterization sampling and analysis. Remediation and Disposal Costs are defined as, but not limited to, equipment (excavator, loader, trucks, etc.), operators (includes lodging, transportation, per diem and wages), materials (cap, backfill, pipe, etc.), and disposal costs of the off-Site disposal facility. All material, equipment, and disposal price calculations were based from verbal or written quotes obtained from licensed, regional vendors approved by the EPA and PRPs. Present Worth O&M Costs are defined as, but are not limited to, engineered monitoring equipment (including installation), annual maintenance, and monitoring. Maintenance and monitoring events are scheduled monthly for the first two years, quarterly for years three through five, and semiannually for the remainder of the 10-year time frame. Semiannual site inspections will be conducted every year in addition to the scheduled sampling events. Scheduled sampling events (years one, two, four, eight, and ten) will include extensive sediment and soil sample collection. Samples will be collected from the same vicinity to verify and validate a true representation of remedial progress over time. Monitoring events include sample collection and analysis to determine status and progress of remedial action implementation and a thorough AOI site inspection. All sample analysis costs were calculated from quotes obtained from a qualified laboratory.

### 6.7.4 ALTERNATIVE 3 - 12-INCH REMOVAL/DISPOSAL AND CONTAINMENT: 12-INCH ARMORED CAP

This alternative requires a 12-inch excavation of the polygons associated with sample numbers MB-10, MB-14, MB-18/MB-18R, MB-21, MB-24, MB-49, MB-52, MB-54, MB-60, and MB-61. Material will be excavated with hydraulic dredge equipment, staged in an area to be de-watered (by filter press or Geo-Tubes) and transported to a licensed off-Site disposal facility. Excavation will be partially backfilled with clay and overlaid with an armored cap that will be utilized to form a barrier between the benthic invertebrates and COC-affected sediment and resist erosion from soft bottom bayou. The hydraulic capacity or the soil/water topography of the canal will not be modified by the cap design. Table 6-6 displays the cost summary to implement this alternative. The costs are separated into three categories: Base Implementation, Remediation and Disposal, and Present-Worth O&M Costs. Base Implementation Costs are defined as, but not limited to, equipment and personnel mobilization to and from the Site, pre-remediation Site work, facilities, and Site characterization sampling and analysis. Remediation and Disposal Costs are defined as, but not limited to, equipment (excavator, loader, trucks, etc.), operators (includes lodging, transportation, per diem and wages), materials (cap, backfill, pipe, etc.), and disposal costs of the off-Site disposal facility. All material, equipment, and disposal price calculations were based from verbal or written quotes obtained from licensed, regional vendors approved by the EPA and PRPs. Present Worth O&M Costs are defined as, but are not limited to, engineered monitoring equipment (including installation), annual maintenance, and monitoring. Maintenance and monitoring events are scheduled semiannually for a 10-year time frame. Monitoring events include sample collection and analysis to determine status and progress of remedial action implementation and a thorough AOI site inspection. All sample analysis costs were calculated from quotes obtained from a qualified laboratory.

## 6.8 MOLASSES BAYOU WETLAND

### 6.8.1 ALTERNATIVE 1 – NO ACTION

A cost estimate is not needed since there is no remedial action taken for the No Action alternative.

### 6.8.2 ALTERNATIVE 2A – MONITORED NATURAL RECOVERY

This alternative utilizes naturally driven degradation and dispersion processes within the polygons associated with sample numbers MB-26, MB-51, MB-56, MB-58, MB-59, MB-62, and MB-63. The MNR alternative lowers the risk of interaction between benthic invertebrates and the sediment very gradually. Overall protection of the environment depends upon the rate of naturally driven degradation and dispersion processes. Natural processes will be monitored by scheduled sampling events over the 10 year time period. Table 6-7 displays the cost summary to implement this alternative. The costs are separated into three categories: Base Implementation, Remediation and Disposal, and Present-Worth O&M Costs. Base Implementation Costs are defined as, but not limited to, equipment and personnel mobilization to and from the Site, pre-remediation Site work, facilities, and Site characterization sampling and analysis. Remediation and Disposal Costs are defined as, but not limited to, equipment (excavator, loader, trucks, etc.), operators (includes lodging, transportation, per diem and wages), materials (cap, backfill, pipe, etc.), and disposal costs of the off-Site disposal facility. All material, equipment, and disposal price calculations were based from verbal or written quotes obtained from licensed, regional vendors approved by the EPA and PRPs. Present Worth O&M Costs are defined as, but are not limited to, engineered monitoring equipment (including installation), annual maintenance, and monitoring. Maintenance and monitoring events are scheduled annually monthly for the first two years, quarterly for years three through five, and semiannually for the remainder of the 10-year time frame. Semiannual site inspections will be conducted every year in addition to the scheduled sampling events. Scheduled sampling events (years one, two, four, eight, and ten) will include extensive sediment and soil sample collection. Samples will be collected from the same vicinity to verify and validate a true representation of remedial progress over time. Monitoring events include sample collection and analysis to determine status and progress of remedial action implementation and a thorough AOI site inspection. All sample analysis costs were calculated from quotes obtained from a qualified laboratory.

### 6.8.3 ALTERNATIVE 2B – MONITORED NATURAL RECOVERY AND CONTAINMENT: 12-INCH COMPOSITE CAP

This alternative utilizes MNR for the Molasses Bayou Wetland polygons that correspond to sample numbers MB-51, MB-56, MB-58, and MB-59; and containment with a 12-inch composite cap for the polygons that correspond to sample numbers MB-26 MB-62, and MB-63. Cap composition and thickness must be designed to prevent infiltration of rainwater and erosion, and provide a new benthic habitat. Cap composition will consist

of a 6-inch layer of clay, to inhibit infiltration, overlaid with a 6-inch layer of top soil to allow for vegetative stabilization. The MNR alternative lowers the risk of interaction between benthic invertebrates and the sediment very gradually. Overall protection of the environment depends upon the rate of naturally driven degradation and dispersion processes. Natural processes will be monitored by scheduled sampling events over the 10 year time period. Table 6-7 displays the cost summary to implement this alternative. The costs are separated into three categories: Base Implementation, Remediation and Disposal, and Present-Worth O&M Costs. Base Implementation Costs are defined as, but not limited to, equipment and personnel mobilization to and from the Site, pre-remediation Site work, facilities, and Site characterization sampling and analysis. Remediation and Disposal Costs are defined as, but not limited to, equipment (excavator, loader, trucks, etc.), operators (includes lodging, transportation, per diem and wages), materials (cap, backfill, pipe, etc.), and disposal costs of the off-Site disposal facility. All material, equipment, and disposal price calculations were based from verbal or written quotes obtained from licensed, regional vendors approved by the EPA and PRPs. Present Worth O&M Costs are defined as, but are not limited to, engineered monitoring equipment (including installation), annual maintenance, and monitoring. Maintenance and monitoring events are scheduled monthly for the first two years, quarterly for years three through five, and semiannually for the remainder of the 10-year time frame. Semiannual site inspections will be conducted every year in addition to the scheduled sampling events. Scheduled sampling events (years one, two, four, eight, and ten) will include extensive sediment and soil sample collection. Samples will be collected from the same vicinity to verify and validate a true representation of remedial progress over time. Monitoring events include sample collection and analysis to determine status and progress of remedial action implementation and a thorough AOI site inspection. All sample analysis costs were calculated from quotes obtained from a qualified laboratory.

### 6.8.4 ALTERNATIVE 2C – MONITORED NATURAL RECOVERY AND 12-INCH REMOVAL AND DISPOSAL AND CONTAINMENT: 12-INCH ARMORED CAP

This alternative utilizes MNR for the Molasses Bayou Waterway polygons that correspond to sample numbers MB-51, MB-56, MB-58, and MB-59; and 12-inch removal/disposal and containment with a 12-inch armored cap for the polygons that correspond to sample numbers MB-26 MB-62, and MB-63. Material will be excavated with hydraulic dredge equipment, staged in an area to be de-watered (by filter press or Geo-Tubes) and transported to a licensed off-Site disposal facility. A 12-inch armored backfill (layer of cobbles, pebbles or other large material and prohibits disturbance by its

ability to prevent burrowing by organisms, stabilize materials, and prevent erosion) will be placed into excavated areas of the polygons and brought to original grade. Armored cap will be utilized to form a barrier between the benthic invertebrates and COC-affected sediment and resist erosion. Monitored Natural Recovery which utilizes naturally driven degradation and dispersion processes will then be employed to monitor the recovery of the AOI. The MNR alternative lowers the risk of interaction between benthic invertebrates and the sediment very gradually. Overall protection of the environment depends upon the rate of naturally driven degradation and dispersion processes. Natural processes will be monitored by scheduled sampling events over the 10 year time period. Table 6-6 displays the cost summary to implement this alternative. The costs are separated into three categories: Base Implementation, Remediation and Disposal, and Present-Worth O&M Costs. Base Implementation Costs are defined as, but not limited to, equipment and personnel mobilization to and from the Site, pre-remediation Site work, facilities, and Site characterization sampling and analysis. Remediation and Disposal Costs are defined as, but not limited to, equipment (excavator, loader, trucks, etc.), operators (includes lodging, transportation, per diem and wages), materials (cap, backfill, pipe, etc.), and disposal costs of the off-Site disposal facility. All material, equipment, and disposal price calculations were based from verbal or written quotes obtained from licensed, regional vendors approved by the EPA and PRPs. Present Worth O&M Costs are defined as, but are not limited to, engineered monitoring equipment (including installation), annual maintenance, and monitoring. Maintenance and monitoring events are scheduled monthly for the first two years, quarterly for years three through five, and semiannually for the remainder of the 10-year time frame. Semiannual site inspections will be conducted every year in addition to the scheduled sampling events. Scheduled sampling events (years one, two, four, eight, and ten) will include extensive sediment and soil sample collection. Samples will be collected from the same vicinity to verify and validate a true representation of remedial progress over time. Monitoring events include sample collection and analysis to determine status and progress of remedial action implementation and a thorough AOI site inspection. All sample analysis costs were calculated from quotes obtained from a qualified laboratory.

### 6.8.5 ALTERNATIVE 2D – MONITORED NATURAL RECOVERY AND 12-INCH REMOVAL AND DISPOSAL

This alternative utilizes MNR for the Molasses Bayou Waterway polygons that correspond to sample numbers MB-51, MB-56, MB-58, and MB-59; and 12-inch removal/disposal for the polygons that correspond to sample numbers MB-26 MB-62, and MB-63. Material will be excavated with heavy equipment and transported to a

licensed off-Site disposal facility. Excavation will not be backfilled and the hydraulic capacity or the soil/water topography will be modified by this design. Monitored Natural Recovery which utilizes naturally driven degradation and dispersion processes will then be employed to monitor the recovery of the AOI. The MNR alternative lowers the risk of interaction between benthic invertebrates and the sediment very gradually. Overall protection of the environment depends upon the rate of naturally driven degradation and dispersion processes. Natural processes will be monitored by scheduled sampling events over the 10 year time period. Table 6-5 displays the cost summary to implement this alternative. The costs are separated into three categories: Base Implementation, Treatment and Disposal, and Present-Worth O&M Costs. Base Implementation Costs are defined as, but not limited to, equipment and personnel mobilization to and from the Site, pre-remediation Site work, facilities, and Site characterization sampling and analysis. Treatment and Disposal Costs are defined as, but not limited to, equipment (excavator, loader, trucks, etc.), operators (includes lodging, transportation, per diem and wages), materials (cap, backfill, pipe, etc.), and disposal costs of the off-Site disposal facility. All material, equipment and disposal price calculations were based from verbal or written quotes obtained from licensed, regional vendors approved by the EPA and PRPs. Present Worth O&M Costs are defined as, but are not limited to, engineered monitoring equipment (including installation), annual maintenance, and monitoring. Maintenance and monitoring events are scheduled monthly for the first two years, quarterly for years three through five, and semiannually for the remainder of the 10-year time frame. Semiannual site inspections will be conducted every year in addition to the scheduled sampling events. Scheduled sampling events (years one, two, four, eight, and ten) will include extensive sediment and soil sample collection. Samples will be collected from the same vicinity to verify and validate a true representation of remedial progress over time. Monitoring events include sample collection and analysis to determine status and progress of remedial action implementation and a thorough AOI site inspection. All sample analysis costs were calculated from quotes obtained from a qualified laboratory.

### 6.8.6 ALTERNATIVE 3 – CONTAINMENT: 12-INCH COMPOSITE CAP

This alternative utilizes a composite cap as the form of containment of COCs within the polygons associated with sample numbers MB-26, MB-51, MB-56, MB-58, MB-59, MB-62, and MB-63. Cap composition and thickness must be designed to prevent infiltration of rainwater and erosion, and provide a new benthic habitat. Cap composition will consist of a 12-inch layer of clay, to inhibit infiltration, overlaid with a 12-inch layer of top soil to allow for vegetative stabilization. Table 6-7 displays the cost summary to implement

this alternative. The costs are separated into three categories: Base Implementation, Remediation and Disposal, and Present-Worth O&M Costs. Base Implementation Costs are defined as, but not limited to, equipment and personnel mobilization to and from the Site, pre-remediation Site work, facilities, and Site characterization sampling and analysis. Remediation and Disposal Costs are defined as, but not limited to, equipment (excavator, loader, trucks, etc.), operators (includes lodging, transportation, per diem and wages), materials (cap, backfill, pipe, etc.), and disposal costs of the off-Site disposal facility. All material, equipment, and disposal price calculations were based from verbal or written quotes obtained from licensed, regional vendors approved by the EPA and PRPs. Present Worth O&M Costs are defined as, but are not limited to, engineered monitoring equipment (including installation), annual maintenance, and monitoring. Maintenance and monitoring events are scheduled semiannually for a 10-year time frame. Monitoring events include sample collection and analysis to determine status and progress of remedial action implementation and a thorough AOI site inspection. All sample analysis costs were calculated from quotes obtained from a qualified laboratory.

### 6.8.7 ALTERNATIVE 4 – PARTIAL 12-INCH REMOVAL/DISPOSAL AND PARTIAL CONTAINMENT: 12-INCH ARMORED CAP

This alternative requires a 12-inch excavation of the polygons, excluding the pipeline servitudes, associated with sample numbers MB-26, MB-51, MB-56, MB-58, MB-59, MB-62, and MB-63. A 25-foot boundary surrounding existing pipelines, within the polygon corresponding to sample MB-56, will be created and excavation will only occur outside of this established boundary. Material will be excavated with hydraulic dredge equipment, staged in an area to be de-watered (by filter press or Geo-Tubes) and transported to a licensed off-Site disposal facility. A 12-inch armored backfill (layer of cobbles, pebbles or other large material and prohibits disturbance by its ability to prevent burrowing by organisms, stabilize materials, and prevent erosion) will be placed into excavated areas of the polygons and brought to original grade. Armored cap will be utilized to form a barrier between the benthic invertebrates and COC-affected sediment and resist erosion. Table 6-7 displays the cost summary to implement this alternative. The costs are separated into three categories: Base Implementation, Remediation and Disposal, and Present-Worth O&M Costs. Base Implementation Costs are defined as, but not limited to, equipment and personnel mobilization to and from the Site, pre-remediation Site work, facilities, and Site characterization sampling and analysis. Remediation and Disposal Costs are defined as, but not limited to, equipment (excavator, loader, trucks, etc.), operators (includes lodging, transportation, per diem and wages), materials (cap, backfill, pipe, etc.), and disposal costs of the off-Site disposal

facility. All material, equipment, and disposal price calculations were based from verbal or written quotes obtained from licensed, regional vendors approved by the EPA and PRPs. Present Worth O&M Costs are defined as, but are not limited to, engineered monitoring equipment (including installation), annual maintenance, and monitoring. Maintenance and monitoring events are scheduled semiannually for a 10-year time frame. Monitoring events include sample collection and analysis to determine status and progress of remedial action implementation and a thorough AOI site inspection. All sample analysis costs were calculated from quotes obtained from a qualified laboratory.

### 6.8.8 ALTERNATIVE 5 – PARTIAL 12-INCH REMOVAL AND DISPOSAL

This alternative requires a 12-inch excavation of the polygons, excluding the pipeline servitudes, associated with sample numbers MB-26, MB-51, MB-56, MB-58, MB-59, MB-62, and MB-63. A 25-foot boundary surrounding existing pipelines, within the polygon corresponding to sample MB-56, will be created and excavation will only occur outside of this established boundary. Material will be excavated with hydraulic dredge equipment, staged in an area to be de-watered (by filter press or Geo-Tubes) and transported to a licensed off-Site disposal facility. Excavation will not be backfilled and the hydraulic capacity or the soil/water topography of the canal will be modified by this design. Table 6-7 displays the cost summary to implement this alternative. The costs are separated into three categories: Base Implementation, Remediation and Disposal, and Present-Worth O&M Costs. Base Implementation Costs are defined as, but not limited to, equipment and personnel mobilization to and from the Site, pre-remediation Site work, facilities, and Site characterization sampling and analysis. Remediation and Disposal Costs are defined as, but not limited to, equipment (excavator, loader, trucks, etc.), operators (includes lodging, transportation, per diem and wages), materials (cap, backfill, pipe, etc.), and disposal costs of the off-Site disposal facility. All material, equipment, and disposal price calculations were based from verbal or written quotes obtained from licensed, regional vendors approved by the EPA and PRPs. Present Worth O&M Costs are defined as, but are not limited to, engineered monitoring equipment (including installation), annual maintenance, and monitoring. Maintenance and monitoring events are scheduled semiannually for a 10-year time frame. Monitoring events include sample collection and analysis to determine status and progress of remedial action implementation and a thorough AOI site inspection. All sample analysis costs were calculated from quotes obtained from a qualified laboratory.

## 7.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

This section presents the comparative analysis of the remedial alternatives for each of the seven AOIs. The objective of the comparative analysis is to identify the advantages and disadvantages of each remedial alternative relative to one another within an AOI, and provide key information for use in determination of the selected remedy. The nine criteria discussed in detail in Section 5.0 (overall protection of human health and the environment, compliance with ARARs, long-term effectiveness and permanence, reduction of toxicity, mobility, and volume, short-term effectiveness, implementability, cost (Section 6.0), state acceptance, and community acceptance) are used to compare the remedial alternatives for each AOI in this section. Tables 7-1 through 7-7 document the comparative analysis of the remedial alternatives based on the nine criteria for Jefferson Canal AOI, Jefferson Canal Spoil Pile AOI, Former Star Lake AOI, Star Lake Canal AOI, Gulf States Utility Canal AOI, Molasses Bayou Waterway AOI, and Molasses Bayou Wetland AOI, respectively.

A criteria and numerical scoring system for the evaluation of remedial alternatives is used in Tables 7-1 through 7-7. The two threshold criteria (overall protection of human health and the environment and compliance with ARARs) are scored with a letter N - does not satisfy the criteria or an S - satisfies the criteria. The balancing criteria (long-term effectiveness and permanence, reduction of toxicity, mobility, and volume, short-term effectiveness, implementability, and cost) are scored by a numerical ranking system to compare these specific criteria for each remedial alternative with one another for each AOI. The ranking system scales the balancing criteria on 1-low, 2-low to moderate, 3-moderate, 4-moderate to high, and 5-high. If an alternative has a ranking of a 1 (low) or 2 (low to moderate), then the alternative does not meet the balancing criteria. The long-term exposure risks prevalent on this Site result in short-term effectiveness as being the least important of the balancing criteria. Implementability was given significant consideration due to the high performing wetland areas at the Site. Modifying criteria (state and community acceptance) are evaluated subsequent to submittal of the FS Report.

### 7.1 JEFFERSON CANAL

The comparative analysis for Jefferson Canal is shown on Table 7-1. The comparison shows:

- Alternative 1, No Action, does not meet the threshold criteria, does not meet the balancing criteria.
- Alternative 2a, containment: soil cap and pipe at JC-7, partial 12-inch removal/disposal, and partial containment: 12-inch soil cap, does not meet the threshold criteria, meets the balancing criteria.
- Alternative 2b, containment: soil cap and pipe at JC-7, partial 12-inch removal/disposal, and containment: 12-inch soil cap on area outside the pipeline servitude and a 12-inch erosion control mat on the pipeline servitude, meets the threshold criteria, meets the balancing criteria.
- Alternative 2c, containment: soil cap and pipe at JC-7, partial 12-inch removal/disposal, and partial containment: 12-inch armored cap, does not meet the threshold criteria, meets the balancing criteria.
- Alternative 2d, containment: soil cap and pipe at JC-7, partial 12-inch removal/disposal, and containment: 12-inch armored cap on area outside the pipeline servitude and a 12-inch erosion control mat on the pipeline servitude, meets the threshold criteria, meets the balancing criteria.
- Alternative 3a, partial 12-inch removal/disposal and partial containment: 12-inch soil cap, does not meet the threshold criteria, meets the balancing criteria.
- Alternative 3b, partial 12-inch removal/disposal and containment: 12-inch soil cap on area outside the pipeline servitude and a 12-inch erosion control mat on the pipeline servitude, meets the threshold criteria, meets the balancing criteria.
- Alternative 3c, partial 12-inch removal/disposal and partial containment: 12-inch armored cap, does not meet the threshold criteria, meets the balancing criteria.
- Alternative 3d, partial 12-inch removal/disposal and containment: 12-inch armored cap on area outside the pipeline servitude and a 12-inch erosion control mat on the pipeline servitude, meets the threshold criteria, meets the balancing criteria.
- Alternatives 2b, 2d, 3b, and 3d take the pipeline servitude into account.
- Alternatives 3d and 3b have similarly high scores for balancing criteria.
- Cost for Alternative 3b is less than Alternative 3d.

Alternative 3b appears to be the best choice based on scores from the balancing criteria.

## 7.2 JEFFERSON CANAL SPOIL PILE

The comparative analysis for Jefferson Canal Spoil Pile is shown on Table 7-2. The comparison shows:

- Alternative 1, No Action, does not meet the threshold criteria, does not meet the balancing criteria.
- Alternative 2a, containment: 2-foot composite cap, meets the threshold criteria, meets the balancing criteria.
- Alternative 2b, removal/disposal of mounds to grade and containment: 2-foot composite cap, meets the threshold criteria, meets the balancing criteria.
- Alternative 2c, partial containment: 2-foot composite cap, does not meet the threshold criteria, meets the balancing criteria.
- Alternative 3a, partial 12-inch removal/disposal and containment: 2-foot composite cap, meets the threshold criteria, meets the balancing criteria.
- Alternative 3b, 12-inch partial removal/disposal and partial containment: composite cap, does not meet the threshold criteria, meets the balancing criteria.
- Alternatives 2b and 3a have similarly high balancing criteria scores.
- The cost for Alternative 2b is less than the cost for Alternative 3a.

Alternative 2b appears to be the best choice based on scores from the balancing criteria.

## 7.3 FORMER STAR LAKE

The comparative analysis for Former Star Lake is shown on Table 7-3. The comparison shows:

- Alternative 1, No Action, does not meet the threshold criteria, does not meet the balancing criteria.
- Alternative 2a, partial 12-inch removal/disposal and partial containment: 12-inch impermeable cap (minimizes erosion), does not meet the threshold criteria, meets the balancing criteria.
- Alternative 2b, partial 12-inch removal/disposal and containment: 12-inch impermeable cap (minimizes erosion) on area outside the pipeline servitude and a 12-inch erosion control mat and composite cap on the pipeline servitude, meets the threshold criteria, meets the balancing criteria.

- Alternative 3a, partial 12-inch removal/disposal and partial containment: 12-inch composite cap, does not meet the threshold criteria, meets the balancing criteria.
- Alternative 3b, partial 12-inch removal/disposal and containment: 12-inch composite cap on area outside the pipeline servitude, and a 12-inch erosion control mat and composite cap on the pipeline servitude, meets threshold criteria, meets the balancing criteria.
- Alternatives 2b and 3b have similarly high balancing criteria scores.
- Cost for Alternative 2b is less than cost for Alternative 3b.

Alternative 2b appears to be the best choice based on scores from the balancing criteria.

## 7.4 STAR LAKE CANAL

The comparative analysis for Star Lake Canal is shown on Table 7-4. The comparison shows:

- Alternative 1, No Action, does not meet the threshold criteria, does not meet the balancing criteria.
- Alternative 2, 12-inch removal/disposal and containment: 12-inch impermeable cap (minimizes erosion), meets the threshold criteria, meets the balancing criteria.
- Alternative 3, 12-inch removal/disposal and containment: 12-inch armored cap, meets the threshold criteria, meets the balancing criteria.
- Balancing criteria for Alternative 2 score is higher than for Alternative 3 and Alternative 2 costs less.

Alternative 2 appears to be the best choice based on scores from the balancing criteria.

Removal of material over the pipeline servitude areas will be determined during the Remedial Design phase and if removal is not possible, the 12-inch Impermeable Cap or Erosion Control Mat will be installed on the pipeline servitude, and removal/disposal will only be implemented in 68 percent of the AOI.

## 7.5 GULF STATES UTILITY CANAL

The comparative analysis for Gulf States Utility Canal is shown on Table 7-5. The comparison shows:

- Alternative 1, No Action, does not meet the threshold criteria, does not meet the balancing criteria.
- Alternative 2, containment without excavation: 12-inch composite cap, meets the threshold criteria, meets the balancing criteria.
- Alternative 3, 12-inch removal/disposal and containment: 12-inch armored cap, meets the threshold criteria, meets the balancing criteria.
- Alternative 4, 12-inch removal/disposal, meets the threshold criteria, meets the balancing criteria.
- Alternatives 2, 3, and 4 all have similar balancing criteria scores.
- Cost for Alternative 2 is less than Alternatives 3 and 4.

Alternative 2 appears to be the best choice based on scores from the balancing criteria.

## 7.6 MOLASSES BAYOU WATERWAY

The comparative analysis for Molasses Bayou Waterway is shown on Table 7-6. The comparison shows:

- Alternative 1, No Action, does not meet the threshold criteria, does not meet the balancing criteria.
- Alternative 2a, Monitored Natural Recovery, meets the threshold criteria, meets the balancing criteria.
- Alternative 2b, Monitored Natural Recovery and 12-inch removal/disposal and containment: 12-inch armored cap, meets the threshold criteria, meets the balancing criteria.
- Alternative 3, 12-inch removal/disposal and containment: 12-inch armored cap, meets the threshold criteria, does not meet the balancing criteria.
- Alternatives 2a and 2b have similar balancing criteria scores.
- Cost for Alternative 2a is less than Alternative 2b.

Alternative 2a appears to be the best choice based on scores from the balancing criteria.

## 7.7 MOLASSES BAYOU WETLAND

The comparative analysis for Molasses Bayou Wetland is shown on Table 7-7. The comparison shows:

- Alternative 1, No Action, does not meet the threshold criteria, does not meet the balancing criteria.
- Alternative 2a, Monitored Natural Recovery, meets the threshold criteria, meets the balancing criteria.
- Alternative 2b, Monitored Natural Recovery and containment: 12-inch composite cap, meets the threshold criteria, meets the balancing criteria.
- Alternative 2c, Monitored Natural Recovery and 12-inch removal/disposal and containment: 12-inch armored cap, meets the threshold criteria, meets the balancing criteria.
- Alternative 2d, Monitored Natural Recovery and 12-inch removal/disposal, meets the threshold criteria, meets the balancing criteria.
- Alternative 3, containment without excavation: 12-inch composite cap, does not meet the threshold criteria, does not meet the balancing criteria.
- Alternative 4, partial 12-inch removal/disposal and partial containment: 12-inch armored cap, does not meet the threshold criteria, does not meet the balancing criteria.
- Alternative 5, partial 12-inch removal/disposal, does not meet the threshold criteria, does not meet the balancing criteria.
- Alternatives 3, 4, and 5 do not meet the balancing criteria due to implementation difficulties.
- Alternatives 2a, 2b, 2c, and 2d have similar balancing criteria scores.
- Alternative 2a is significantly less costly than Alternatives 2b, 2c, and 2d.

Alternative 2a appears to be the best choice based on scores from the balancing criteria.

## 7.8 SUMMARY OF PREFERRED ALTERNATIVES

The preferred alternatives were selected based on the nine criteria. The following are preferred:

- Jefferson Canal – Alternative 3b: Partial 12-inch Removal/Disposal and Containment: 12-inch Soil Cap on area outside the pipeline servitude and a 12-inch Erosion Control Mat on the pipeline servitude: $1,122,000
- Jefferson Canal Spoil Pile – Alternative 2b: Removal/Disposal of Mounds to Grade and Containment: 2-foot Composite Cap: $2,398,000
- Former Star Lake – Alternative 2b: Partial 12-inch Removal/Disposal and Containment: 12-inch Impermeable Cap on area outside the pipeline servitude and a 12-inch Erosion Control Mat and 12-inch Composite Cap on the pipeline servitude: $5,236,000
- Star Lake Canal – Alternative 2: 12-inch Removal/Disposal and 12-inch Impermeable Cap: $4,336,000
- Gulf States Utility Canal – Alternative 2: Containment 12-inch Composite Cap: $693,000
- Molasses Bayou Waterway – Alternative 2a: Monitored Natural Recovery: $1,453,140
- Molasses Bayou Wetlands – Alternative 2a: Monitored Natural Recovery: $2,165,340

The estimated cost of these alternatives is $17,403,480.

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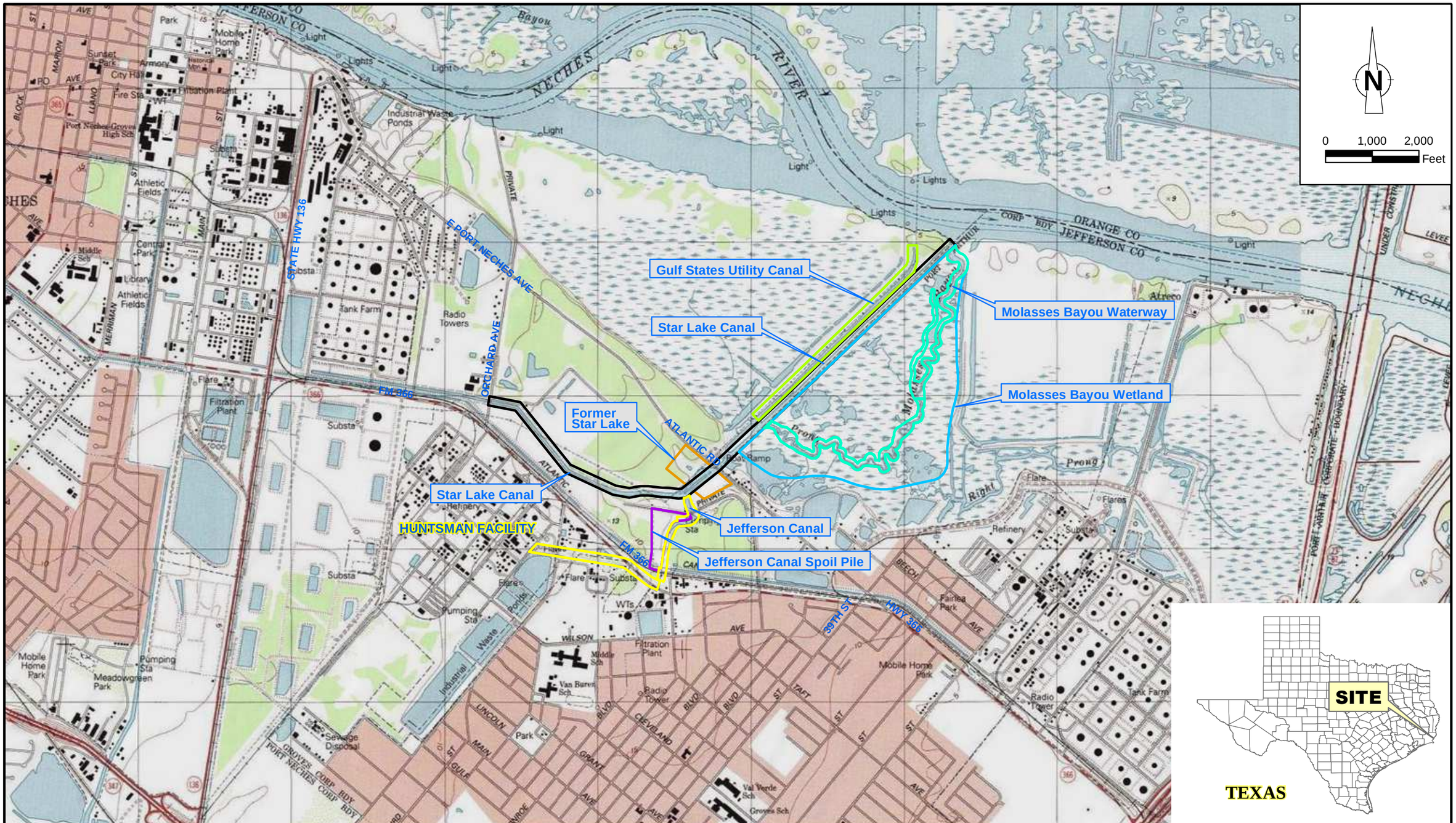
FIGURES




RE: USGS 1996 7.5 Minute Topographic Maps.

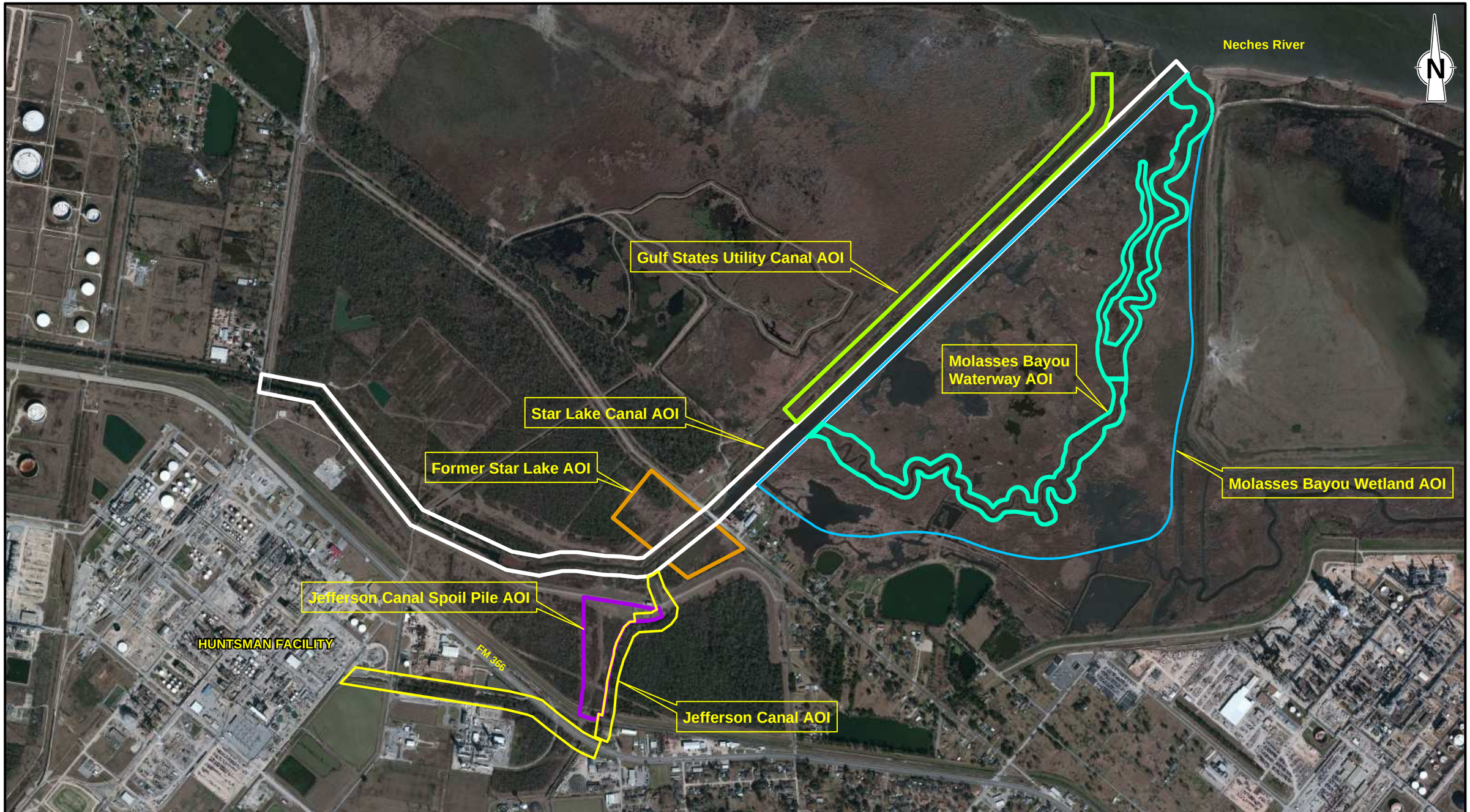
Figure 1-1
VICINITY MAP
STAR LAKE CANAL SUPERFUND SITE, JEFFERSON COUNTY, TEXAS
*Chevron Environmental Management Company, Bellaire, Texas*

27545-00(019)PR-BR002 MAR 29/2012

RE: USGS 2007 Aerial Photograph "High Resolution State Orthoimagery for Southeast Texas."

Figure 1-2
AERIAL PHOTOGRAPH
STAR LAKE CANAL SUPERFUND SITE, JEFFERSON COUNTY, TEXAS
*Chevron Environmental Management Company, Bellaire, Texas*

27545-00(019)PR-BR003 Apr 13/2012

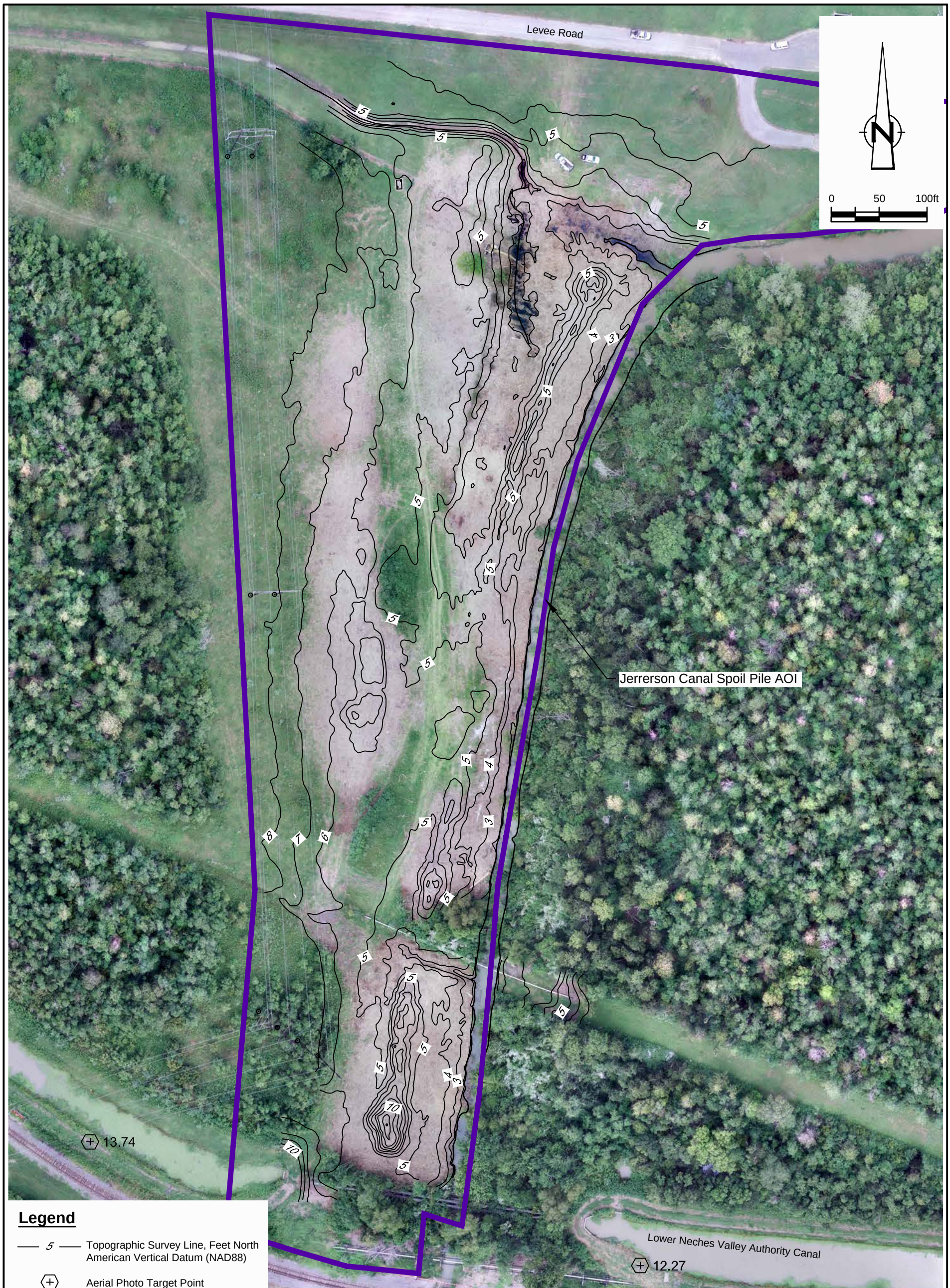



RE: 2010 Aerial by Microsoft Corp and its data suppliers.

0 500 1,000
Feet

Figure 1-3
SITE MAP - AREAS OF INVESTIGATION
STAR LAKE CANAL SUPERFUND SITE, JEFFERSON COUNTY, TEXAS
*Chevron Environmental Management Company, Houston, Texas*

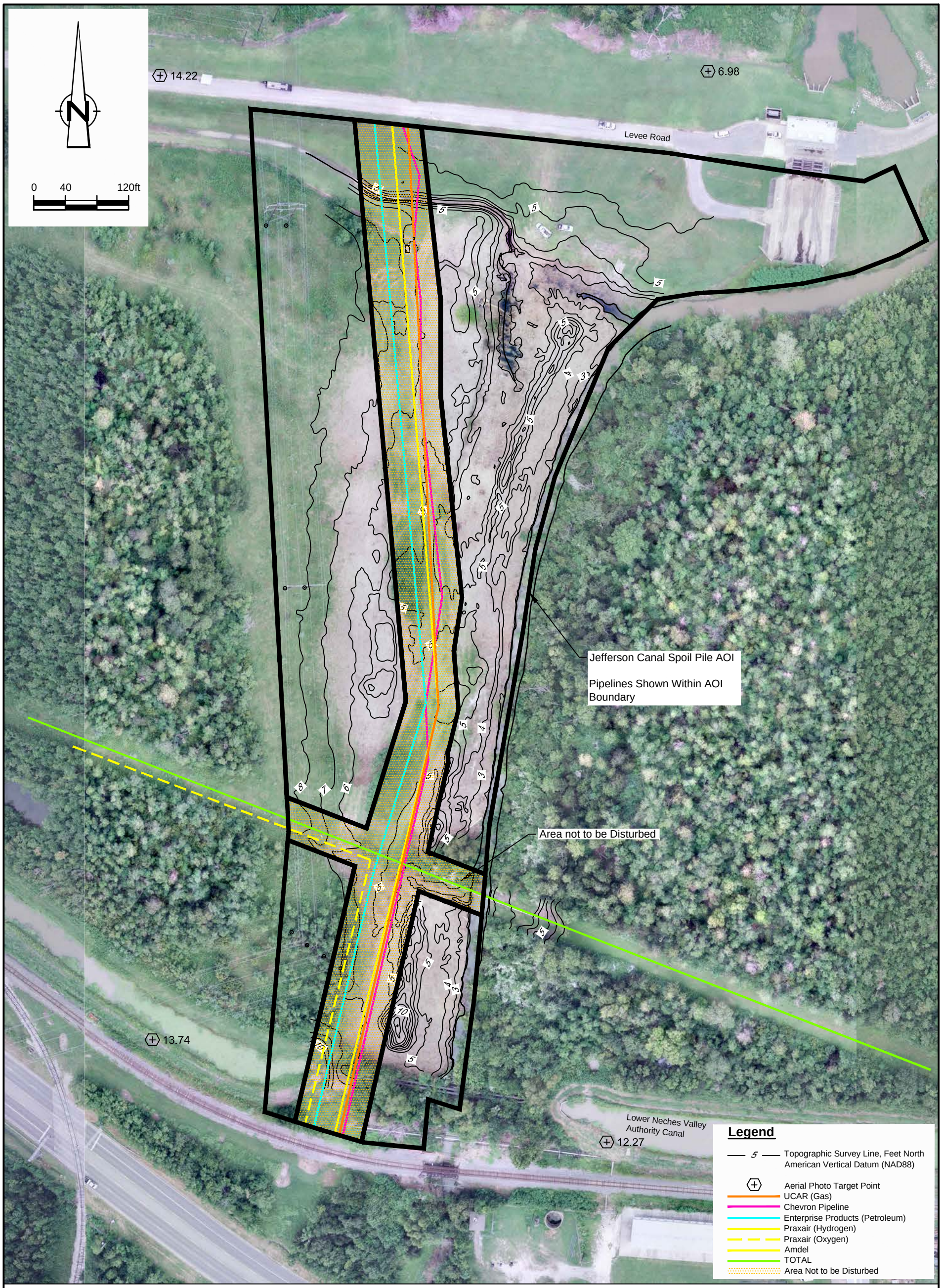
27545-00(019)PR-BR004 MAR 29/2012




RE: Aerial photograph by Gulf Coast Aerial Mapping dated August 31, 2009.

Figure 1-4
JEFFERSON CANAL SPOIL PILE AOI TOPOGRAPHIC SURVEY MAP
STAR LAKE CANAL SUPERFUND SITE, JEFFERSON COUNTY, TEXAS
*Chevron Environmental Management Company, Bellaire, Texas*

027545-00(019)GN-BR004 MAR 30/2012




RE: Aerial photograph by Gulf Coast Aerial Mapping dated August 31, 2009.

Figure 1-5
PIPELINES IN THE VICINITY OF JEFFERSON CANAL SPOIL PILE AOI
STAR LAKE CANAL SUPERFUND SITE, JEFFERSON COUNTY, TEXAS
*Chevron Environmental Management Company, Bellaire, Texas*

CRA

027545-00(019)GN-BR005 Jun 4/2012

| ID No. | Address | Acreage | Owner | Owner Location |
|---|---|---|---|---|
| 1 | Port Arthur, TX | 6.39 | Harbor Marine Service | Port Arthur, TX |
| 2 | Port Arthur, TX | 2.485 | (b) (6) | |
| 3 | Port Arthur, TX | 33.018 | | |
| 4 | Port Arthur, TX | 2.191 | | |
| 5 | Port Arthur, TX | 1.84 | | |
| 6 | Port Arthur, TX | 1.251 | | |
| 7 | Port Arthur, TX | 3.38 | | |
| 8 | Port Arthur, TX | 11.335 | | |
| 9 | 5000 Atlantic Road | 0.443 | | |
| 10 | 4934 Atlantic Road | 0.664 | | |
| 11 | 4924 Atlantic Road | 0.365 | | |
| 12 | 4914 Atlantic Road | 0.478 | | |
| 13 | 4910 Atlantic Road | 0.468 | | |
| 14 | 4906 Atlantic Road | 0.395 | | |
| 15 | 4900 Atlantic Road | 0.281 | | |
| 16 | 4848 Atlantic Road | 0.25 | | |
| 17 | Atlantic Road | 0.495 | Total Petrochemicals | Austin, TX |
| 18 | 4740 Atlantic Road | 0.514 | (b) (6) | |
| 19 | 4728 Atlantic Road | 0.25 | | |
| 20 | 4700 Atlantic Road | 0.671 | | |
| 21 | Atlantic Road | 0.664 | | |
| 22 | 4642 Atlantic Road | 0.647 | | |
| 23 | 4540 Atlantic Road | 1.453 | | |
| 24 | 4550 Atlantic Road | 0.253 | | |
| 25 | 4500 Atlantic Road | 0.372 | | |
| 26 | 4500 Atlantic Road | 0.604 | | |
| 27 | 4438 Atlantic Road | 0.69 | | |
| 28 | 4428 Atlantic Road | 1.096 | | |
| 29 | Atlantic Road | 10.643 | | |
| 30 | Port Arthur, TX | 3 | | |
| 31 | Port Arthur, TX | 1.191 | | |
| 32 | 4400 Atlantic Road | 3.397 | | |
| 33 | 4416 Atlantic Road | * | | |
| 34 | 4402 Atlantic Road | 3.397 | | |
| 35 | Atlantic Road | * | | |
| 36 | 4404 Atlantic Road | 3.397 | | |
| 37 | 4328 Atlantic Road | * | | |
| 38 | 4300 Atlantic Road | * | | |
| 39 | 4300 Atlantic Road | * | | |
| 40 | 4228 Atlantic Road | 2.002 | | |
| 41 | Coke Road | 2.917 | Total Petrochemicals | Austin, TX |
| 42 | 4225 Coke Road | 0.534 | (b) (6) | |
| 43 | Coke Road | 0.759 | Jefferson Co Drainage Dist 7 | Port Arthur, TX |
| 44 | Coke Road | 0.09 | Jefferson Co Drainage Dist 7 | Port Arthur, TX |
| 45 | Coke Road | 0.34 | Jefferson Co Drainage Dist 7 | Port Arthur, TX |
| 46 | Coke Road | 0.691 | Jefferson Co Drainage Dist 7 | Port Arthur, TX |
| 47 | Coke Road | 4.19 | Total Petrochemicals | Austin, TX |
| 48 | Coke Road | 4.75 | (b) (6) | |
| 49 | 4843 Coke Road | 0.329 | | |
| 50 | 4550 Atlantic Road | 3.705 | | |
| 51 | Coke Road | 0.502 | Jefferson Co Drainage Dist 7 | Port Arthur, TX |
| 52 | 39th St | 1.632 | Jefferson Co Drainage Dist 7 | Port Arthur, TX |
| 54 | Port Arthur, TX | 636.927 | Econo Rail Corp | Humble, TX |
| 55 | Port Arthur, TX | 8.627 | (b) (6) | |
| 56 | Port Arthur, TX | 1.624 | Jefferson Co Drainage Dist 7 | Port Arthur, TX |

*Combined with other acreage

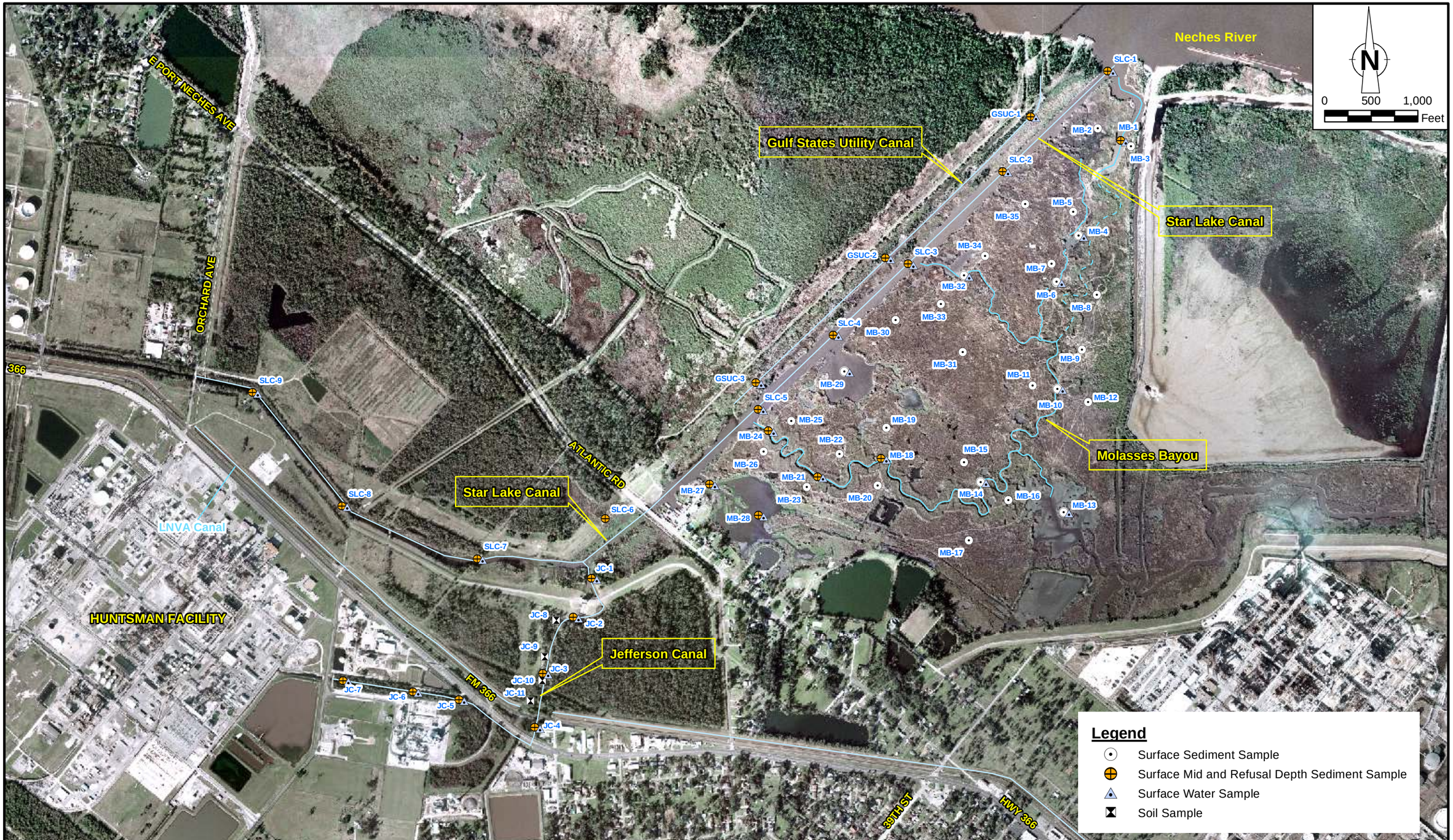
RE: 2010 Aerial by Microsoft Corp and its data suppliers
Jefferson County Appraisal District Office Maps, Sheet 315D, B315, 326C.

Note: Property boundaries depicted are exactly as shown on
Jefferson County Appraisal District Office Maps.

0 200 400
Feet

Figure 1-6
PROPERTY BOUNDARY MAP
STAR LAKE CANAL SUPERFUND SITE, JEFFERSON COUNTY, TEXAS
*Chevron Environmental Management Company, Houston, Texas*

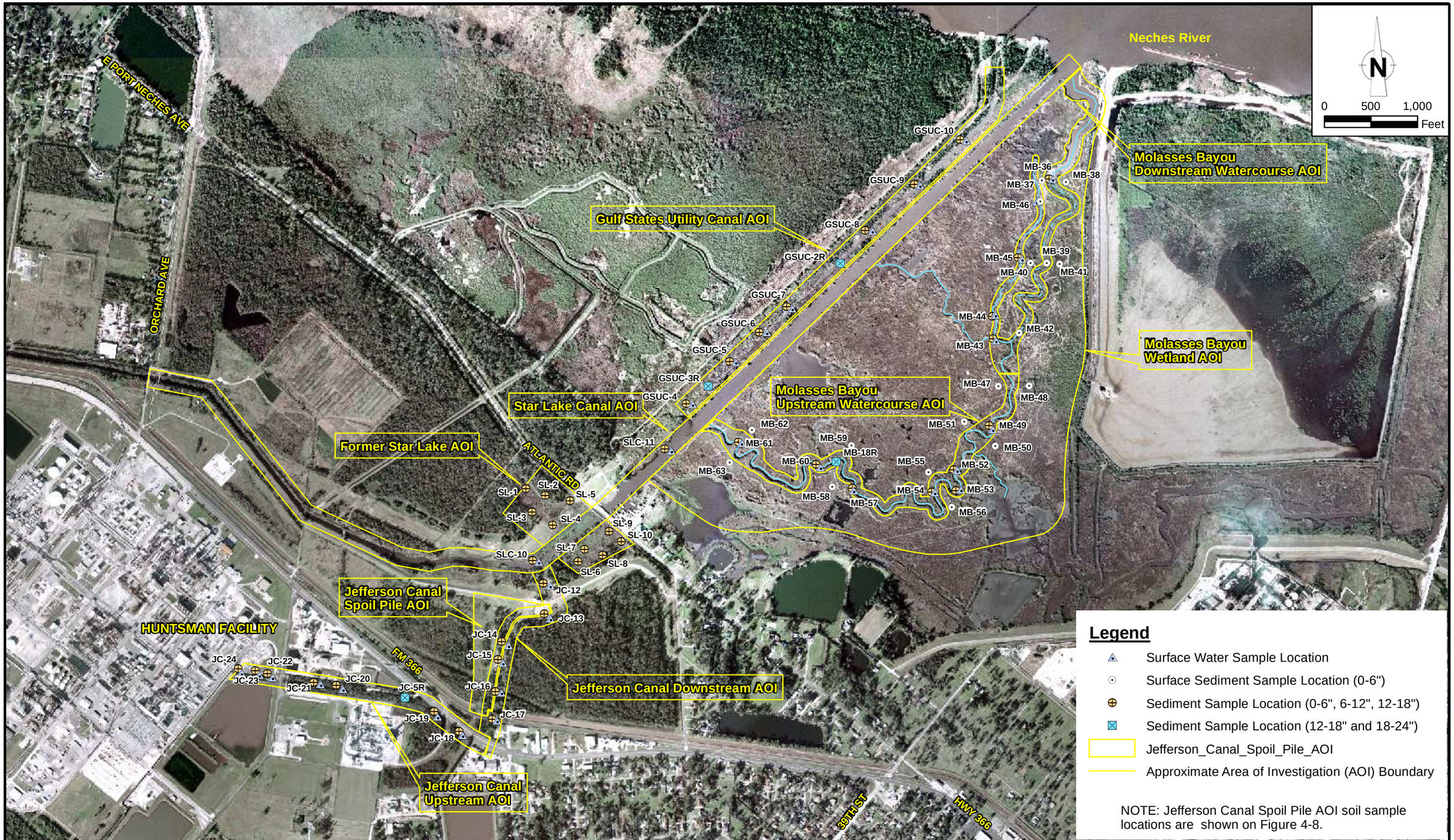
27545-00(019)PR-BR011 Mar 29/2012




RE: USGS 2007 Aerial Photograph "High Resolution State Orthoimagery for Southeast Texas."

Figure 2-1
TIER 1 REMEDIAL INVESTIGATION SAMPLE LOCATIONS
STAR LAKE CANAL SUPERFUND SITE, JEFFERSON COUNTY, TEXAS
*Chevron Environmental Management Company, Bellaire, Texas*

27545-00(019)PR-BR005 mar 29/2012




RE: USGS 2007 Aerial Photograph "High Resolution State Orthoimagery for Southeast Texas."

Figure 2-2
TIER 2 REMEDIAL INVESTIGATION SAMPLE LOCATIONS
STAR LAKE CANAL SUPERFUND SITE, JEFFERSON COUNTY, TEXAS
*Chevron Environmental Management Company, Bellaire, Texas*

27545-00(019)PR-BR0006 mar 29/2012